FEASIBILITY REPORT

ON

LINK ROAD BETWEEN MALTA AND GOZO ISLANDS

MALTA

MARCH 1974

OVERSEAS TECHNICAL COOPERATION AGENCY

GOVERNMENT OF JAPAN

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FOREWORD

In compliance with the request of the Government of Malta, the Government of Japan undertook to conduct a feasibility study for the Link Road Project to connect Malta and Gozo Islands, and entrusted the Overseas Technical Cooperation Agency with its execution.

Noting that the completion of the Link Road Project will undoubtedly afford an important foundation for future socio-economic development of Malta, the Agency organized a five-member survey team, headed by Mr. Akimaro MATSUZAKI of Honshu-Shikoku Bridge Authority, and dispatched it to Malta in December 1971 in an attempt to grasp the outline of the project.

In August 1973, the Agency sent a second survey team comprising eleven experts to Malta. During its two-and-a-half-months' stay in Malta, the second survey team, led by Mr. Tatsuo ASAMA of the Road Bureau, Ministry of Construction, was able to carry out survey activities smoothly as scheduled with unlimited and very helpful cooperation offered by the competent Maltese authorities.

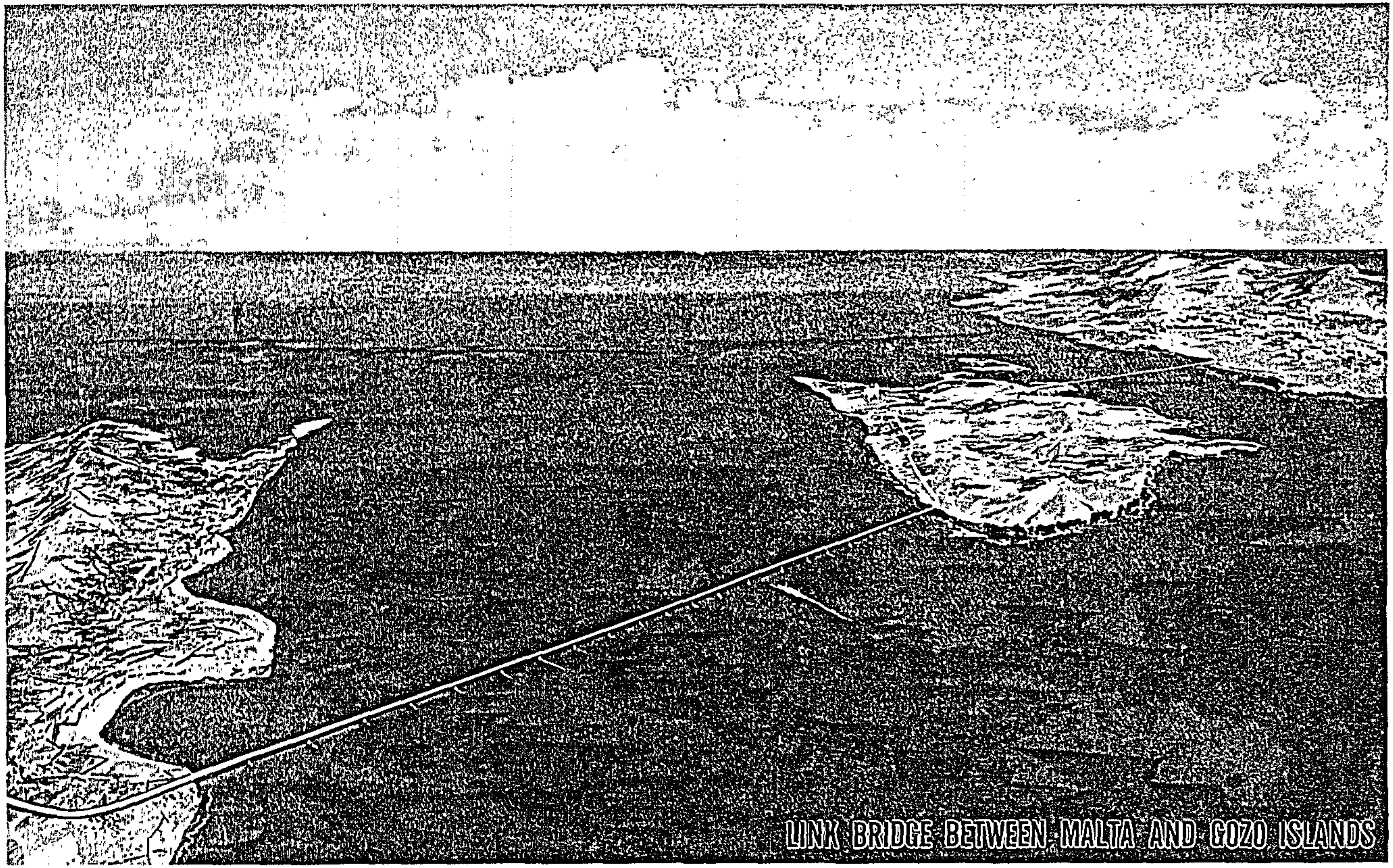
After its return to Japan, the team undertook a review and compilation of data collected during the survey for preparation of the feasibility report which is submitted herewith.

With a view to stabilizing the people's welfare and promoting the economic development of Malta, the technical as well as economic feasibility of constructing a bridge between Malta and Gozo Islands is studied in this report. The bridge construction, it may be added, is the final plan adopted after careful comparison with and scrupluous examination of two other alternative plans for the project implementation, i.e., the causeway construction plan and submerged tunnel plan.

It will give us great pleasure if the outcome of the survey contained in this report proves instrumental in promoting the development of Malta, and at the same time in contributing to fostering the friendly relations now existing between Malta and Japan.

K. Tatsuke

Keiichi Tatsuke
Director General
Overseas Technical Cooperation Agency


LINK BRIDGE BETWEEN MALTA AND GOZO ISLANDS

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SUMMARY

SUMMARY

1. Outline of the Survey

At present, ferries operating between Malta and Gozo serve as the means of transportation linking the two islands. But there is no connecting roadway between the two islands, giving rise to various in conveniences and other difficulties not only for the inhabitants but also for visitors.

As a follow up to the preliminary survey, we investigated, from the viewpoint of technology and economy, the feasibility of the construction of a link road which, it is considered, will remove all the traffic inconveniences and other related problems.

In the preliminary survey, we examined three plans - causeway, submerged tunnel and bridge - to connect directly Malta and Gozo, and concluded that the bridge construction plan excels others in every respect.

This is due to the following reasons:

1) The causeway plan calls for the use of rocks and rubble to fill the roadbed. Since an open waterway must be left for navigation, either a bridge or a tunnel is indispensable in order to join that open space. This, however, increases construction costs. The causeway plan might possibly give rise to various other unforeseen and unpredictable problems, such as environmental changes around the channels.

2) The topography of the South Comino Channel is suitable for the adoption of a submerged tunnel system. The North Comino Channel, however, involves difficulties in the connection of the road to the Gozo island due to the cliff there and undersea work including excavation of sea bottom and settling of submerged tunnel segments, is difficult and makes the construction costs prohibitive compared to the other alternatives.

3) The undersea rock in the area forms an acceptable stratum to bear bridge substructures, making it possible to simplify the bridge substructure which can be constructed more easily than the other alternatives.

The construction costs for the channels are largely dependent on the undersea works, and it is recommended, for the sake of economy, that the structure, type method of construction be selected so as to minimize the marine construction work. Considering work safety, labour-saving, period of work required, and other various factors, the bridge is advantageous over the causeway and submerged tunnel plans.

In the final survey, the bridge plan has been examined at length on the basis of the data acquired by the preliminary survey, with reference to economic and technical feasibility as well as environmental conservation and in consideration of more effective operation of the existing ferries than at present.

2. Bridge Plan

2.1 Design Criteria

The fundamental conditions for planning the road and bridge are as follows.

Design speed	:	60 km/hr
Width	:	8 m
Applied design standard	:	Highway Structural Standards (Japan)

2.2 Selection of Route

According to our reconnaissance survey of lands, there has been no particular obstruction standing in the way of route planning. In general, the soil conditions were also found to be favourable. As a consequence, the plan and profile projections have been drawn up to meet the highway structural standards in tially set and to select an economic route by utilizing as far as possible the existing roads in their relation to the bridge approach.

The costs for the construction across the channels are expected to vary largely depending on the depth of the water encountered during the work. In this connection, it would be advantageous as well as economical to select the shallowest part and the shortest route to be spanned by the bridge.

With this in mind, and using a 1/2,500 topographical map and the depth sounding data acquired during the final survey, we selected three Routes, A, B and C, as shown in Fig. 1, for study. Although Routes B and C, make the bridge length shorter than Route A, they cover a longer distance of deep water area, requiring much greater costs for undersea foundation work. Therefore, Route A was decided on. On the other hand, the site of the bridge over the North Comio Channel has been selected so as to span shallow waters with a minimal possible distance between Comino and Gozo.

The routes considered are shown in Fig.-1, and the most promising Route A has been divided into the following sections for further study.

Table-1 ROUTE A - LENGTH BY DIVISION OF STUDY

	Length					
Section	Length overall	Malta	South Comino Channel	Comino	North Comino Channel	Gozo
Road	4,711 m	828 m	-	3,236 m	-	647 m
Bridge	3,240 m	-	2,040 m	-	1,200 m	-

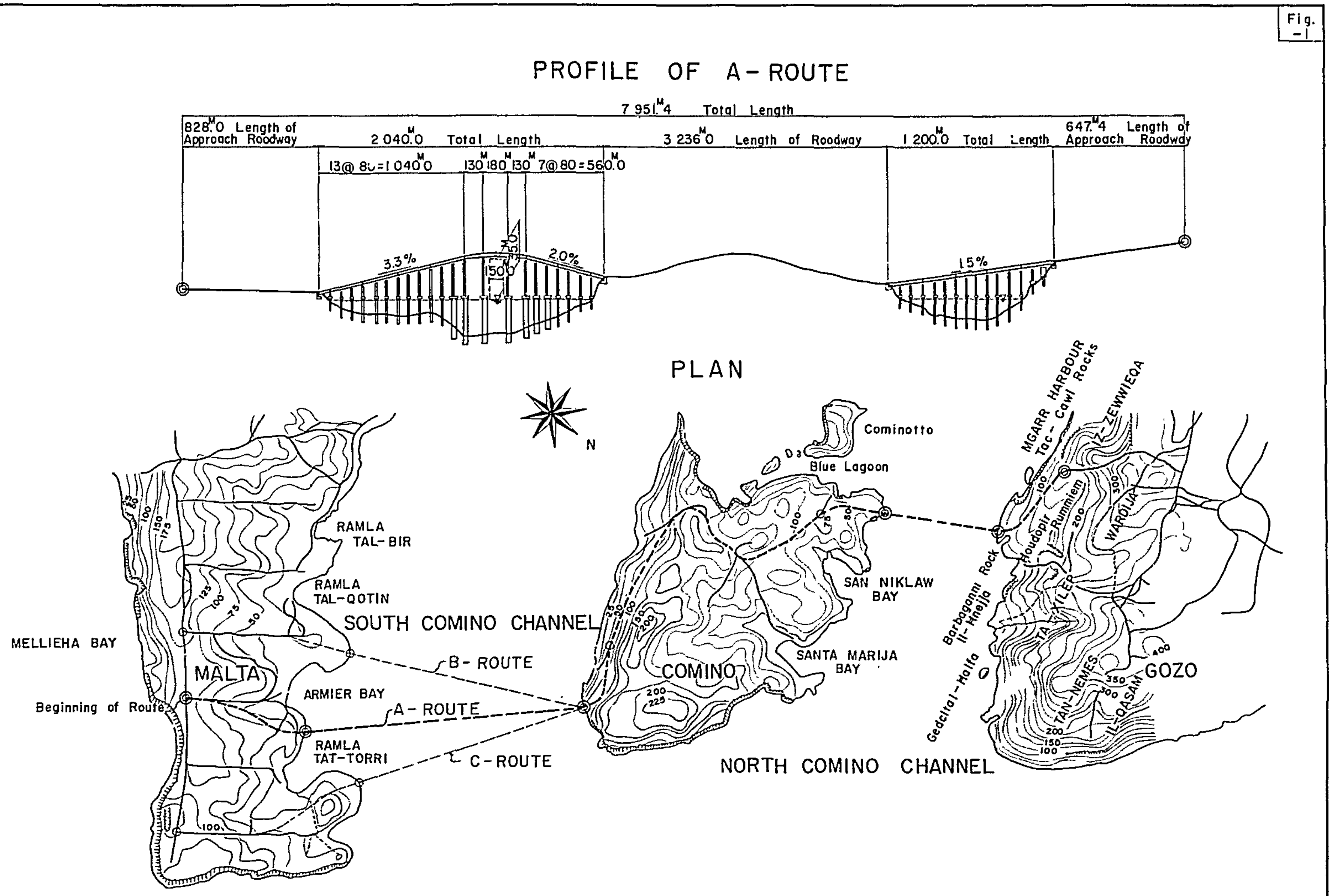

Fig -1	LINK ROAD BETWEEN MALTA AND GOZO ISLANDS
	LOCATION MAP

2.3 Structural Design

A large tract of coral rock forming the sea bottom is favourable for the construction of the bridge substructure, and we have selected a method in which piers are built of submerged concrete grouted into a confinement prepared by driving in precast prestressed concrete piles. Iron-reinforced concrete with iron framing as a timbering has been selected for the substructure. A 3-span continuous deck floor type box girder which permits the use of the so-called floating crane method with a minimum of maritime work was adopted for the bridge superstructure. In order to secure navigable waterways in the South Comino Channel, the span and height of the central part of the bridge was determined with the following clearance (Fig. 2) taken into consideration and according to the structural design standards now practiced in Japan.

It is to be understood however that the design and structure of the bridge explained above are based on rough data so far available to us.

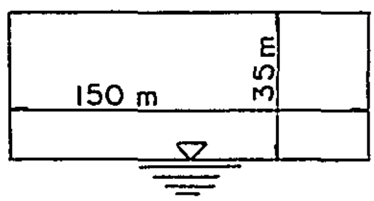

Fig. -2 NAVIGATION CLEARANCE FOR SOUTH COMINO CHANNEL

2.4 Construction Costs and Schedule

The construction costs and schedule for the route under consideration have been estimated as follows.

Construction Costs: -

Table-2 CONSTRUCTION COSTS

		Amount, LM	Amount, million yen	Remarks
(1) Direct construction costs for link road	Road	354,700	226	-
	South bridge	5,208,000	3,906	-
	North bridge	2,274,700	1,706	-
Total		7,837,400	5,878	(1)
(2) Costs for detailed engineering, surveying, studies, etc.		235,100	176	(1) x 3%
(3) Taxes		548,600	410	(1) x 7%
(4) Reserves		1,567,400	1,176	(1) x 20%
(5) Total construction cost		10,188,500	7,640	(1)+(2)+(3)+(4)
Maintenance and operating costs		54,700/yr.	41/yr.	Yearly costs

Schedule

Total period	Approx. 7 years
Survey period (incl. investigations, studies, surveying, detailed engineering, etc.)	Approx. 2 years
Construction period for the entire coverage	Approx. 5 years

3. Economic Appraisal

3.1 Traffic Volume in Future

In order to predict the future traffic demand, the correlation between the prevailing characteristics of economic and industrial activities in Malta and the existing ferry traffic volume has been analyzed, and the extent to which the economic and industrial activities will be developed in Malta in future has been forecast and studied from the correlative analysis.

The future traffic volume estimated by the above approach is given in Table 3.

Table-3 VOLUME OF TRAFFIC BETWEEN MALTA AND GOZO ISLANDS (Vehicles/Year)

Year	1971	1980	2010
Traffic volume	79,660	151,800	450,700
Remarks	Number of motor vehicles by ferryboats	Incl. originating, generated and diverted traffic	

In the year 2010, the traffic volume in the peak hour in the peak month has been estimated at 510 vehicles/hr.

According to the highway structural standards enforced in Japan, a two-lane bridge is estimated to have a traffic capacity of 1,140 vehicles/hr, justifying the construction of a two-lane bridge for the expected future traffic volume.

3.2 Economic Impacts

With reference to the originating and generated traffic volumes expected between Malta and Gozo in future, the cost-benefit ratio and internal rate of return have been calculated by taking into account the following benefits.

1) Running benefit
2) Time benefit
3) Abatement of costs for operation and maintenance of small vessels
4) Saving of costs for maintenance and operation of ferries and for the reconstitution and expansion of the port and harbour facilities

Assuming that the geological survey, location surveying and detailed engineering will be begun in 1974, the proposed route will enter into operation in 1981, 7 years from now.

If the redemption is to be phased out in 30 years, it will be completed at the end of the year 2010.

The value of accrual benefits varies according to how the lucrative items are selected and how they are combined. Various combinations have duly been examined for the assessment of economic impacts. In the most profitable case, the internal rate of return, r, is expected to be 2.93%, which is far below the limits of loan terms prescribed by conceivable international financial institutions. A study made by way of reference on a toll system applied to the bridge operation has revealed that in the most profitable case the internal rate of return, r, is 4.86%.

Two cases - one available to users free of charge and one most profitable for operation - are compared in relation to cost-benefit ratio and internal rate of return as shown in Table 4 below.

Table-4 COST-BENEFIT RATIO AND INTERNAL RATE OF RETURN

Interest rate, %	Final year of redemption	Cost-benefit ratio in 30 years (1981 - 2010)
0.5	2001	1.41
1.0	2002	1.31
1.5	2004	1.22
2.0	2006	1.14
2.5	2008	1.06
3.0	2011	0.99
3.5	2015	0.93
4.0	2020	0.87
4.5	2030	0.82
5.0	-	0.77
Internal rate of return	r = 2.93%	

The three existing ferries, operating 10 to 11 round-trips a day, can transport 433,000 vehicles a year. Since the originating traffic volume in the year 2010 is expected to be 298,000 vehicles a year, the existing ferry lineup alone will do for the purpose insofar as it can be worked efficiently.

It is therefore suggested that efforts be exerted to make the most use of the existing ferries for the time being, and that the construction of the bridge be put off until the Maltese development activities will have increased the traffic volume enough to admit of such construction, because the protraction will prompt the manifestation of the investment impacts. At an opportune time, therefore, the construction schedule should be carefully decided after closely investigating the matters surrounding the project.

In connection, the considerations above may be summarized as follows.

1) The present project is less in investment return.
   (Max. internal rate of return: r = 2.93%)

2) It is suggested that the existing ferries be fully exploited for the time being.

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ACKNOWLEDGEMENTS

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Our debt in this respect is great to the following government authorities, agencies, offices, organizations, their officials and members and other individuals.

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Mr. Lorry Sant-----Minister

Mr. C.V. Psaila----Director

Mr. Joe Gambina----Deputy Director

Mr. Joe Huntingford.----Senior Planner

Mr. Gillian Calleja----Architect in Charge of Roads

Mr. Herbert Crockford----Architect in Charge of Airport Extension Program

Mr. Carm A. Bonello----In Charge of Harbour Development

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Mr. Paul Micallef----Assistant Land Survey Officer

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Mr. Anthony Pellegrini----Director of Information

Mr. Michael Pizzuto----Assistant Director of Information

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Gozo

Mr. Joseph Cefai----Assistant Secretary for Gozo

Mr. John Piscopo----Police Inspector in charge of Gozo District

Mr. Caristo Zammit of Zammit & Sons Ltd., ----Owners of the ferry boats to Gozo

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CHAPTER 1

INTRODUCTION

CHAPTER I INTRODUCTION

The present chapter outlines the preliminary survey conducted for the Malta-Gozo Link Road Construction Plan and the purposes and objects of the final survey carried out in succession to substantiate it.

1.1 Outline of the Preliminary Survey

In order to study the technical feasibility of the Malta-Gozo Link Road Construction, a survey team, comprising five experts, was sent on a mission to the projected site for the preliminary survey over some 19 days from Dec. 1, 1971. Along with the technical feasibility study, the team also investigated and examined what types and structures of the link road be employed for the bridges across the channels.

A rough representation of the projected site is given in Fig. 1-1. As is seen in Fig. 1-1, the connection between Malta and Gozo includes Comino in between, and the aggregate length of the channels to be crossed over is approximately 5 km, if direct linking is feasible, or about 1.8 km (Malta-Comino) plus 1.0 km (Comino-Gozo) if Comino is used as a stepping stone.

The maximum water depth is some 24 m in the South Comino Channel and some 20m in the North Comino Channel, and there is an eastward tidal current having a maximum velocity of 1 knot.

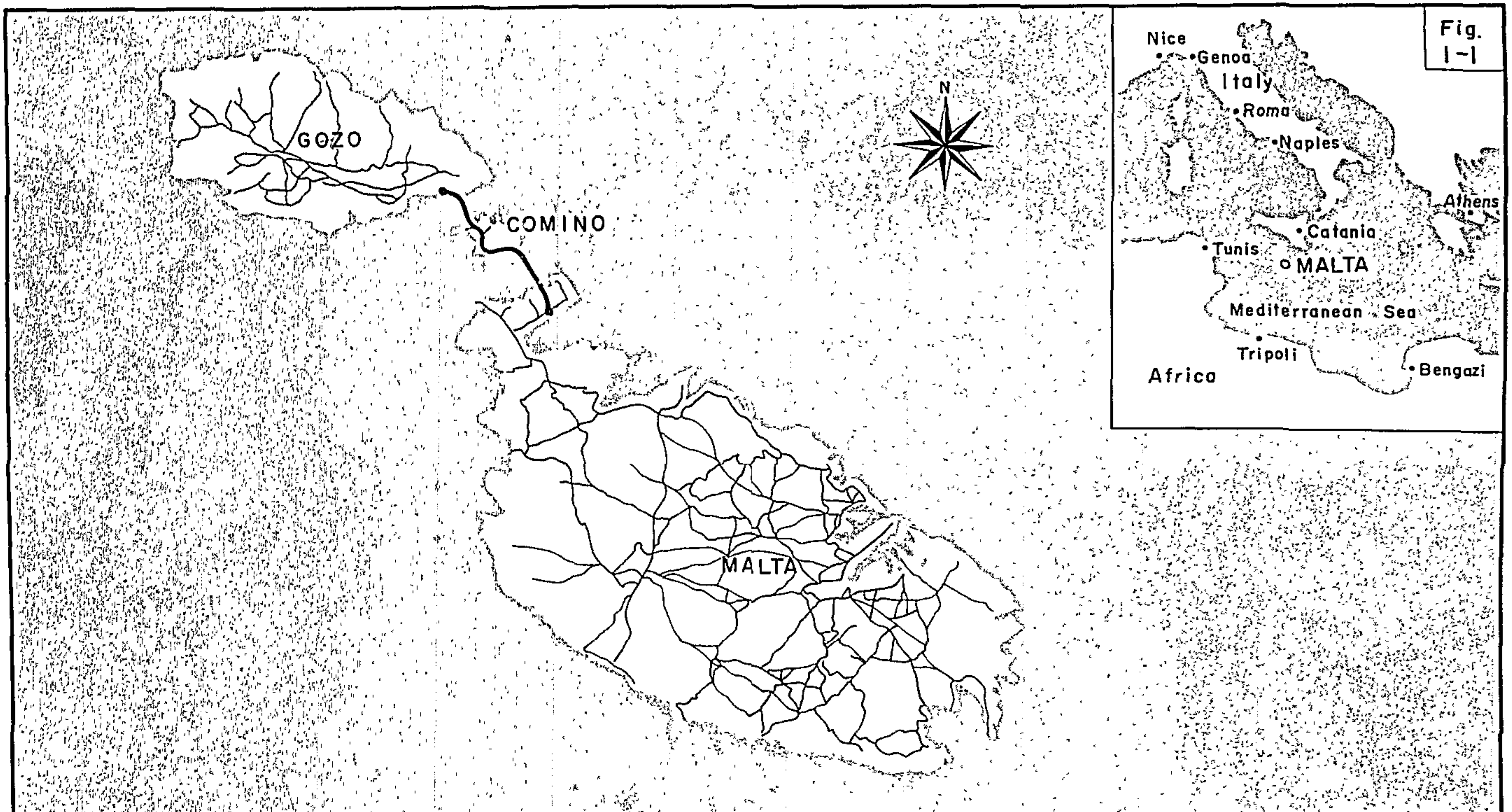


Fig. 1-1	LINK ROAD BETWEEN MALTA AND GOZO ISLANDS
	CONNECTING ROAD BETWEEN MALTA AND GOZO ISLANDS

1.1.1 Roadway Plan

After the reconnaissance survey, eligible routes were examined, and the most promising one was selected out of them considering various conditions, including topography, geology, compensations, water depth, etc.

Namely, the selected route consists of some 1,920 m of the South Comino Channel, some 820 m of the North Comino Channel and an aggregate length of some 8,720 m of link road. The road structural standards now practiced in Japan have been applied, which require the following as fundamental conditions.

Design speed	:	60 km
Minimum radius of curvature	:	120 m
Longitudinal slope	:	5%
Number of lanes	:	2
Width	:	8 m (2 × 3.25 = 6.5 m)

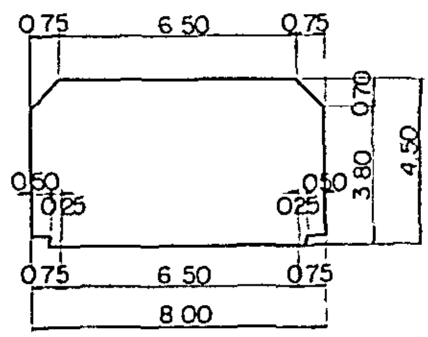


Fig. 1-2 CONSTRUCTION GAUGE

Construction gauge for channels: for navigable waterway of approx. 35 m above water and approx. 150 m in width (for the South Comino Channel only)

1.1.2 Bridge Plan

For the bridge construction in a strait or channel, it is usually practiced to lengthen the span of superstructure with a view to minimizing the number of substructures which are always endangered by indeterminates.

At first, the superstructure was planned and examined to be a concrete one, but it was found to outweigh the entire structure and overtax the substructure, making the insitu construction work very difficult. What is worse, the management and control of the construction work indispensable for high-quality structure were found prohibitively difficult.

For these reasons, studies have been concentrated mainly on a steel bridge. For the substructure, iron-reinforced concrete having precast P.C. piles as a foundation has been selected in view of excellent workability.

1.1.3 Submerged Tunnel

Topographically, the South Comino Channel permits the installation of a submerged tunnel. In the North Comino Channel, however, approach work to the shore is considered difficult. As regards the South Comino Channel, the requirements for navigation (water depth: 10 m; width: 150 m) can amply be satisfied.

An example of submerged tunnel construction is shown in Fig. 1-3, in which tunnel casings are to be settled about one-third full into a ditch excavated in the subsea bedrock.

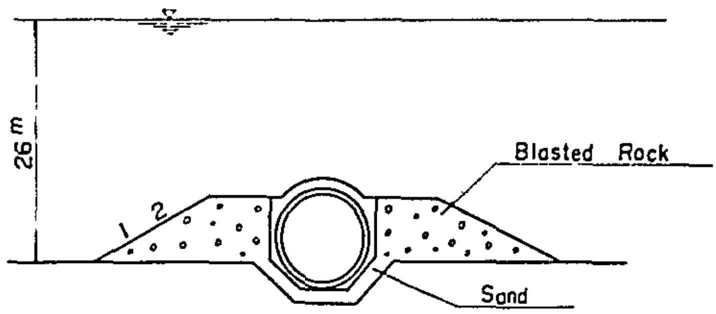


Fig. 1-3 SUBMERGED TUNNEL

1.1.4 Causeway

One reclaimed road proposed herein is of a structure having a reclaimed embankment, measuring 5 m above the mean tidal level in the top height and 20 m in top width, of which 8 m in the central part is appropriated for the road.

The embankment will be provided with openings at an adequate interval. This type of road can be achieved, provided that it has to be replaced partially with a bridge or a submerged tunnel for the purpose of accommodating navigable way. Fig. 1-4 illustrates the section of the proposed reclaimed road.

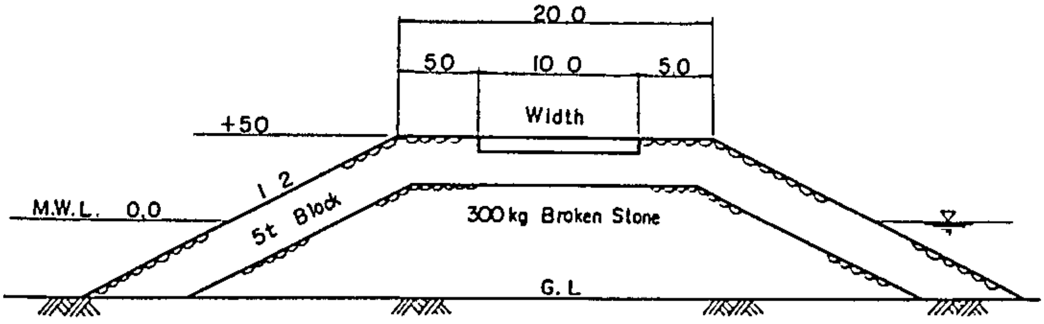


Fig. 1-4 CROSS SECTION OF CAUSEWAY (in meters)

1.1.5 Comparative Study of the Proposed Types of Link Road

It is obvious that the submerged tunnel scheme is advantageous over any other types when the clearance for navigation is considered. But, the submerged tunnel is expected to be most costly among the three, involve much difficulty in construction, require high maintenance cost when put in service, and to be inferior in running comfort to any other type.

As regards the causeway, a good deal enough quantity of rubbles of various sizes and of high quality is available near the projected site, but the construction cost will become high. In addition, the embankment will deteriorate the environs of the channels.

Judging from the construction cost, environmental impact, navigation clearance and other various factors, the bridge plan will be the best.

1.2 Objectives and Purposes of the Final Survey

As explained in para. 1.1, "Outline of the preliminary survey," it has been concluded after comparative study of various types of link road structure for connecting Malta and Gozo that the bridge plan excels others. In the final survey, therefore, the bridge plan has been examined more closely from the viewpoint of structural design, workability, economics, beautility, etc.

As regards the road, the approach ways for Malta and Gozo and transverse route for Comino have been subjected to reconnaissance study in order to use as far as possible the existing roads for the sake of economy. For the construction of the road, the standards referred to under para. 1.1.1 have been applied.

Aside from the link road plan, the improvement of the existing ferry system has also been considered with reference to transportation capacity, services, operating time, trip time, berthing facilities, etc. in trading off the future traffic volume between Malta and Gozo, because it is expected to absorb the traffic demand to some extent.

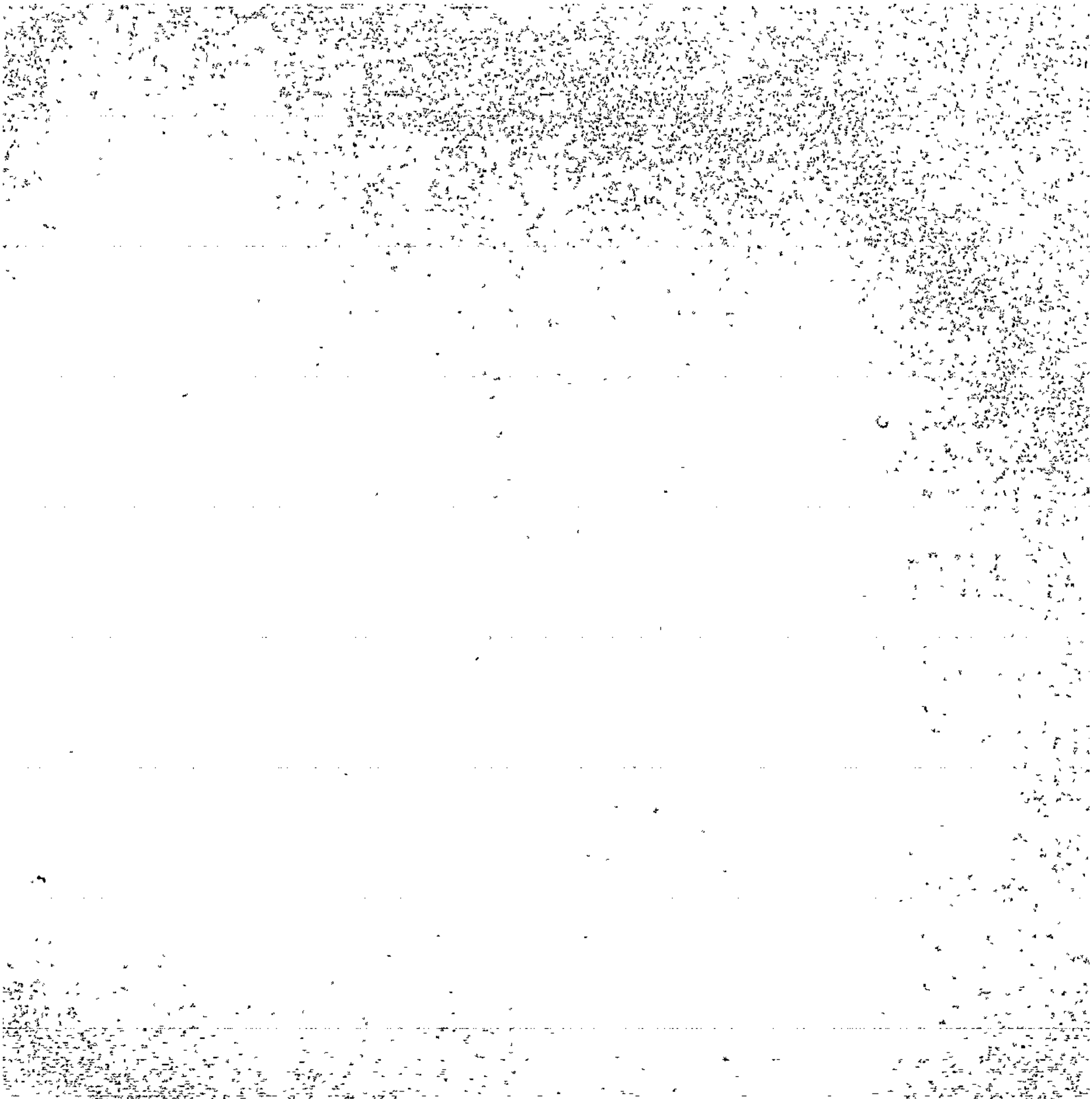
The bridge plan has been pushed forward on the premise that the bridge will be operated free of tollage, but toll system has also been examined by way of example for economic assessment.

The construction of a bridge could dispense with various costs and expenditures for the operation, maintenance and reconstruction of the port and harbour facilities, and the resultant benefits expected have been studied with respect to the following three cases.

1) Where the costs for the construction of port and harbour facilities are estimated high
2) Where the costs for the construction of port and harbour facilities are estimated low
3) Where any new port and harbour facilities are not constructed in Malta irrespective of the construction of a link bridge.

CHAPTER 2

SURVEY



CHAPTER II SURVEY

The hydrographic and oceanographic surveys have been conducted from August to October, 1973, covering the South Comino Channel between Malta and Comino and the North Comino Channel between Comino and Gozo, roughly 6 km^2 and 2 km^2 in area, respectively (Ref. Fig. 2-1).

Sounding, sonic prospecting and observation of tides and tidal currents have been carried out.

2.1 Sounding

To accomplish the survey of submarine topography, the Echo-sounder PDR-4 (using 4 beams) was employed.

For position fixing of the survey boat, radial line guidance and transit cut method were applied in the area where dense sounding intervals were required for the area of 500 meters width of the both sides of the bridge construction route.

In the other area where 100 meters intervals of sounding line was applied, position fixing of the survey boat was made by the straight line guidance and transit cut method.

The reduction of the tide level during sounding and sonic prospecting, was made by checking the tide curve obtained from the tide gauge in front of the Marfa Point Bench Mark shown in Fig. 2-1.

2.1.1 Results

1) Submarine Topography of the South Comino Channel

The South Comino Channel is about 1.8 km wide from Malta to Comio where the water depths are -10 to -70 meters as shown in Fig. 2-2.

The water depths in the bridge construction route (South Bridge) are less than -26 meters.

Increase of the depth is reported in the directions to the east and west of the bridge construction route.

The topography of the eastern part of the Channel is uneven and complicated while, on the contrary, the western part is flat.

2) Submarine Topography of the North Comino Channel

The width of the North Comino Channel from Comino to Gozo is about 1 km while the depths of the sea are -10 to -40 meters as shown in Fig. 2-3.

The depths of the bridge construction routh (North Bridge) are less than -20 meters.

In the central part of the bridge construction route where the depth is as shallow as -20 meters and the sea floor was shown to be uneven and rough.

No major differences in depths can be seen as compared with the Admiralty

Chart No. 2623, London, 1959.

2.2 Sonic Prospecting

In order to survey the submarine geology and the structure of the sea floor, the Sparker and the Sonoprobe (both made in Japan) were employed for sonic prospecting. The former was applied to the study of the lower part of the structure, down to the depth of 100 meters below the floor.

While, the latter was applied to analysing the sedimentation of the upper part of the sea bed.

The plotting allowance of sonic prospecting is estimated to be 2 meters for the Sparker while for the Sonoprobe the allowance is of about 0.3 to 0.5 meter

The total length of the survey lines of the sonic prospecting is about 62 km. in the South Comino Channel and 24 km. in the North Comino Channel.

For fixing of the survey boat position, straight line guidance and transit cut method were applied in the direction of north to south, and west to east, two sextants were used for three-point fix method.

For analysing the Sparker and the Sonoprobe profiles, sound wave velocity was assumed as 1500 m/sec in the sandy deposits of Recent Period and 2500 m/sec for Tertiary sediments.

2.2.1 Results

The stratigraphy of the survey area is shown in Table 2-1 below.

Table 2-1 STRATIGRAPHY OF THE CHANNELS

Epoch	Formation	
Recent	A	Sandy Deposits
Tertiary (Miocene)	B*	Upper Coralline Limestone
	C	Blue Clay
	D	Globigerina Limestone
	-	Lower Coralline Limestone

* B Formation is classified into 4 members.

Many faults develop along the southern coast of Gozo running in the direction of east to west. These faults on Gozo separate the Upper Coralline Limestone from the Lower Coralline Limestone, Globigerina Limestone and Blue Clay.

The development of the Lower Coralline Limestone of the Channels was not clearly disclosed from the result of survey.

The distribution of both the Upper Coralline Limestone and the Sandy Deposits (A formation) is shown in Fig. 2-4 for the South Comino Channel and in Fig. 2-5 for the North Comino Channel.

Fig. 2-6 shows the geological profiles of the bridge construction route.

The following are the distribution of the each formation.

1) Globigerina Limestone (D formation)

This formation lies partially in the western part of the North Comino Channel and also near Gozo, covered by the sandy deposits. The faults separate this formation from the Upper Coralline Limestone. Well developed alternative bedding planes are recognized on the sonic prospecting profiles.

2) Blue Clay (C formation)

Covered by the sandy deposits, this formation distributes partially in the shoreside of the eastern part of the South Comino Channel.

3) Upper Coralline Limestone (B formation)

This is the youngest Tertiary formation in the islands. As determined, Comino is fully composed of the Upper Coralline Limestone, the formation distribute widely in the survey area.

This formation outcrops in the central part of the both Channels and thus forming an adequate supporting ground for the construction.

As the result of the analysis of the sonic prospecting profiles, the formation was divided into four members as shown in Table 2-2

Table 2-2 STRATIGRAPHY OF THE B FORMATION

Formation	Member	Lithological Character
B	B_1	Coralline Limestone
	B_2	Sandy Deposits (?)
	B_3	Sandy (?) - Coralline Limestone
	B_4	Coralline Limestone

There are lack of borehole data in the survey area. So that in order to study a sound wave velocity and a geological structure more in detail, it is recommended that the borehole survey should be carried out. Further, reexamination of the record of sonic prospecting may be required, depending upon the result of the borehole survey.

2.3 Survey of Tidal Currents and Tides

As shown in Fig. 2-1, the observations of tidal currents were conducted at the four stations A, B, C and D, where the survey boats were positioned at anchor The current meters, Type CM-2 (made in Japan), were employed for twenty-four hour observation of hourly current direction and speed.

The observations were carried out at the surface layer 1 meter below the sea surface, middle layer 6-9 meters below the sea surface and the bottom layer 2 meters above the sea bed.

For the observation of tides, a portable tide gauge, LPT Type (made in Japan) was installed on the sea bed at Marfa Point as indicated in Fig. 2-1. The continuous observation was conducted.

As the results of the observations, the harmonic analysis of tidal currents for 25 hours and the harmonic analysis of tides have been made so as to obtain the harmonic constants for the tidal currents and the tides.

The periods of the observations of the tidal currents and the tides are as follows:

Tidal currents observation	
Stations ; A, B	From 14th to 15th Sept., 1973
Stations ; C, D	From 29th to 30th Sept., 1973
Tide observation	From 17th Aug. to 7th Oct., 1973

2.3.1 Results

The results of tidal current observations are shown as the current vectors in Figs. 2-7-10.

The duration of the—north eastgoing current was longer than the opposit one in the Channel between Comino and Gozo. The maximum speed of the current in this Channel is reported as 0.5 m/sec (1 knot) in south—west going current at the surface layer.

In the Channel between Malta and Comino, the south—westgoing current prevailed.

The maximum speed of the current observed was reportedly 0.4 to 0.6 m/sec (0.8 - 1.2 knot) in the south-west going current.

The velocity of the current observed became lower as the depth increased and the current speed of the bottom layer was less than one half of that of the surface layer in the Channel between Comino and Gozo and three quarters of that of the surface layer in the Channel between Malta and Comino.

According to the results of observation of tides, the semi-diurnal constituents were predominant. And high water and low water occurred twice daily. However, tidal range was as small as 20 cm at the maximum.

The heights of the Bench Mark at the Ministry of Public Works at Marfa and the

Bench Mark installed on the Marfa Point shown in Fig. 2-1 are shown in Fig. 2-11 in connection with the reference levels of tides.

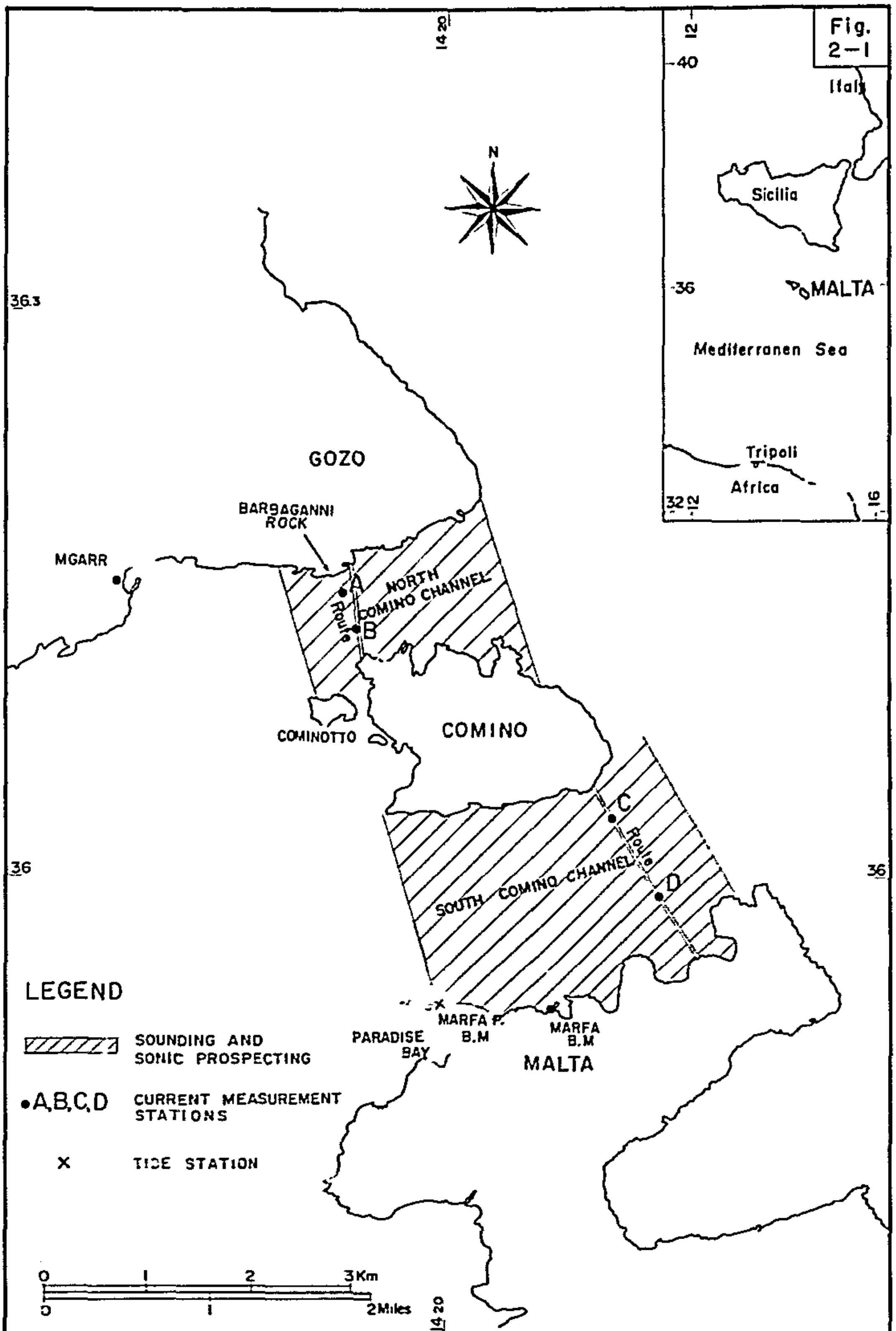


Fig. 2-1 | LINK ROAD BETWEEN MALTA AND GOZO ISLANDS

SURVEYED AREA OF THE MALTESE ISLANDS

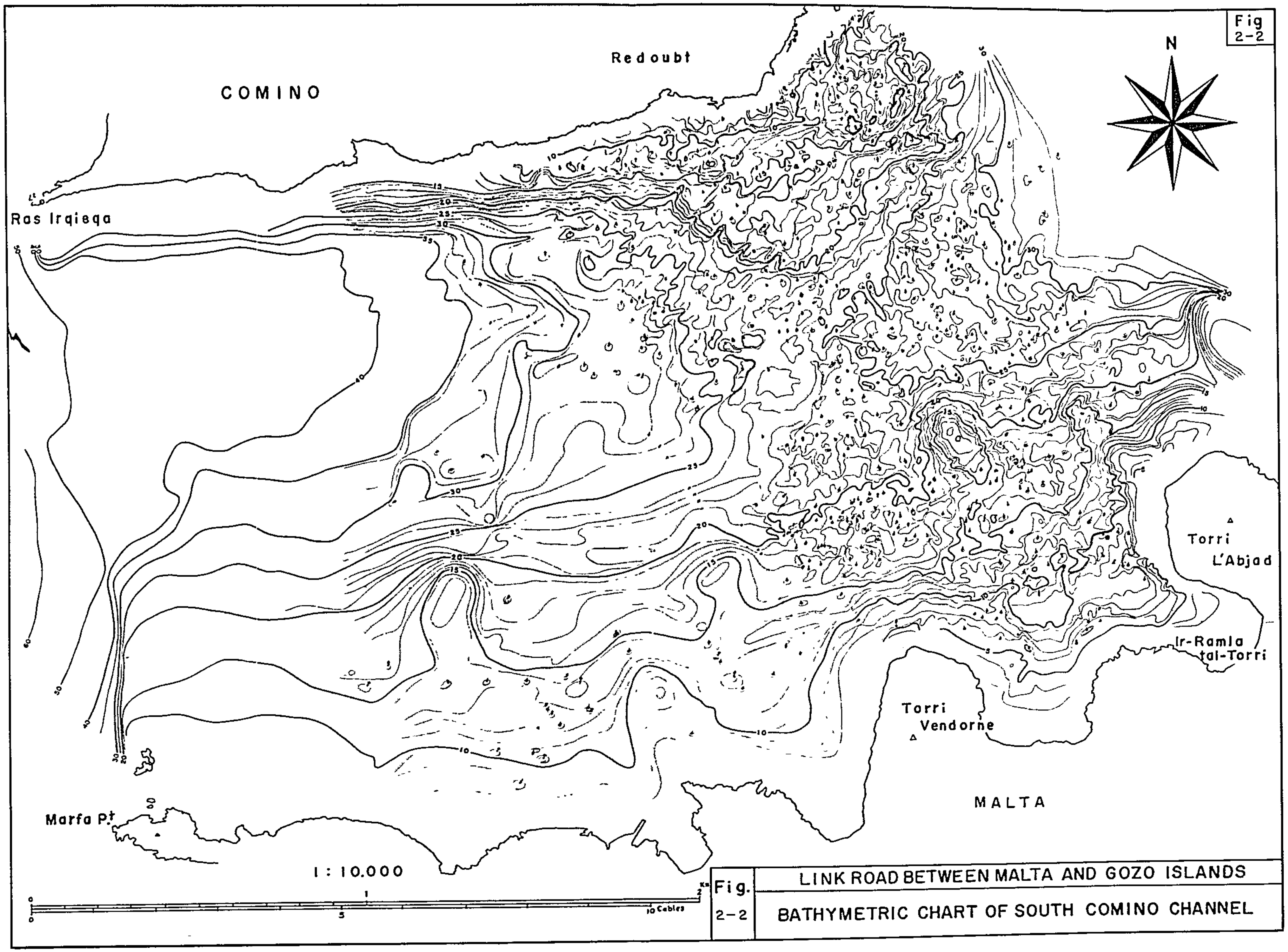


Fig. 2-2 LINK ROAD BETWEEN MALTA AND GOZO ISLANDS

BATHYMETRIC CHART OF SOUTH COMINO CHANNEL

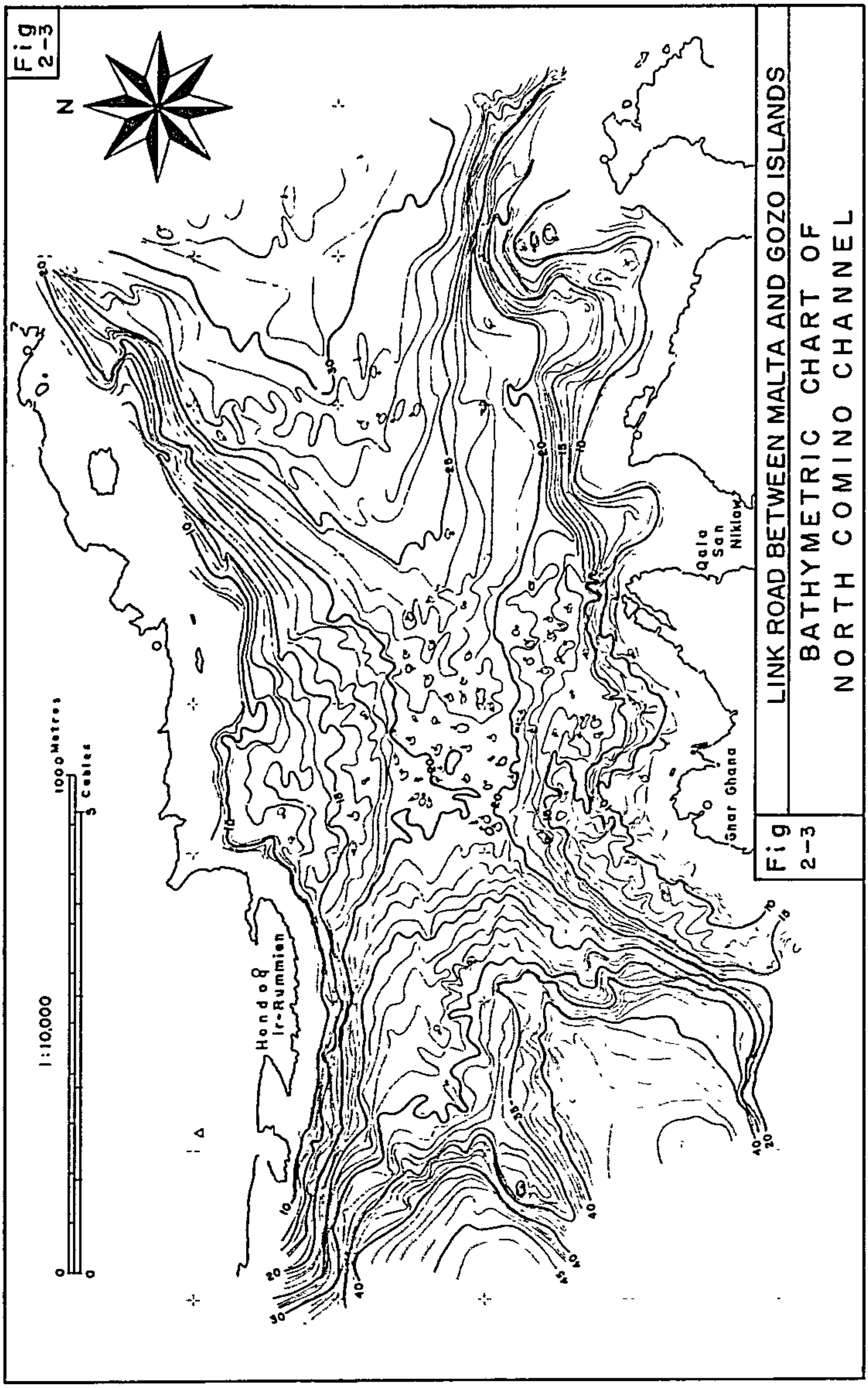


Fig 2-3
LINK ROAD BETWEEN MALTA AND GOZO ISLANDS
BATHYMETRIC CHART OF
NORTH COMINO CHANNEL
N
1:10,000
1000 Metres
5 Cables
Qala San Niklaw
Ghar Ghana
Hondoq Ir-Rummien

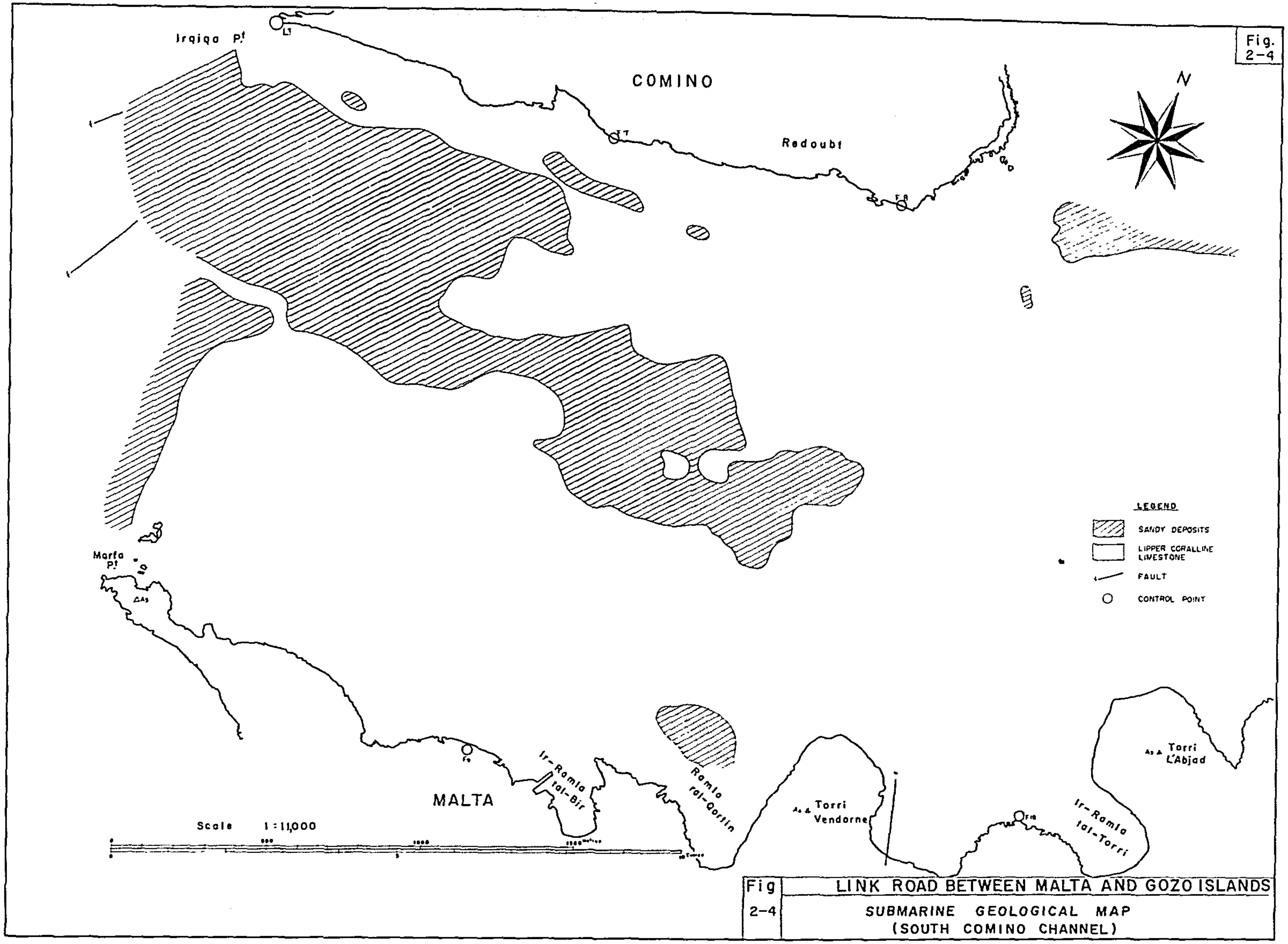


Fig 2-4 LINK ROAD BETWEEN MALTA AND GOZO ISLANDS
SUBMARINE GEOLOGICAL MAP
(SOUTH COMINO CHANNEL)

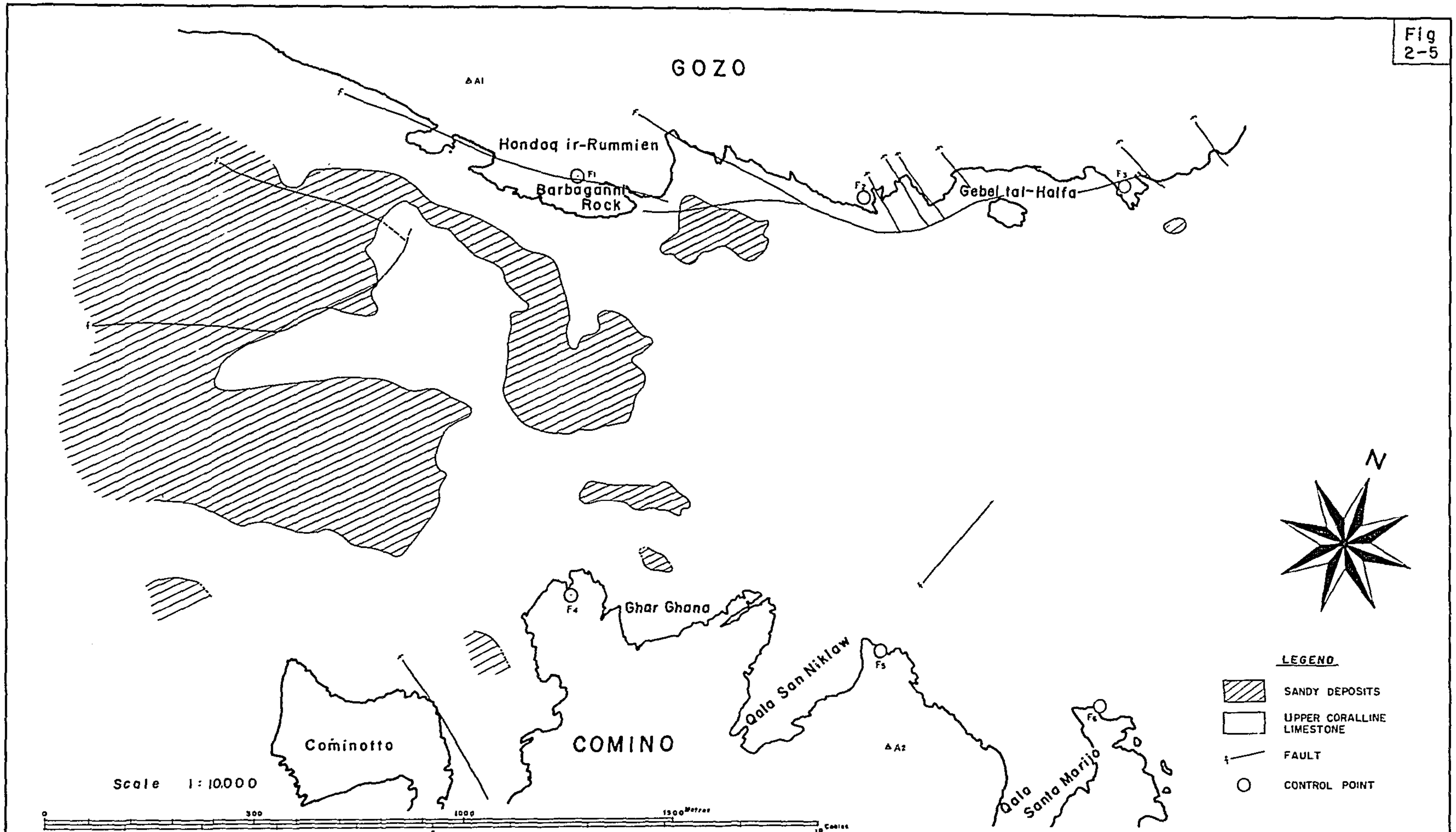


Fig 2-5	LINK ROAD BETWEEN MALTA AND GOZO ISLANDS SUBMARINE GEOLOGICAL MAP (NORTH COMINO CHANNEL)

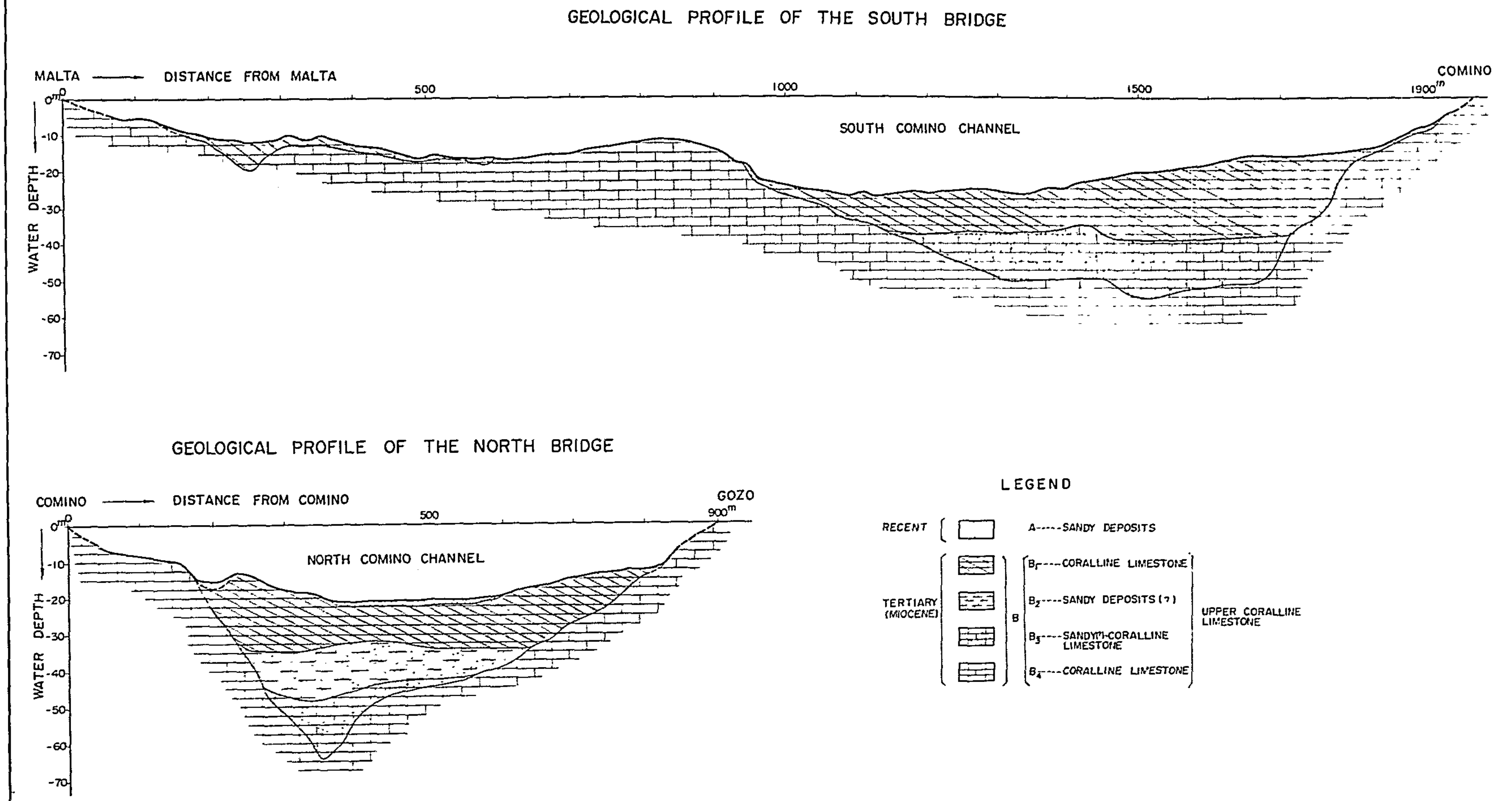
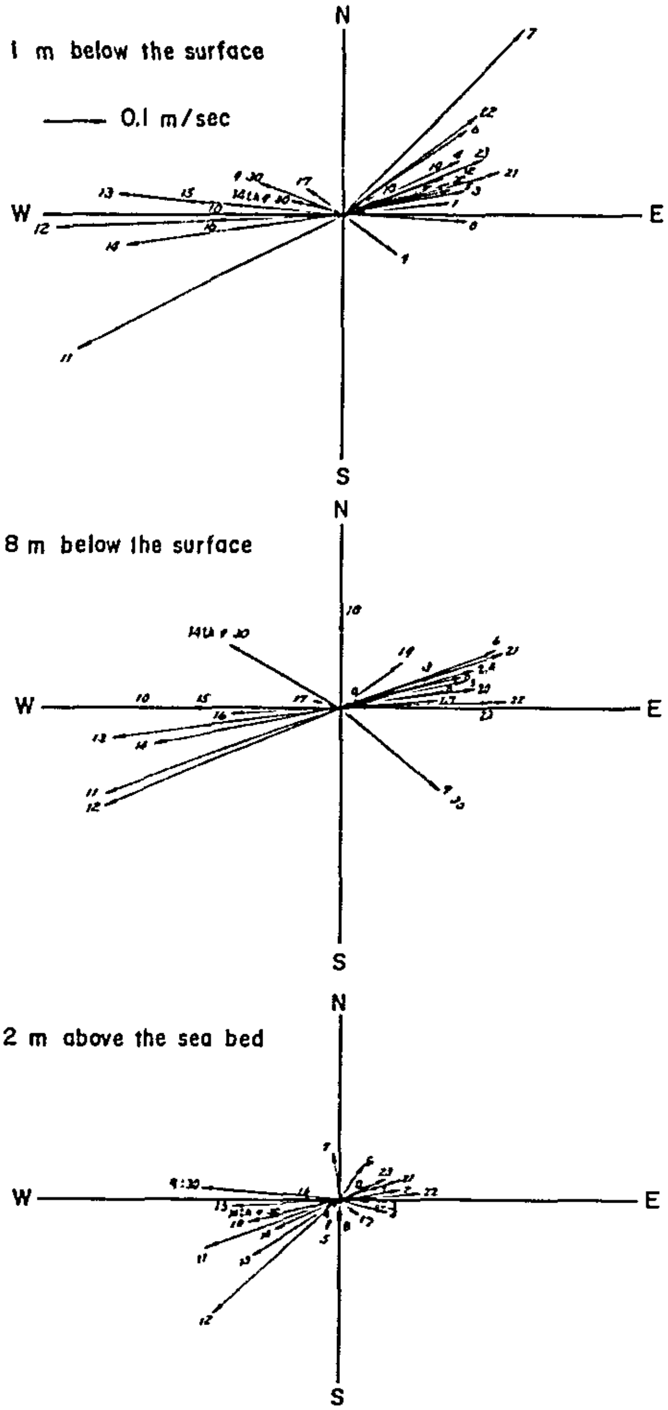


Fig 2-6

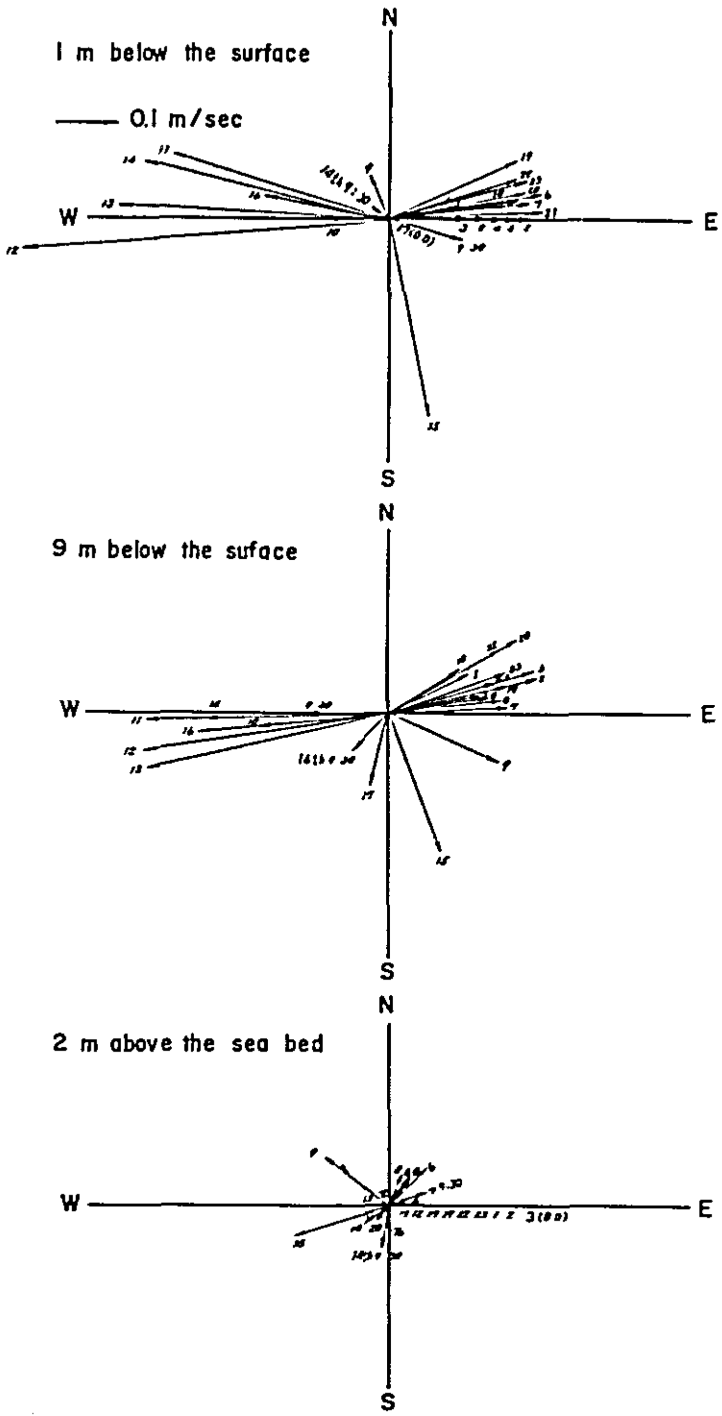
Fig 2-6	LINK ROAD BETWEEN MALTA AND GOZO ISLANDS
	GEOLOGICAL PROFILE OF THE BRIDGES

Fig. 2–7



DATE OF SURVEY 14∼15 SEP. 1973

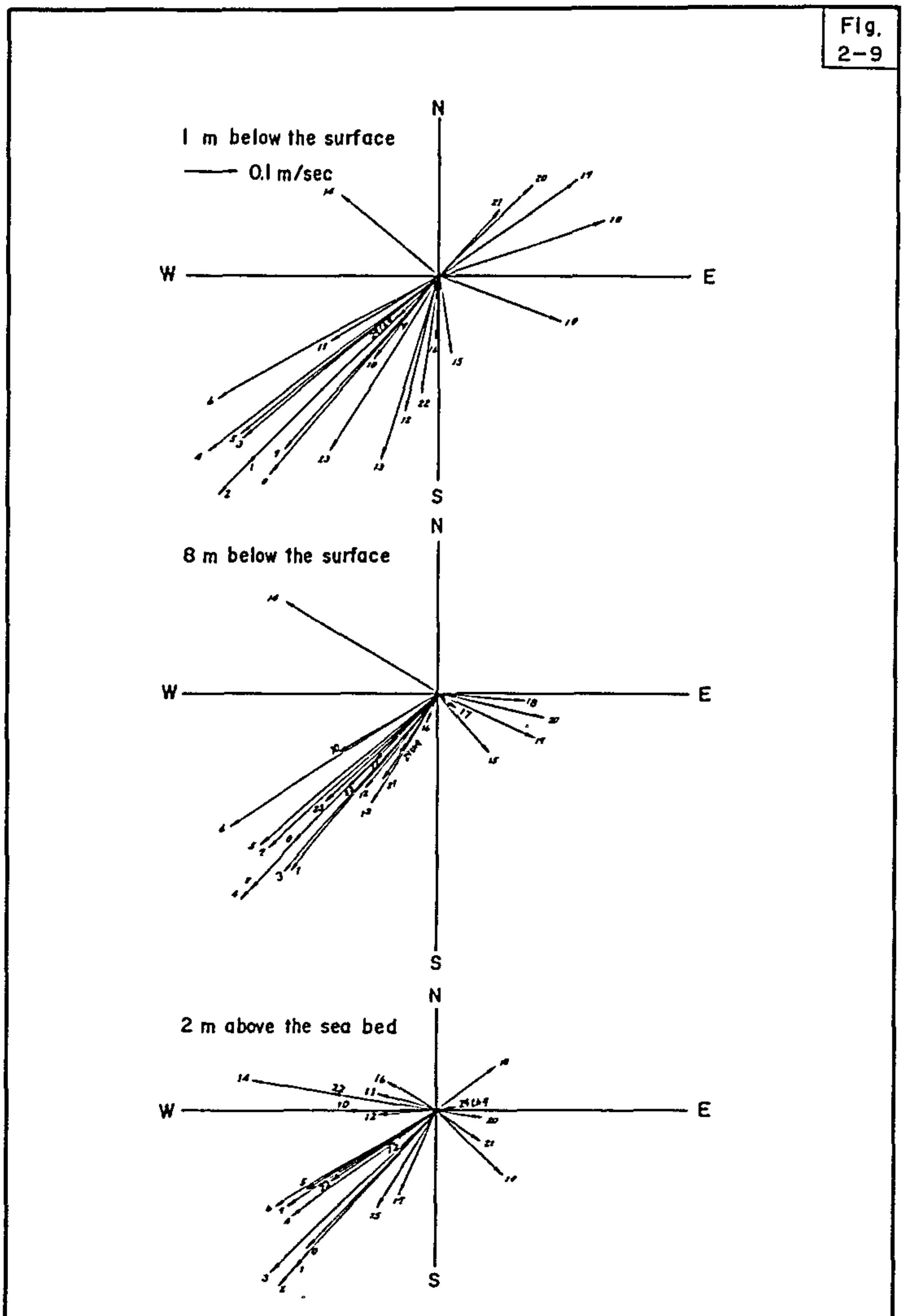
Fig. 2–7	LINK ROAD BETWEEN MALTA AND GOZO ISLANDS
	CURRENT VECTOR (STATION NO. A GOZO ∼ COMINO)



DATE OF SURVEY : 14~15 SEP 1973

Fig. 2-8	LINK ROAD BETWEEN MALTA AND GOZO ISLANDS
	CURRENT VECTOR (STATION NO. B GOZO ~ COMINO)

Fig. 2-8



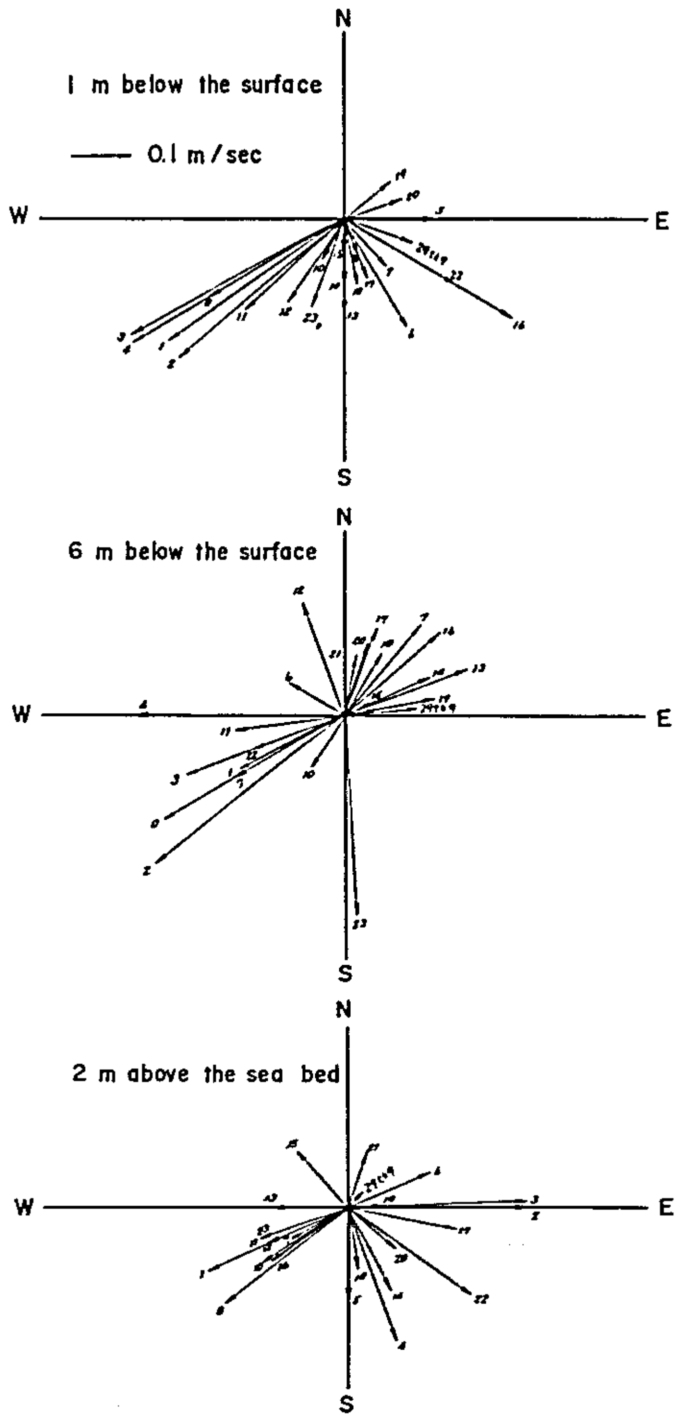
DATE OF SURVEY · 29~30 SEP 1973

Fig. 2-9

LINK ROAD BETWEEN MALTA AND GOZO ISLANDS

CURRENT VECTOR
(STATION NO. C COMINO ~ MALTA)

Fig. 2-10



• DATE OF SURVEY 29~30, SEP. 1973

Fig. 2-10	LINK ROAD BETWEEN MALTA AND GOZO ISLANDS CURRENT VECTOR (STATION NO. D COMINO ~ MALTA)

Fig. 2-11

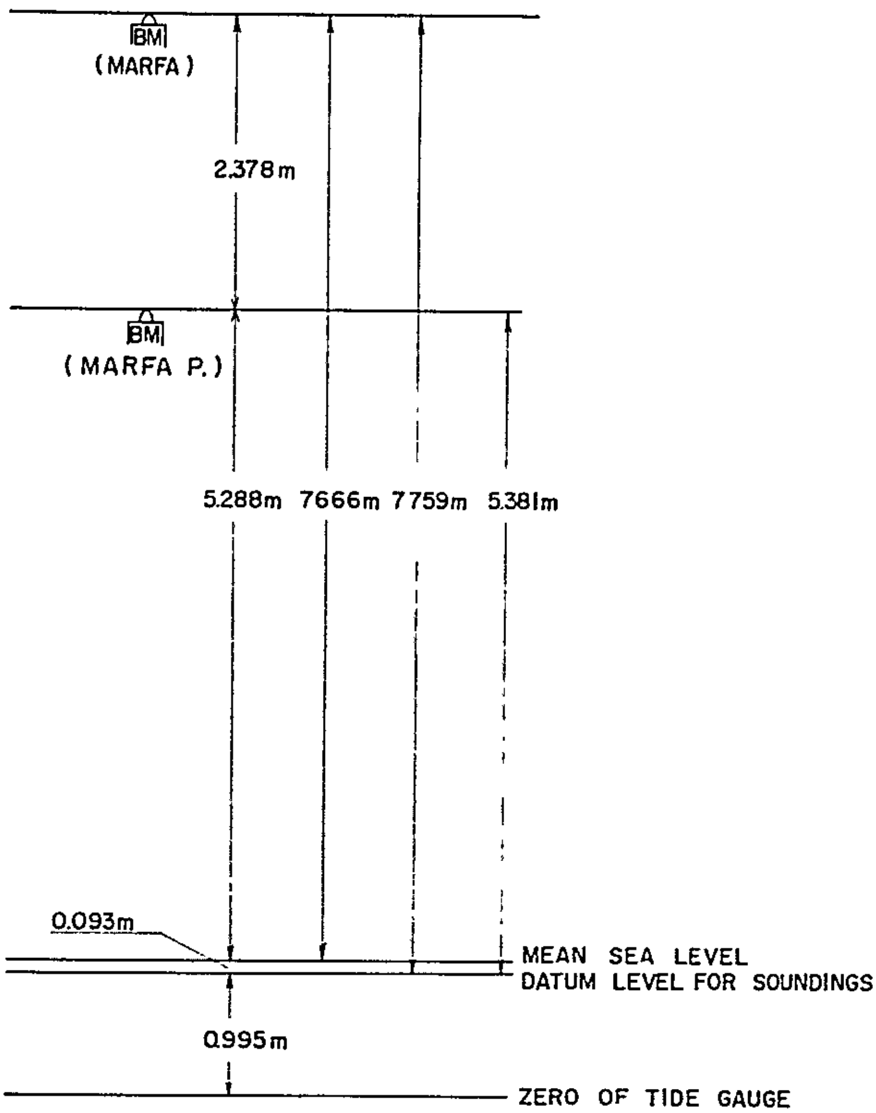


Fig. 2-11	LINK ROAD BETWEEN MALTA AND GOZO ISLANDS
	RELATION BETWEEN B.M. AND DATUM LEVEL

2.4 Economic Survey

The construction of a bridge between Malta and Gozo will bring about various impacts including reduction in travel time, etc. In order to visualize the impact of the bridge construction on Maltese economy, we have collected data which is indispensable for the stochastic analysis of the future traffic demand underlying the estimation of economic impacts.

After return home, we have reviewed the collected materials to find the correlation between a number of economic factors, obtained a general equation by the principal component analysis for the ferry-using traffic volume, and estimated the future traffic volume by substituting economic factors in that equation.

Then, according to the calculated future traffic volume, the benefits of eight items to be developed over 30 years have been estimated, along with the estimation of the cost-benefit ratio and internal rate of return over 30 years in relation to the estimated benefits and construction costs of bridge and road.

2.5 Survey of Bridge Sites

Reconnaissance studies were made around the approaches (in the neighborhoods of Armer Bay) for Malta, Comino and Gozo (around Barbaganni) in the search for the optimal route of the link road.

After return home, the survey team has examined the location and topographic data, soundings data, echo exploration data, tides and tidal current data and other information collected at site, from general point of view and from various angles, and conducted comparative study of routes, types and spannings for several bridge plans.

An outline of our investigations is given below.

A route crossing the most shallowest waters has been selected in order to minimize the construction costs, and a bridge with a sufficient navigation clearance has been designed and evaluated as to working procedures and construction costs. Like the bridge routing, approaches for Malta, Comino and Gozo have been survyed for the purpose of picking up the most adequate roadway routing and engineering.

The reconnaissance study conducted at site has covered compensations for removal of private houses, properties and public facilities, etc., control points for linear design, economic road structure using as far as possible the existing roads, connection of the bridge and existing roads, topography, geology, etc.

After return home, the survey team has carried out paper location based on the site survey results, map (1/2,500) and other data collected.

There has not been seen any particular obstacle in the route mapping. Geological conditions are also found favourable to secure the line and grade necessary for the satisfaction of the road structural standards and coordinate the selected route with the approaches to the channels.

For the selected route, the plan, section and profile have been projected in detail, along with the planning of earthworks and cost estimate.

CHAPTER 3

PHYSICAL BACKGROUND

CHAPTER III PHYSICAL BACKGROUND

3.1 Location and Area

The Maltese islands lie 93 km south of Sicily islands, Italy and 340 km north of Tripoli, Africa, consisting of three islands, Malta, Comino and Gozo (Ref. Fig. 2-1).

The islands are located between 35°-47' and 36°05' N. latitude and 14°-10' and 14°-35' E. longitude.

The total area of the Maltese Islands is roughly 315 km^2. The largest island is Malta, 246 km^2 in area. Next smaller one is Gozo of 67 km^2 and then Comino of 2.6 km^2, respectively, in area.

From the geographical point of view, the location of the islands is mostly adequate for developing the civilization. However, the islands are almost fully covered with rocky ground and barren soil.

The capital of the country is Valleta on the Malta island.

3.2 Topography

The topography of the islands differs depending on the formation of the Coralline Limestone and the Blue Clay. The former forms plateau uplands and the latter appears in the slope.

The majority of the plateau uplands are located in the western part of Malta and the northwestern and eastern part of Gozo, which topographically make contrast with surrounding areas (Ref. Fig. 3-1).

Comino is composed of low plateau and reaches the maximum height of 74 meters.

Number of faults run in the direction of ENE-WSW in Malta and Gozo. And thus the above mentioned plateau uplands are often cut by faults forming well defined escarpments. The good example is seen in the southern cliff of Gozo.

3.2.1 Submarine Topography of the Channel

the following are the description of the submarine topography between Malta and Comino (South Comino Channel) and between Comino and Gozo (North Comino Channel).

1) The South Comino Channel has a width of 1.8 km. The deepest place is about -70 meters and the shallowest about -10 meters.

2) The North Comino Channel has a width of about 1 km. The deepest place is about -40 meters and the shallowest about -10 meters.

3.3 Geology

The Maltese islands are entirely composed of Tertiary limestones belonging to Miocene Period (12 million years ago). The succession of the formations in ascending

Fig.
3-1

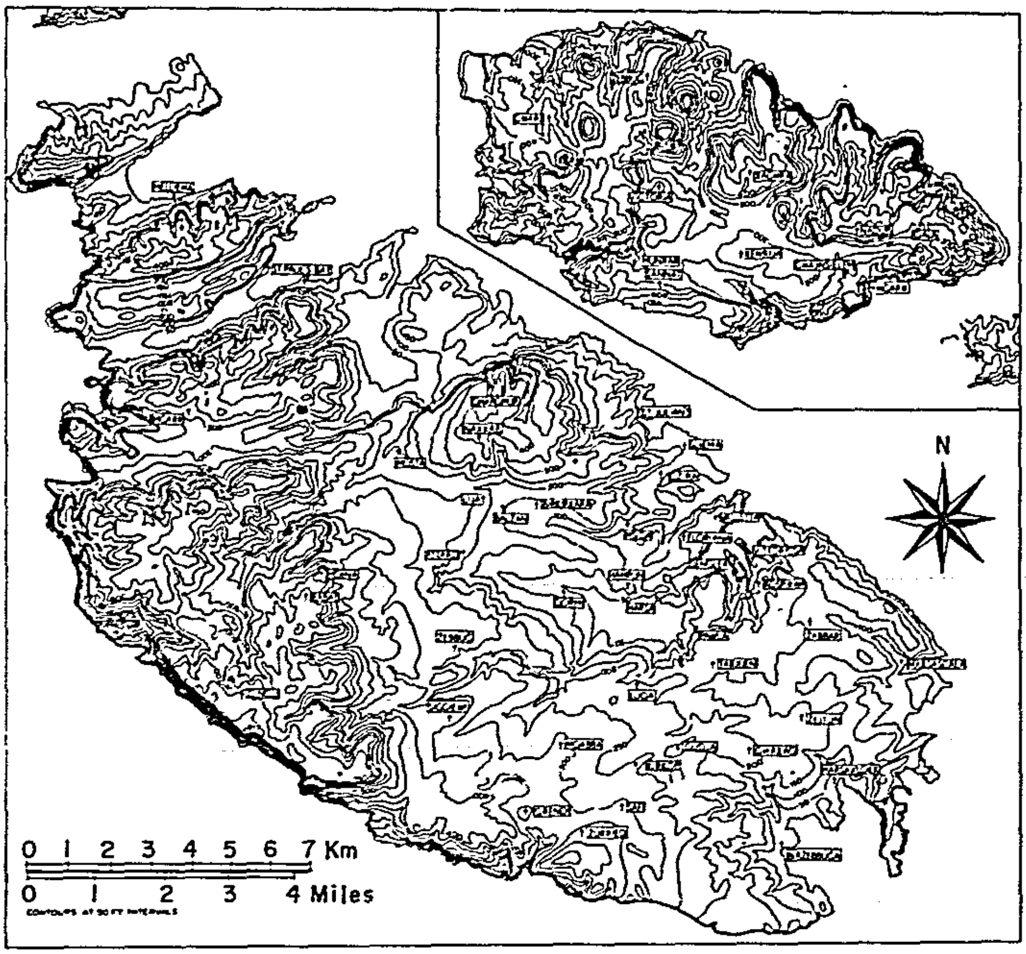


Fig. 3-1	LINK ROAD BETWEEN MALTA AND GOZO ISLANDS
	MALTA AND GOZO RELIF

order is the Lower Coralline Limestone, Globigerina Limestone, Blue Clay and Upper Coralline Limestone.

The geological map of the Maltese islands is shown in Fig. 3-2.

3.3.1 Distribution of the Formations

1) Lower Coralline Limestone

Partially distributed in Malta and Gozo.

2) Globigerina Limestone

This formation is widely distributed in Malta and Gozo, composed of soft sandy limestone.

This rock is the most important building stone on the islands. Its crushed pieces are used for concrete.

3) Blue Clay

This formation is the blue colour clay, partially mixed with yellow ones, distributed in Malta and Gozo.

4) Upper Coralline Limestone

This formation is composed of compact white and porous soft limestone.

The formation is widely distributed in Malta and Gozo. Noteworthy is that Comino is fully composed of the Upper Coralline Limestone.

3.3.2 Geology of the Channels

On the surface of the sea floor of the South Comino Channel and the North Comino Channel, in many places, outcrops the Upper Coralline Limestone.

There are faults partially in the Channels.

Under the sea floor of the eastern part of the South Comino Channel and the western part of the North Comino Channel, the Blue Clay and the Globigerina Limestone are distributed, however, these formations affect scarcely to the bridge construction.

3.4 Climate and Weather

The climate of the Malta is of a Mediterranean type. It is a dry and hot season in summer and a mild and wet season in winter.

The annual average temperature is about 19°C (Ref. Fig. 3-3).

The rain falling is seen mainly in the seven months from September to March. It scarcely rains from April to August. The annual average rainfall is about 590 mm. The annual average rainfall in the Channel area is less than 530 mm.

The northwesterly wind prevails there. The northwesterly wind is used to blow in the seasons of vernal and autumnal equinoxes. The summer is characterized by the southwesterly wind.

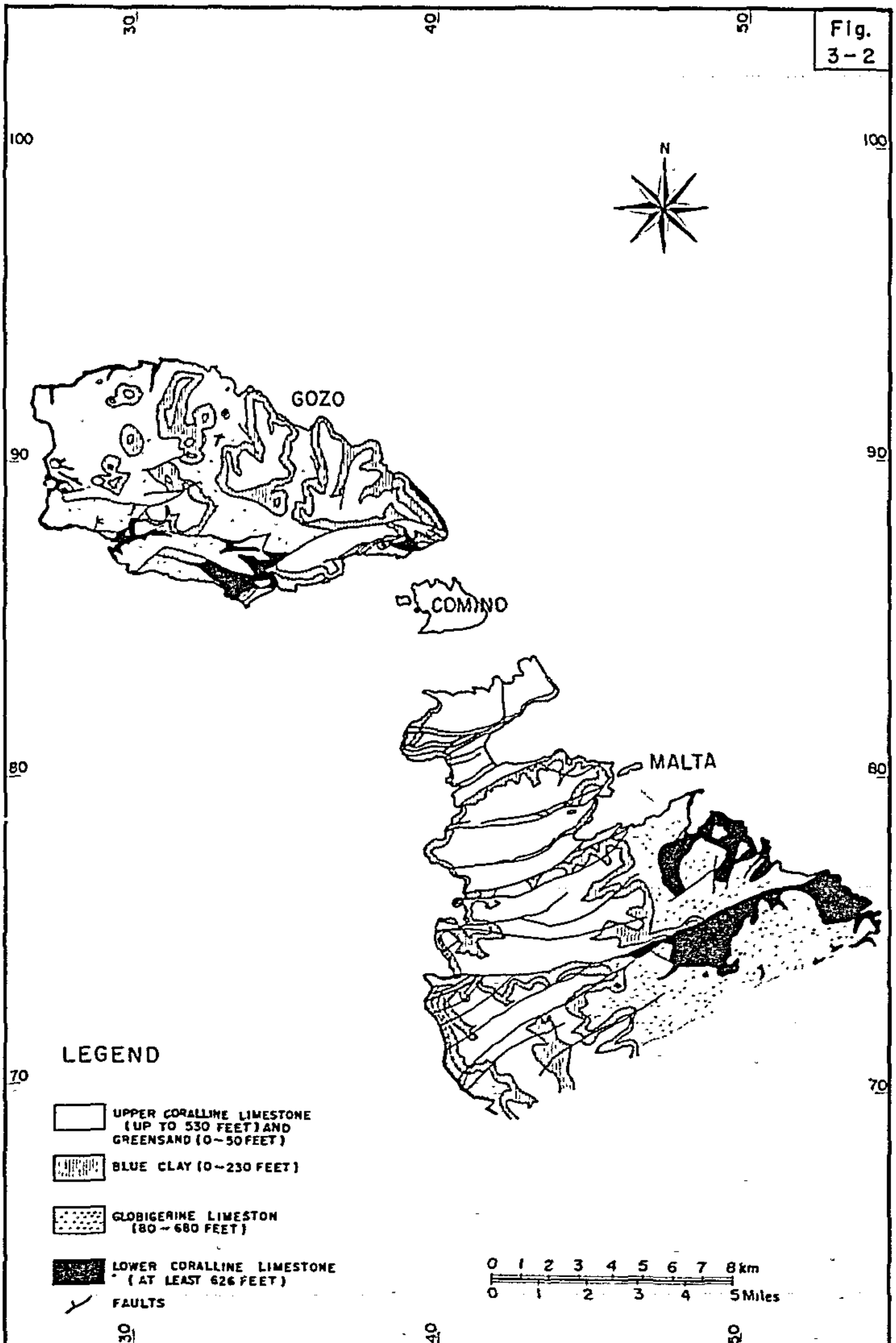
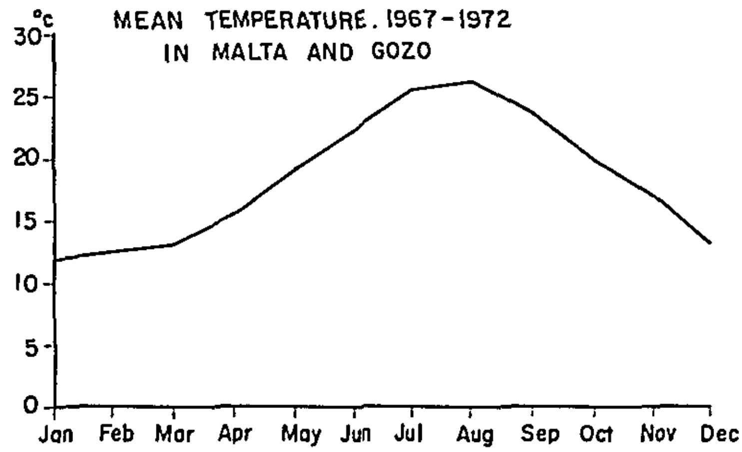


Fig. 3-2	LINK ROAD BETWEEN MALTA AND GOZO ISLANDS
	GEOLOGY OF MALTA, COMINO AND GOZO

Fig. 3-3



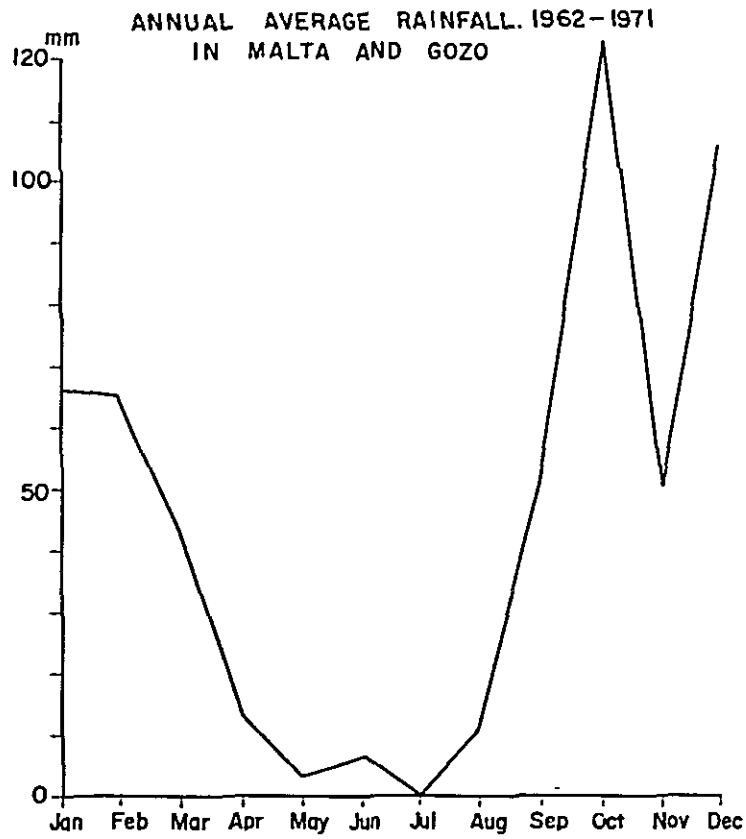


Fig. 3-3	LINK ROAD BETWEEN MALTA AND GOZO ISLANDS
	MONTHLY CHANGE OF TEMPERATURE AND RAINFALL

The average wind direction diagram, from 1962 to 1971 at the airport of Luqa, is shown in Fig. 3-4.

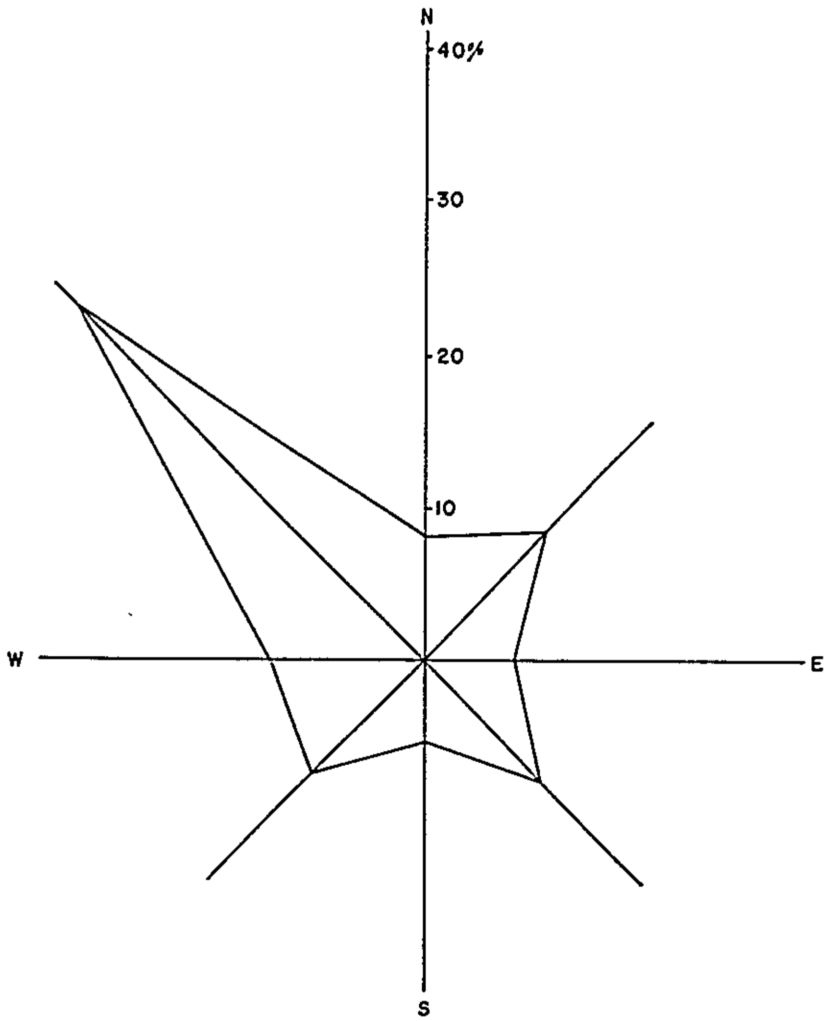


Fig. 3-4 AVERAGE WIND-DIRECTION DIAGRAM
(1962 - 1971 AT LUGA)

3.5 Tidal Currents and Tides

The currents in the Mediterranean Sea, except the Gibraltar Strait, prevails esaterly and the strength of the currents is of 0.2 to 1.0 knot.

In the vicinity of the Malta island easterly or southeasterly current prevails with its speed of 0.5 to 0.6 knot. However, depending on the wind direction and strength, the westerly current sometimes occurs.

In the Channels between Comino and Gozo, Malta and Comino, the direction of the current is mostly northeasterly or southwesterly. The maximum speed is roughly 1 knot. The speed of the current is reported to decrease as the depth of water increases. The current speed at the bottom layer is about half of that of the surface layer.

Generally, the tide of the Mediterranean is semi-diurnal, high water and low water occuring twice daily, but the tidal range is small. As the Maltese islands lie in the vicinity of the amphidromic point, the tidal range is very small.

The tides at the Marfa Point are shown in Table 3-1.

Table 3-1 Tides in Marfa Point

Mean High Water Level in Springs	Mean Sea Level	Mean Low Water Level in Springs	Datum Level for Sounding	Mean High Water Interval
0.176 M	0.093 M	0.011 M	0.000 M	3 Hours 3 Min.

CHAPTER 4

SOCIAL, ECONOMIC AND INDUSTRIAL BACKGROUND

CHAPTER IV SOCIAL, ECONOMIC AND INDUSTRIAL BACKGROUNDS

4.1 Economic Activities - Today and Tomorrow

4.1.1 Economic Outlook

1) Outline

Malta holds an important part at the center of the Mediterranean, and had prospered as a transit trade port from olden times. Since early eighteenth, she had been destined as a bridgehead of the defence line set by the British Empire, and naturally her economics had been increasing its dependence on British expeditionary base at the expense of local industries and international balance of payments; local industries gave way to the base economics, which caused a trade imbalance because a sharp increase in the imports supported by the base-oriented demand overshadowed the exports.

After her independence in 1964, she has made every effort for the promotion of industry and tourism in hope of sloghing off the so far base-dependent economic constitution.

2) National Income and GNP

The economic standard of Malta will be well understood from Table 4-1 in which national incomes per capita are compared between Malta and other ten European countries. According to Table 4-1, Malta registered a nearly 90 per cent increase during 1960-71 period, while Greece and Spain, which in 1960 were all much of a muchness with Malta, marked more than 250 per cent during the corresponding period.

This manifests that the conversion from the base-dependent economics to something else has been too difficult to be maneuvered onto the right track.

Table 4-1 ESTIMATE OF NATIONAL INCOME PER CAPIA (IN US DOLLORS)

Country	1960	1971	1971/1960
France	1,202	2,581*	2.15
West Germany	1,188	3,118	2.62
Italy	644	1,729	2.68
United kingdom	1,277	2,198	1.72
Greece	399	1,036*	2.60
Malta	420	812	1.93

Source: United Nations Statistical Yearbook, 1972

Note : *Data in 1971

From Table 4-2, the industry-wise GNP in Malta almost doubled during the 7 years from 1964 to 1971, but the industrial constitution did shaw any significant change.

In 1971, the primary industry accounted for 7 per cent, the secondary industry for 27 per cent, and the tertiary industry for as high a value as 66 per cent. Of this, about one quarter of the total was divided between military services and public administration. However, the proceedings from the military services have tended to settle at some 5.60 million ₤M and in fact it is beginning to be replaced with the public administration gradually.

Table 4-2 INDUSTRIAL ORIGIN OF GROSS DOMESTIC PRODUCT AT CURRENT FACTOR COST (in 1,000 ₤M)

	1964	1968	1971
Agriculture and fisheries	3,176	4,545	6,092
Construction and quarrying	2,316	3,888	5,419
Manufacturing	7,847	12,619	17,201
Electricity, gas, water and sanitary service	1,446	2,737	4,028
Transport and communications	2,063	2,628	3,160
Wholesale and retail trade	9,140	11,091	13,957
Banking, Insurance and real estate	1,249	3,033	4,230
Private services	2,283	3,779	6,089
Public administration	5,912	8,990	20,625
Military services	5,721	5,640	
Property income from	2,381	3,108	4,409
GDP at factor cost	43,534	62,058	85,210

3) Trade

So long as the international balance of payments position is concerned, Malta has recorded a chronic deficit. Table 4-3 shows the trade balance between 1961 and 1971.

Table 4-3 BALANCE OF FOREIGN TRADE (in 1,000 ₤M)

Year	Total imports	Total exports	Negative balance	Domestic exports
1961	29,443	4,648	24,795	1,932
1962	28,583	4,314	24,269	2,063
1963	30,258	5,267	24,991	3,050
1964	34,594	6,918	27,676	4,231
1965	35,144	8,653	26,491	6,199
1966	38,880	10,755	28,125	7,645
1967	40,509	9,890	30,619	7,159
1968	51,399	14,144	37,255	10,205
1969	61,516	15,957	45,559	12,506
1970	67,121	16,065	51,056	12,212
1971	65,377	18,815	46,562	15,117

It is noteworthy that in Table 4-3 the trade deficit with foreign countries which climbed up to the peak in 1970 has since been on the constant decline.

This is considered due to the growth of manufacturing industries which have promoted export of their goods. The more the manufacturing industries will be developed, the more will be improved the balance of payments position in the commodity trade.

4.1.2 Development Policies

Because of Mediterranean climate, Malta has less rainfalls. Also Malta is less endowed with underground resources.

Naturally, Malta's tomorrow is heavily dependent on how effectively they use their scanty resources.

According to the "Outline of Development Plan for Malta 1973-1980" prepared by the Prime Minister's Office of Malta, the development policies may be crudely divided into the following three.

A first policy is to slough off the conventional economic pattern, that is, to sustain themselves without counting on the military services, to abrogate absolutely pro-British economic trade, to promote trade and interdependence with many foreign countries, and to establish the stronghold of self-independence and self-decision both politically and economically.

A second policy is to promote production activities, that is, to amplify the chance of employment in the extractive industry, to increase domestic production and promote export businesses. In this respect, much is expected for the promotion of manufacturing industry and tourism.

A third policy dedicated by the Maltest Government is to raise the national standard of living by intensification of economic power and social development.

From this point, drastic investment in production and social development is urged in order to level off the differences among Malta, Gozo and Comino.

Table 4-4 shows the GDP by industries targets excerpted from the "Outline of Development Plan for Malta 1973-1980."

Table 4-4 SECTORAL CONTRIBUTION TO GROSS DOMESTIC PRODUCT

Sector	1972 ₤M million	1979 ₤M million	Rate of Change %
1. Agriculture and fisheries	6.7	8.8	4.0
2. Construction and quarrying	4.4	4.4	-
3. Manufacturing, incl. drydocks	22.0	47.6	11.6
4. Government enterprises	4.4	6.4	5.5
5. Tourism and private services	5.3	12.0	12.4
6. Other services	20.3	27.0	4.2
Total production and trade	63.1	106.2	7.7
7. Public administration	14.4	18.0	3.2
8. Military base departments	5.6	0.4	-31.4
9. Property income from domestic sources	6.5	6.5	-
GDP at factor cost	89.6	131.1	5.5

Item 4: includes gas, electricity, water, milk marketing, posts and telephones, etc.

Item 6: comprises transport and communications, wholesale and retail trades, insurance, banking and real estate.

4.2 Population

In 1971, Malta sustained a total population of 325,468 of which 155,166 were accounted for by males, and the remaining 170,302 by females. The population density is amazingly high. In Malta Island, 300,202 people reside, and in Gozo Island 25,266 people live. (according to mid-year estimates)

Looking at Table 4-5, it is found that the population increase has been accelerated since 19th century: in the middle of the 19th century, the population was on the level of 110 thousand, which was increased up to 180 thousand; entering the 1930s, it amounted to 240 thousand, and a sharp increase during the World War II sent up the post war population over 300 thousand. But, the increase culminated in 1950s, and the total population thereafter has been settled at around 320 thousand.

This stabilization of population, however, is attributable, not to the saturation of natural growth, but to the immigration promotion policy taken by the Maltese Government.

Indeed, the population increase has posed a grave concern in Malta from long ago. Naturally, Malta had to push forward immigration thoughout the previous century. People emigrated to the litoral countries of the Meditteranean and far to Australia and the United States.

Especially after the World War II when the population exceeded 300 thousand, a strong immigration policy had been pursued by the Government under the financial assistance from the British Government. Table 4-6 shows the transition of the immigration. According to this table, during 21 years from 1946 to 1971, 127,000 people were emigrated, mostly to Australia where 73,000 emigrants were settled, followed by the United Kingdom, Canada and U.S.A.

Table 4-5 POPULATION BY SEX

	Malta and Gozo			Malta	Gozo
	Persons	Male	Female	Persons	Persons
1842	114, 499	55, 168	59, 331	100, 912	13, 587
1901	184, 742	91, 994	92, 748	164, 952	19, 790
1931	241, 621	117, 457	124, 164	217, 784	23, 837
1948	305, 991	150, 665	155, 325	278, 311	27, 680
1957	319, 620	153, 108	166, 512	292, 019	27, 601
1960	328, 517	156, 852	171, 665	300, 788	27, 729
1965	319, 164	152, 422	166, 742	293, 455	25, 700
1967	318, 573	152, 989	165, 584	292, 237	26, 336
1969	322, 749	154, 901	167, 848	296, 834	25, 915
1971	325, 468	155, 166	170, 302	300, 202	25, 266
1972	298, 800	143, 300	155, 500		
1979	296, 100	140, 600	155, 500		

1842-1957: Census figures

1960-1971: Mid-year estimates

1972, 1979: Population projections in "Outline of Development Plan for Malta 1973-1980"

Table 4-6 MIGRATION

	Emigrants						Repatriated Emigrants	Migration Balance
	Country of Future Permanent Residence							
	Australia	Canada	U.K.	U.S.A.	Other	Total	Total	
1937/38 -1939/40	577	8	2, 141	551	1, 656	4, 933	-	
1946-1950	10, 513	1, 870	5, 426	2, 396	540	20, 745	1, 318	-19, 427
1951-1955	22, 455	4, 445	7, 698	3, 372	53	38, 023	4, 239	-33, 784
1956-1960	9, 832	2, 608	4, 548	1, 021	26	18, 035	3, 805	-14, 230
1961-1965	19, 615	3, 783	6, 614	447	418	30, 877	2, 537	-28, 340
1966-1970	8, 601	2, 604	3, 909	1, 319	214	16, 647	1, 171	-15, 476
1971	1, 762	308	527	178	23	2, 798	143	- 2, 655
Total (1946-1971)	72, 778	15, 618	28, 722	8, 733	1, 274	127, 125	13, 213	-113, 912

In this way, the immigration policy has raised a substantive result, constituting the main cause of offsetting the natural growth in population and setting it around 320 thousand. However, the recent trend in immigration is on the decline, and the Maltese Government itself is also beginning to curb the immigration. This change of attitude toward immigration may be said to reflect the fact that the natural growth in the last ten years has declined nearly half. In the meantime, the Maltese Government has proclaimed in its "Outline of Development Plan for Malta 1973-1980" that the population will be whittled away a little from 298,800 in 1972 to 296,100 in 1979.

4.3 Labour Force

In Malta, the labour force increased up to 109,005 workers in 1971, registering a marked growth over 1962 when it was 93,176 workers. Employment status by industries is shown in Table 4-7.

As is clear from the table, majority is occupied by the tertiary industry, particularly the employment by Government and military camp. Enlargement of employment opportunity is one of the main economic and social concerns the Maltese have long been preoccupied with. One reason is that the ratio of unemployment has been chronically high.

Now, the unemployment ratio is in the range of 5 to 6 per cent, whereas it was in excess of 8 per cent when Malta celebrated her independence. Although it tended to drop for a while, it is again emerging. This high ratio corresponds to that in the Republic of Korea if sought in the Asian countries.

Table 4-9 shows the number of persons seeking their situation and employment status. Job hunters have totaled more than 10 thousand every year; in 1971, the ratio of the situation wanted to the total manpower reached as high as 14 per cent. The ratio of the acceptance to the application has been tending to go down in recent years, though it is not so low. There are still many who are underpriviledged in finding their jobs.

Table 4-7 DISTRIBUTION OF GAINFULLY OCCUPIED POPULATION

	1964	1968	1971	Development Plan 1973-1980 1972	1979	1979/1972(%)
Agriculture and fisheries	7,420	6,510	6,160	6,408	5,600	87
Construction and quarrying	6,290	10,580	11,010	7,199	7,000	97
Manufacturing	17,400	20,320	25,480	28,036	44,910	160
Transport and communications	4,270	4,300	5,520			
Wholesale and retail trade	12,840	13,340	12,630	18,144	18,990	105
Banking and insurance			4,210			
Private services	8,850	11,960	10,850	12,752	15,500	122
Malta Government	17,730	19,860	21,180	22,406	20,900	93
Service department	11,730	8,950	6,040	5,463	0	0
Gainfully occupied	86,530	95,820	103,080	100,408	112,900	112
Registered unemployed	7,645	4,199	5,925	6,234	2,300	37
Labour force	94,175	100,019	109,005	106,642	115,200	108

Table 4-8 PERCENTAGE OF UNEMPLOYMENT

Year	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1979
%	6.8	7.5	8.1	8.2	6.8	5.5	4.2	3.7	4.7	5.4	5.8	2.0

Table 4-9 NUMBER OF APPLICANTS FOR EMPLOYMENT, PLACEMENTS AND NUMBER OF UNEMPLOYED

	Applicants for employment(A)	Placements during the year (B)	B/A, %	Applicants on the register on Dec. 31
1966	16,319	3,358	20.6	6,584
1967	14,871	4,334	29.1	5,387
1968	12,978	3,677	28.3	4,199
1969	12,286	3,069	25.0	3,813
1970	12,878	2,932	22.8	4,962
1971	14,965	2,648	17.7	5,925

That in Malta the employment is attracting a serious attention from the viewpoint of economics comes from the fact that the reduction in employment in the military base and the removal of base are planned. According to the "Outline of Development Plan for Malta 1973-1980", it is projected that as many as 5,500 workers engaged in camp services will be reduced to nil in 1979. To absorb them, there should be provided new employment opportunity.

Another factor is the curtailment of immigration plan proclaimed in the "Outline of Development Plan for Malta 1973-1980." In the fact of these circumstances, it might involve much difficulty to keep the unemployment ratio below some 2 per cent.

For the Maltest to go their way to a high employment standard for their economic and social improvements, the manufacturing industry and the tertiary industry including tourism are highly expected to open up a new outlet of labour force.

To this end, a revolution of economic structure has been strongly voiced for.

4.4 Agriculture and Fishery

4.4.1 Agriculture

In Malta, the agricultural business is operated by 46,000 farmers, which account for 14 per cent of the total population. Of them, 5,600 are full-time farmers and take a 5 per cent part of the gainfully occupied population.

The remaining 8,300 are part-time farmers who offer seasonal labour. There are many who are engaged jointly in farming and other job as a side business.

In recent years, however, the agricultural population is beginning to diminish at a striking rate.

The arable land now available to the farmers is 135,000 tmien (15,100 ha) which is also beginning to be encroached by residential houses, office buildings and other facilities. Among other things, deficiency of water supply is the most difficult problem standing in the way of agriculture; the irrigated land is only 4 per cent of the cultivated land, standing for a bleakness in performing year-round cropping. For want of rainfalls, most of dry land is worked only in a limited season from Autumn to Spring when it rains.

The operating scale of the farming household is also small; 58 per cent of farming households are living on as small a land as 9 tmien (approx. 1 ha). In addition, arable land is compartmentalized into very fine pieces, making it difficult to introduce mechanization.

Another feature of agriculture in Malta is the great majority of tenant farmers to the land owners who are mostly Government, churches and landlords. Generally speaking, the tenants are not so expensive, however.

Table 4-10 AGRICULTURAL LAND AREA (TMIEN)

	1965	1971
Total	146,560	135,133
Dry land	122,531	112,307
Irrigated land	5,581	5,579
Waste land	18,448	17,247

Table 4-11 YIELD OF CROPS (1,000 TONS)

	1965	1967	1969	1971
Total yield	83.7	89.3	99.4	83.1
Cereals, legumes and other crops	33.5	34.1	28.3	25.1
Vegetables	42.8	46.7	62.9	53.9
Fruits	7.5	8.5	8.2	4.1*

* Figures for grapes are under review.

Table 4-12 CATTLE, SHEEP, PIGS, POULTRY AND OTHER ANIMALS IN AGRICULTURAL HOLDING IN SEPTEMBER OF EACH YEAR

	1965	1967	1969	1971
Bovines	7,256	8,849	8,849	9,590
Cows	5,427	6,108	6,251	6,616
Bulls	1,829	2,741	2,598	2,974
Ovines	10,485	9,962	8,820	7,530
Caprines	25,982	23,430	18,650	15,747
Swine	15,166	23,440	31,290	23,397
Poultry	437,375	368,258	641,034	858,098
Other animals				
Rabbits	48,194	50,896	52,344	50,685
Equines	4,944	4,711	4,352	3,837

The agricultural products are channeled mainly to the domestic consumption. They include potatoes, onions, tomatoes, grapes, wheat, barley and forages. Although the agricultural production has moved sideways, the cereals have went down, while the vegetables have been on the upward trend.

Livestock farming is favourable, marking a sizeable output of meat, milk and eggs in a striking contrast to the poor production from cultivated land.

The rearing of milk cows, flesh cattle and poultry has been increasing conspicuously in recent years.

Since the agricultural production is far below the subsistence level, a lot of foodstuffs must be imported. But potatoes, onions, meat and cut flowers are listed as export items, and in fact almost half of the exports was occupied by foodstuffs some 10 years ago.

In this context, the agricultural production had a great significance on the Maltese economy, but the situation is changed now.

The problems for the agricultural industry in Malta are as follows.

A first problem is deficiency of water supply. In order to amplify the agro-economy, the produrement of water supply is the must because it governs irrigation capability. A second problem is compartmentalized. For efficient agricultural performance, land readjustment should be pushed forward overcoming difficulties. If this is impractical, one way left for the Maltest agriculture may be greenhouse farming if water supply is not a problem. A third problem is transportation. This is especially the case with Gozo Island. Although Gozo is most endowed from the viewpoint of agriculture in Malta, its market viability is less. This is because it is isolated and limited in transport to Malta. Under these conditions, the agricultural activities cannot make any progress. Should the transport conditions be improved, flow of agricultural products between Gozo and Malta will be increased, giving impetus to the production and export of agricultural goods from Gozo.

4.4.2 Fisheries

As of 1971, the fishery population in Malta was 1,985 of which 378 were full-time fishermen and were 0.4 per cent of the gainfully occupied population.

Like the farmers, members of fishing households have side jobs.

There are eight fishing home ports in all, including M'xlokk and St. Paul's Bay in Malta and Mgarr in Gozo. Commercial fishing operations in Malta are classified into three seasons; May-August season for mackerel, August-December season for dolphine, and December-May season for trawling. Despite the reconstruction of major fishing ports and the encouragement to introduce trawlboats for the fishermen to enjoy all-season operations, the trawlboats now available are only 9 bottoms.

Most of fishing boats are 30 feet or less in length.

For all that Malta and Gozo are surrounded by the sea, enterprising fishery is hard to see.

In 1971, the catches were 24,500 cwts or ₤M 430 thousand.

Most of marine products are imports, however.

Table 4-13 LANDINGS OF FISH

	1965	1968	1971
Weight (100 cwts)			
Total	261	243	252
of which local catches:	256	237	245
Value (₤M 100)			
Total	3,407	3,495	4,406
of which local catches:	3,349	3,410	4,305

4.5 Industry

It has already been pointed out that the industry in Malta has been growing.

The number of 1971, 2,704 of which 1,997 were in the manufacturing industry. The employment was 28,800 of which 21,700 went to the manufacturing industry. While the quarrying business is on the ceiling recently, both the manufacturing and the construction trade are on the upward trend. These two have marked a sharp increase in both shipments and added values.

So long as the scale of business is concerned, small businesses constitute the great majority. Statistics on the establishments by scale indicate that those operated by not more than 5 persons account for 71 per cent and those having more than 100 for less than 2 per cent. However, the establishments as viewed from the number of employes, are highly variable, because there are many which are very small in scale or rather like household. Although the establishments having less than 10 persons account for 84 per cent, their employes are only 25 per cent of total.

On the other hand, those with 100 persons plus which fall short of 2 per cent to the total number of enterprises employ 39 per cent of the total manpower.

This tendency will be pursued as comparatively large businesses are beginning to open in Malta.

Referring now to the manufacturing industry, Malta originally specialized in food processing and textile industries. Even today, such industries carry some weight. As of 1971, the number of employed persons was 20 per cent for food processing industry and 24 per cent for textile industry.

Table 4-14 NUMBER OF ESTABLISHMENTS, PERSONS GAINFULLY OCCUPIED, GROSS AND NET OUTPUTS IN MANUFACTURING, QUARRYING AND CONSTRUCTION INDUSTRIES

		Industry overall	Manufacturing	Quarrying	Construction
Establishments	1968	2,571	1,910	82	579
	1971	2,704	1,997	81	628
Gainfully occupied persons	1968	24,577	17,861	697	6,019
	1971	28,845	21,666	625	6,554
Gross output (£M 1,000)	1968	36,959	29,818	592	6,549
	1971	51,775	40,981	689	10,105
Net output (£M 1,000)	1968	15,551	11,471	400	3,680
	1971	22,373	17,307	471	4,595

Table 4-15 MANUFACTURING, QUARRYING AND CONSTRUCTION ANALYSIS OF ESTABLISHMENTS BY SIZE OF EMPLOYMENT

Size of Employment	Establishments		Persons Gainfully Occupied	
Total range	2,704	(100.0)	28,845	(100.0)
1 - 5	1,930	(71.3)	4,510	(15.6)
6 - 10	352	(13.0)	2,600	(9.0)
11 - 19	180	(6.7)	2,610	(9.0)
20 - 49	149	(5.5)	4,659	(16.2)
50 - 99	46	(1.7)	3,286	(11.4)
100 - 199	27	(1.0)	3,607	(12.5)
200 - 299	10	(0.4)	2,455	(8.5)
300 and over	10	(0.4)	5,118	(17.8)

Values parenthesized denote percentages.

Table 4-16 GAINFULLY OCCUPIED POPULATION AND GROSS OUTPUT IN MANUFACTURING INDUSTRIES

	Gainfully Occupied Gross Output				
	1968	1971	1964	1968	1971
Food	15.6	12.2	24.3	20.8	17.1
Beverages	8.1	6.8	13.6	11.1	9.4
Tobacco	1.9	1.4	11.6	7.9	6.9
Textiles	15.5	13.9	12.1	17.9	16.1
Clothing	6.8	9.7	4.2	3.6	5.6
Footwear	2.6	1.8	1.6	1.1	0.9
Furniture and allied trades	7.6	7.5	2.9	3.7	4.3
Printing and publishing	6.5	6.6	2.9	3.6	4.6
Chemicals	4.5	5.4	7.4	5.2	6.1
Manufactures of non-metallic minerals	6.0	5.5	3.5	4.3	5.0
Manufactures of metals	4.3	3.9	4.0	3.7	4.3
Machinery	2.8	7.0	1.8	2.4	5.3
Rubber and transport equipment	10.8	12.3	6.0	9.9	9.7
Miscellaneous	6.9	5.8	4.0	4.8	4.7
TOTAL	100.0	100.0	100.0	100.0	100.0

By value of shipments in 1964, the food industry realized 49.5 per cent, and textile and clothing industry 16.3 per cent, all these combining to gain 66 per cent of the total shipment values. In 1971, the food industry was 33 per cent and the textile and clothing industry 22 per cent, impounding 55 per cent.

These two are still ahead of other industries, holding more than half of the total industrial output. But, the food industry is beginning to descend. On the contrary, the textile industry, one of the traditional businesses in Malta, is noticeably rising, regaining its power.

Other sectors are more or less small in the weight of shipment values, but rubber industry, machinery, printing and non-metallic minerals are all booming. Regretably, however, Malta is scarce of industrial resources, and it is particularly hard to find promising sectors which if exist would trigger the explosion of the economic development of Malta.

Among other things, the inavailability of industrial water, both in quantity and quality, a fettering factor.

Not that there are no promising factors. Compared with advanced countries in Europe, Malta can offer low-wage labour without management-labour dispute. In addition, the people are well educated. Accordingly, such sectors as machinery production centering around, say assembling of parts which is non-water-oriented and labour-intensive are said predictable.

There is a useful move in drydock business that by additional investment in drydocks for improvement the facilities and skilled labour for them should be used only for the repair of ships, but should also be made available to other machine industry. These will go a long way toward development and progress of new industrial sectors.

Area-wise, however, there is an indubitably large difference in the level of industrial development between Malta and Gozo Islands. Gozo has remained industrially untouched. Accordingly, many are going from home to Malta Island for work. They stay in Malta from Monday to Friday every week, and return home and take repose during Saturday and Sunday.

For the well-balanced local development and provision of a solid transit means, it is of great significance to install a link road between Malta and Gozo Islands.

4.6 Tourism

For Malta, the tourism is the most important industry. Abundant in the sunshine and blue water, Malta is well endowed with sight-seeing resources. Everywhere there are all vivid ingredients of the excitement. Spreading from the eastern part to the north and farther into the west is a chain of bathing resorts of scenic beauty, and the southern coast forms a manly cliff. Also, Malta is rich in venerable historic remains. So are Gozo and Comino.

Many a place preserves pristine beauty. Since the last half of 1960s when she eyed the tourism, Malta has been attracting a good deal number of foreign visitors who amounted to 170 to 180 thousand in 1970 as against around 10 thousand in the early 1960s. Naturally, the tourist revenues have had the foremost bearing on the Maltest economy. From European countries, from America, Africa, and from far distant places including Australia and Asia, come people for respite.

Among others, the peoples from U.K., Italy, Sweden, U.S.A., W. Germany and France are regular customers.

A stampede of tourists to Malta is concentrated around the summer vacation (July - September), however. During the January-February period in winter, the tourists are about a quarter or a fifth of the volume in August, the high time of the season. Considering that the climate in Malta is genial even in winter, the perenniality of its tourism is even more than mere speculation.

In order to promote the tourism, the following considerations should be made.

A first problem is accommodation facilities. As shown in Table 4-25, hotels have been developed to a considerable extent. During the high time of the season, however, the accommodations sometimes fall short of demand.

Table 4-17 NUMBER OF HOTELS AND TOURIST ARRIVALS TO MALTA

	Hotel	Bed	Room	Employe	Visitor arrival	Length of stay	Total guest-night, 1,000	Gross income £M1,000
1960	25	1,218	n.a.	-	12,583	-	176	765 (4)
1965	38	2,380	1,236	819	47,804	-	669	1,890
1966	54	3,112	1,625	1,082	72,889	13.04 (3)	950	3,220
1967	71	4,710	2,396	1,910 (2)	97,519	15.88	1,548	5,062
1968	89	6,101	3,142	2,473	136,995	12.87	1,763	7,998
1969	101	7,562	3,885	2,778	186,084	12.63	2,350	10,836
1970	110	7,935	3,942	2,723	170,853	14.23	2,431	9,820
1971	113	8,512	4,277	3,315	178,704	13.31	2,379	10,601
1972	80 (1)	7,971 (1)	4,103 (1)	2,695	149,913	12.49	1,873	8,500

Notes: (1) As classified by the H.C.E.B. on Jan. 1, 1973
(2) Department of Labour
(3) M.G.T.B. Sample Surveys
(4) Central Office of Statistics

This also holds true to bathing places and rental cars. It is therefore recommended to amplify the accommodation facilities more; for example, the western beaches in Malta Island will be a promising exploration subject to accommodate a surplus. In this case, also, the development of sightseeing resources should be in keeping with the development of water supply.

A second problem is the procurement of transit route to tie Malta with foreign countries. Most of visitors from abroad are airlifted, and their most peeve is a struggle to find a seat to sit on when they come at the apex of the season. To cope with this problem, expansion work of the Luca Airport is now under progress, and when completed will accept jumbo jets.

A third problem is the traffic network across the country, especially the route interconnecting Malta, Comino and Gozo for which the present project is now at work.

At present, tourists while away their time mostly in Malta, and few extend their trip as far as Gozo. Once the Malta and the Gozo are connected in a short rip, the Gozo will probably become a flourish place of tourism. Also, the Comino Island, which now is almost devastated, will come to life again, because it is abundant in picturesque sites, including among others a spectacular commanding view of the Gozo over a channel.

Malta is truly a paradise on the earth, and is profoundly responsible to conserve her overflowing bounty of the nature. Now the environmental pollution is a worldwide concern, and not limited to the European Continent and other developed industrial sites. It is therefore strongly hoped that Malta may be cheered up through agriculture, industry and tourism forming a trinity without disrupting the boon of her own.

The problems concerning the preservation of the natural environment may be summarized as follows.

Firstly, Malta should keep healthy entourage as a resort. Strict restrictions should therefore be imposed on the land utilization, development and building construction. Dilemmatically, increase in the number of tourists will accelerate pollution. Worrying about this, the Maltese Government has taken a strong attitude toward pollution, combing beaches to gather wastes, limiting dumping and discharge of effluents, and designating deep waters for sewage disposal.

Secondry, there arises a problems of sewage disposal as touched upon above. Added to domestic sewage, industrial effluents and discharge of waste water from tourism facilities will increase when economic and social activities advance on. All these might probably disrupt precious environment, and should be checked by all possible measures. In the light of scarcity of water supply, the sewage should be reused after appropriate treatment. One effective way will be reuse for irrigation purposes.

Thirdly, the existing current should be protected in connection with the Malta-Gozo Link Road Project.

A plan to reclaim the channels for direct connection between Malta, Gozo and Comino should be avoided, or else the resultant stagnation of waters will induce various ailments to the environment, especially marine ecosystem.

The bridging, in this respect, is excellent from every point of view, because it is not only feasible technically, but can conserve the natural environment.

Fourthly, it is desirable to promote forestration for the greening of the country, particularly in Malta and Gozo. It is strongly hoped that the Maltese Government will tackle something of a forestation program in a long perspective.

4.7 Education

Table 4-18 NUMBER OF SCHOOLS, TEACHERS AND PUPILS, 1971

	Institution	Teacher	Pupil
Total	260	4,473	76,520
Government	183	3,469	60,175
Private	77	1,004	16,345
Nursery school	21	57	1,212
Primary school	115	1,418	32,282
School for handicapped children	8	41	313
Nursery and primary school	24	151	3,650
Primary and grammer school	11	318	5,008
Nursery, primary and grammer school	5	160	3,892
Secondary school	44	1,501	18,363
Technical school/institute	4	147	1,414
Evening class	22	315	7,511
Industrial training center	2	23	105
Teachers training college	2	41	365
Polytechnic	1	109	1,302
University	1	192	1,103

Though small, Malta is proud of high level of education. The schools are 260 in all, of which 183 schools are national and 77 are private. The national schools are hierarchically graded into primary school, secondary school and university.

In addition, industrial training centers and teachers training colleges are operated. A total of 76,500 pupils and students have benefited from these institutions. The ratio of school attendance to the total population is comparatively high. Judging from this high level of education, Malta should be considered in quite a different way from host of other developing nations. The university forms the hub of advanced learning. In the past, those who wished to receive advanced education had to go to the United Kingdom. Although the number of students in the university is as small as 1,100, it offers the varieties of outlet into the various departments of philosopy, including theology, jurisprudence, medical science, pharmacology, dentistry, technology, civil engineering, etc.

Also a postgraduate school and a junior college are annexed to the university. 178 academic staff of which 25 are accounted for by professors form an echelon of professorate. Although a doctor course is installed, those who want to make a special study are likely to go to England.

4.8 Water Resources

The water supply is the paramount factor that ways the economic future of Malta. Ample supply of water is prerequisite to the enhancement of living standard, to the growth of tourism, and also to the development of industry and agriculture. The only water source available for Malta is underwater. Until recently, the water supply is said to have been sufficiently available from the underground aquifer for the extracting. A recent rapid progress in economic development in Malta, however, is paralizing the demand and supply of water, hitting a snag in the development of Malta.

The present-day conditions of water supply and consumption are shown in Table 4-19. Aside from agriculture use, the extraction of underground water as of 1971-72 period was 3, 150 mil. gals. in Malta and 199 mil. gals. in Gozo of 3, 349 mil. gals. in total.

Table 4-19 WATER SUPPLY AND CONSUMPTION, 1971-72

	Malta	Gozo
Railfall (in.)	21.36	16.34
Yield of spring (mil. gals.)	131.01	-
Total water extraction (mil. gals.)	3, 149.8	198.9
Desalination of water (mil. gals.)	822.7	-
Aggregate storage capacity of reservoirs (mil. gals.)	98.4	8.9
Yearly consumption (mil. gals.)	3, 908.5	196.9
Average daily consumption (mil. gals.)	10.70	0.539
Service installation (number)	116, 435	10, 111

Malta has a desalination plant with a capacity of 823 mil. gals a year. The annual water consumption was 3, 909 mil. gals. in Malta and 197 mil. gals. in Gozo. (1971-72 period).

Water consumption increases with the progress of economic activities, however. According to a report by a United Nations survey mission, the per capita water consumption now is 150 lit. (33.0 gals.) in Malta and 120 lit. (26.4 gals.) in Gozo, and is forecast to increase up to 200 lit. avg. (26.4 gals) and 230 lit. max. (50.6 gals.) in the year 2000. The total consumption in 2000 will be 6, 180 to 11, 120 mil. gals. or 1.6 to 1.85 times as much as the today's level. The U.N. mission's estimate is moderate and not exaggerated, and naturally demands the water supply be amplified to a greater extent.

The underground water now available in Malta is divided into two sources; one from the Upper Coralline Limestone aquifer and the other from the mean sea level aquifer.

If the extraction from these sources exceeds a limit, salinity in water increases. Namely, the extraction is limitative not only quantitatively but also qualitatively. As a matter of fact, the extraction reportedly has exceeded a limit because the salinity has already been high in value.

An expert claimed, "If the rainfalls are 20 inches, and should the acceptable water be less than 500 ppm in the content of salts, the extraction from underground water should be limited to within 2,500 mil. gals." Similarly, the aforesaid mission also placed the extraction limit at 2,740 mil. gals. The matter is pressing now that the extraction has already gone beyond the limit.

Besides, Malta may have to procure an increasingly large volume of water for her economic and social prosperity. A new method which has been put to practice very recently in Gozo is desalination of sea water, if the cost is not a problem. The only method that may increase water supply without sacrificing the economic payability, is the amplification of underground water use, requiring additional galleries and boreholes. In the report by the aforesaid mission, the investment for that purpose is discussed in a planned manner.

Referring now to the water for agricultural purposes, the following three methods may be proposed in order to expand the agricultural output from what can be raised from the present level of irrigated land which is only 4 per cent of the total area of cultivated land to what can be expected by expanding the share of irrigated land.

Namely, these three irrigation sources are:

(1) Desalination plant

(2) Construction of dams by excavation gallaries

(3) Reuse of sewage

The method (1) will be costly for the irrigation purposes, and should be dismissed. The method (2) seems likely to have been practised little by little year by year. The method (3) is considered most promising, however.

This method is discussed in the report of the said mission, and its rough idea is reiterated in Table 4-20.

If the proposed method is realized on the schedule, the irrigated land will be more than doubled. By the year 2000, an additional 980 ha (8,750 tmien) will join with the existing irrigated land, sending up the portion of the irrigated land in the total cultivated land from 4 per cent to 11 per cent to push up the agricultural production.

Table 4-20 RECLAMATION OF SEWAGE FOR IRRIGATION ONLY, FOR THE PERIOD 1978/2000

Scheme	Region or origin of sewage	Irrigable area, ha	Quantity of irrigation water available, 10^6 m^3/a	Unit cost of irrigation water £/m^3	d/m^3
A	Marsa Land	320	2.7	0.056	13.4
B	Zejtium-Zabber	80	0.6	0.098	23.5
C	Pwales Valley	20	0.17	0.16	38.4
D	Mellieha Bay	20	0.17	0.17	40.8
E	Marsa Land and Sea	540	5.4	0.051	12.3

SOURCE: Wastes Disposal and Water Supply Project in Malta, Master Plan and Related Studies, Vol. 1, Part 1, Oct., 1972.

It is therefore concluded from the above that in order to solve water supply problem in Malta new measures and methods should be combined with vast sums of money.

CHAPTER 5

TRAFFIC DEMAND FORECAST

CHAPTER V TRAFFIC DEMAND FORECAST

5.1 Status Quo in Traffic

5.1.1 Traffic Volume by Ferries

As is clear from Fig. 5-1, the traffic volume of autos using ferries plying between Malta and Gozo has been on the constant yet sharp increase since around 1967, recording 80 thousand autos in 1971 or some 7.6 times the 1963 value.

Although the traffic volume culminated in 1971, there is the intimate relationship between the number of tourists visiting Malta and the traffic volume of autos using ferries (see Fig. 5-1).

A sharp decline in the number of visitors from England, which so far had accounted for some 65 to 75 per cent of the total, pushed down the total number of visitors in 1970 to 1972, making, it seems, the ceiling in the traffic volume in 1971. The downfall of English visitors was due to a discord on the Trade and Commerce Pact between Malta and the U.K.

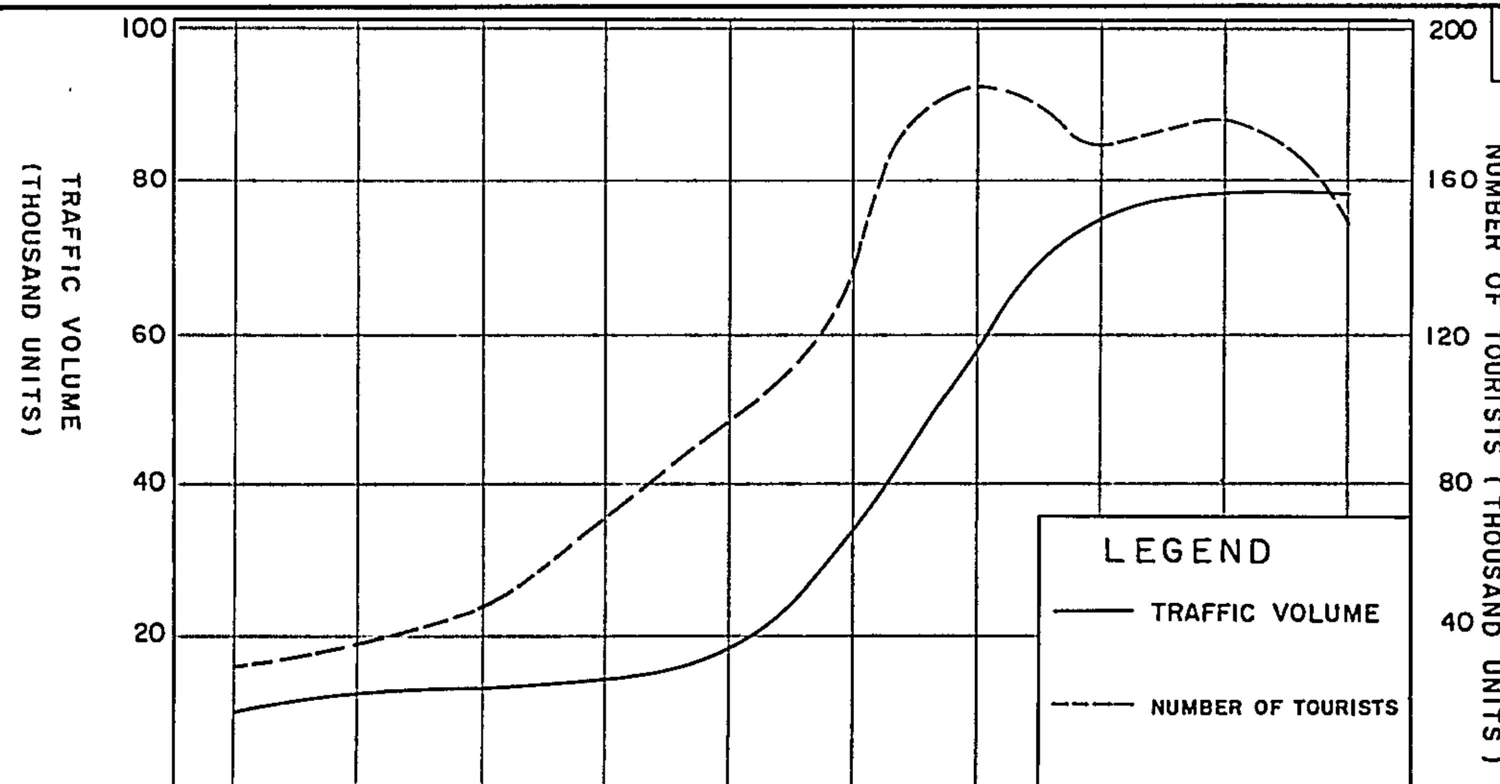
It is however considered that this loss of custom will be transitory. Malta, full of glamor sight-seeing resources, would soon regain a good deal of visitors once the trouble with the U.K. is settled.

The data now available for the traffic volume by vehicle type are limited to those on 1970 and 1971. So far as it is concerned, however, the cars register on overwhelming majority, accounting for some 85 to 90 per cent, followed by vans and trucks which account for 7 to 17 per cent.

In addition to vehicles, person trips were some 407,000 persons in 1971 and 498,000 persons in 1972. Of them, those not using cars or vans took busses shuttling between Valleta and the Pier Marfa Ridge in Malta and between Victoria and the Port Mgarr in Gozo.

The establishment of the proposed bridge might probably contribute toward the expansion of the existing bus routes and services for direct communication between Malta and Gozo.

Fig. 5-1



ITEM \ YEAR	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
TRAFFIC VOLUME	10557	12985	14053	14879	19221	35522	59111	76349	79669	79319
NUMBER OF TOURISTS	32299	38380	47804	72889	97519	136995	186084	170853	178704	149913

SOURCE 1 MINISTRY OF TRADE, INDUSTRY, AGRICULTURE, AND TOURISM
2 ANNUAL ABSTRACT OF STATISTICS

Fig. 5-1	LINK ROAD BETWEEN MALTA AND GOZO ISLANDS TRAFFIC VOLUME BY FERRYBOAT BETWEEN MALTA AND GOZO, AND NUMBER OF TOURISTS

Table 5-1 TIME TABLE OF MALTA AND GOZO FERRIES

Season	Day of Week	Time: Boat leaves Gozo	Time: Boat leaves Malta
1st. October ~ 14th. October	Mondays	6.15 a.m.	7.30 a.m.
		9.00 a.m.	9.45 a.m.
		1.00 p.m.	2.00 p.m.
		4.30 p.m.	5.15 p.m.
	Tuesdays to Saturdays	6.45 a.m.	7.30 a.m.
		9.00 a.m.	9.45 a.m.
		1.00 p.m.	2.00 p.m.
		4.30 p.m.	5.15 p.m.
	Sundays & Public Holidays	7.00 a.m.	7.45 a.m.
		9.00 a.m.	9.45 a.m.
		2.00 p.m.	2.45 p.m.
		4.30 p.m.	5.15 p.m.
15th. October ~ 31st. March	Mondays	6.15 a.m.	7.30 a.m.
		9.00 a.m.	9.45 a.m.
		1.00 p.m.	2.00 p.m.
		4.00 p.m.	4.35 p.m.
	Tuesdays to Saturdays Fridays	6.45 a.m.	7.30 a.m.
		9.00 a.m.	9.45 a.m.
		1.00 p.m.	2.00 p.m.
		4.00 p.m.	4.35 p.m.
	Sundays & Public Holidays	7.00 a.m.	7.45 a.m.
		9.00 a.m.	9.45 a.m.
		2.00 p.m.	2.45 p.m.
		4.00 p.m.	4.35 p.m.
1st. April ~ 31st. May	Mondays to Saturdays	6.15 a.m.	7.30 a.m.
		9.00 a.m.	9.45 a.m.
		1.00 p.m.	2.00 p.m.
		3.30 p.m.	4.15 p.m.
		5.30 p.m.	6.15 p.m.
	Sundays	6.45 a.m.	7.45 a.m.
		9.00 a.m.	9.45 a.m.
	& Public Holidays	1.30 p.m.	2.15 p.m.
		3.30 p.m.	4.15 p.m.
		5.30 p.m.	6.15 p.m.
1st. June ~ 31st. August	Mondays to Fridays	6.15 a.m.	7.30 a.m.
		9.00 a.m.	9.45 a.m.
		1.15 p.m.	2.15 p.m.
		5.00 p.m.	5.45 p.m.
		7.00 p.m.	7.45 p.m.
	Saturdays	6.15 a.m.	7.30 a.m.
		9.00 a.m.	9.45 a.m.
		1.15 p.m.	2.15 p.m.
		3.30 p.m.	4.15 p.m.
		5.30 p.m.	6.15 p.m.
		7.00 p.m.	7.45 p.m.
	Sundays & Public Holidays	6.15 a.m.	7.00 a.m.
		7.45 a.m.	8.30 a.m.
		9.15 a.m.	10.00 a.m.
		3.00 p.m.	3.45 p.m.
		5.00 p.m.	5.45 p.m.
		6.30 p.m.	7.15 p.m.
		8.00 p.m.	8.45 p.m.
1st. September ~ 30th. September	Mondays to Saturdays	6.15 a.m.	7.30 a.m.
		9.00 a.m.	9.45 a.m.
		1.00 p.m.	2.00 p.m.
		3.30 p.m.	4.15 p.m.
		5.30 p.m.	6.15 p.m.
	Sundays & Public Holidays	6.45 a.m.	7.45 a.m.
		9.00 a.m.	9.45 a.m.
		1.30 p.m.	2.15 p.m.
		3.30 p.m.	4.15 p.m.
		5.30 p.m.	6.15 p.m.

5.1.2 Plan for Ferryboat Operation

Separate schedules of operation for ferries are worked out depending on season, day of week, ordinary day and holiday. In summer, when Malta attracts many sightseers, the ferries are operated 7 turnarounds more in holidays and 6 more in saturdays than in ordinary days, and in Winter the operation is reduced to 5 round trips only.

There are three workhorses now as follows.

Minor Eagle (367 GT)
Jylland (824 GT)
Calypso Land (1, 960 GT)

In Winter months, the ferry operations sometimes are suspended for 10 days a month because of bad weather. In Malta, piers have not yet been fully developed, and the ferries are often forced to find harbour in Marfa Point, Ramla Tal-Bir. or St. Paul's Bay according to sea conditions, serving a major trouble in traffic between Malta and Gozo.

5.1.3 Fares of Ferries

The current fares for passengers and trucks are listed in Table 5-2.

A truck with goods requires 3 ₤M of basic rate plus an additional charge of 1 ₤M a ton of goods; a truck with a 2-ton load is required to pay a total 5 ₤M for boarding.

Table 5-2 FARES OF FERRIES

	CLASS OR TYPE	FARES	REMARKS
PASSENGERS	1st class	15 C	One way trip
	3rd class	10 C	
VEHICLES	Small car (About 14 feet)	80 C	Pound trip
	Medium car (14 - 16 feet)	1 ₤M	
	Large car (More than 16 feet)	1. 25 ₤M	
	Trucks	3 ₤M	Empty
		3₤M+1₤M (per 1 Ton)	With goods

5.2 Correlations Between Traffic Volume and Economic Factors

The stochastics on the forecast of ferry-minded traffic volume in the foreseeable future between Malta and Gozo and on the traffic volume expected by the installation of the proposed bridge presupposes investigations and analysis of the correlations between the current conditions of ferry-intensive traffic volume and economic and industrial indices as well as the considerations over the future development plans and future traffic volume based on these correlations.

First of all, here, the pattern of economic and industrial indices in the past will be investigated, and the correlation between their secular change and ferry exploitation will be discussed from various angles.

A secular change of economic and industrial indices or factors (based on data for the period 1963-71) is listed in Table 5-3. The figures appearing in the extreme right-hand end column denote correlation coefficients.

According to Table 5-3, the correlation coefficients of number of owned vehicles (designated as "Others"), resident population, agricultural production, and number of persons unemployed are relatively small, showing that their patterns of secular change are asystematic.

Fig. 5-2 shows the number of owned vehicles by kind, evincing that the secular change of the vehicles other than cars, vans trucks and busses does not show any specific propensity.

Fig. 5-3 states that the yearly change of population is irregular as the overall population has increased in Malta, though decreased in Gozo.

Fig. 5-4 is a data prepared by the Ministry of Trade, Industry, Agriculture and Tourism, which forecasts a constant increase of tourists in the future.

Since the ferry traffic and the number of tourists hold a straight forward similarity, they can be expressed by a function with a comparatively high correlation coefficient of R = 0.935, as calculated in No. 12 item of Table 5-3.

In the preliminary survey report, the future traffic demand was estimated with reference to the number of sightseers. It is believed therefore that such estimation as relying upon a single index will leave much of uncertainty.

In the present report, the stochastics for the future traffic demand is given more reliability by extensive studies and analyses of 20 economic and industrial factors referred to under para. 5.3.1 "Outline."

Table 5-4 is a matrix into which the correlation coefficients combining the ferry-using auto traffic volumes and the economic factors are arranged.

Those items which show high correlation with ferry-using auto traffic volumes, include, according this table, secular change (R = 0.9276), number of owned cars (R = 0.9820), number of owned vans and trucks (R = 0.9669), total number of owned vehicles (R = 0.9896), ratio by type of vehicle of cars (R = 0.9375), number of tourists

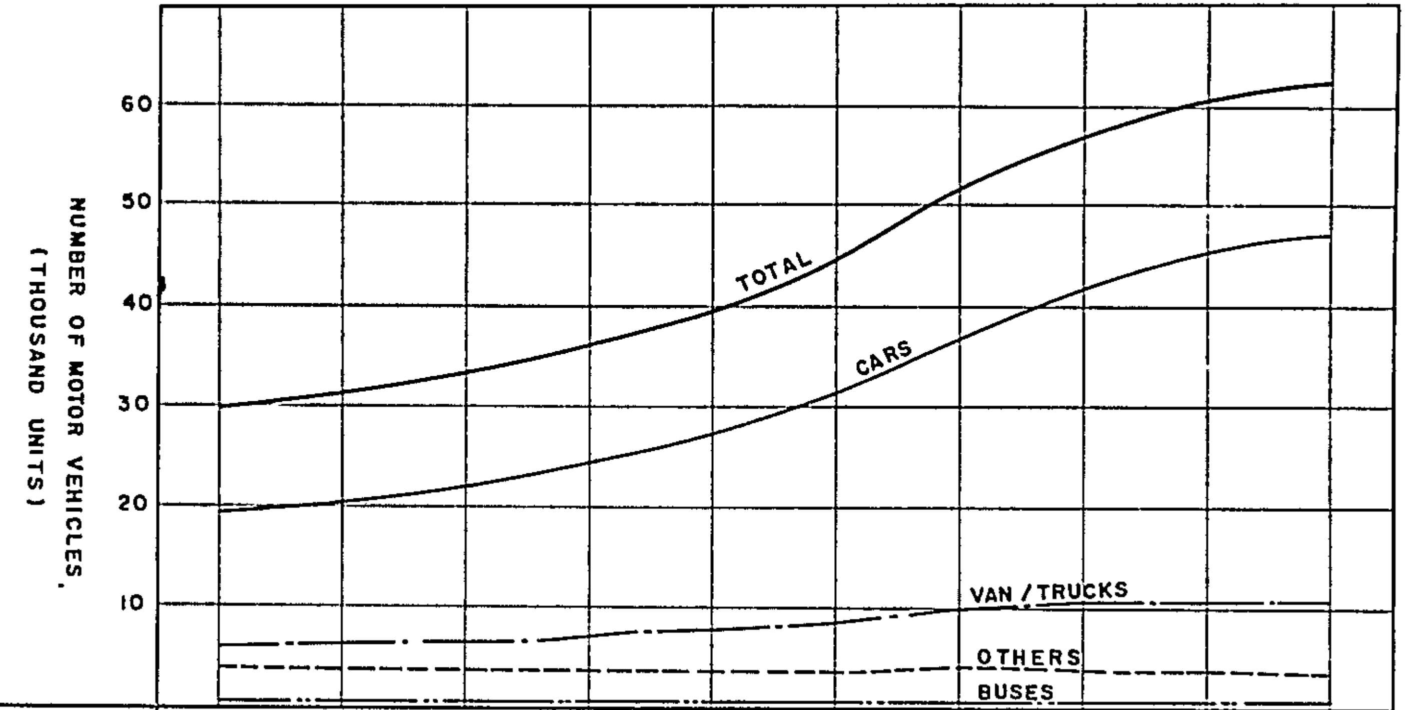
(R = 0.9254), tourists receipts (R = 0.9298), GDP per capita (R = 0.9751), ratio of vehicle ownership (R = 0.9761) average income per capita (R = 0.9829), the number of employees (R = 0.9519), industrial production (R = 0.9697), amount exported (R = 0.9273) and amoung imported (R = 0.9790).

Table5-3 REDRESSION STRAIGHT LIND AMD CORRELATION COEFFICIENT OF THE ECONOMIC FACTORS

No.	Y	X 1	X 2	Regression straight line	Correlation coefficient
1	Number of owned vehicles - Cars	Year	——	$Y = 3412X_1 - 6681000$	0.9782
2	Do. - Vans/Trucks	Do.	——	$Y = 677.3X_1 - 1324000$	0.9841
3	Do. - Buses	Do.	——	$Y = 1.016X_1 - 1381$	0.7788
4	Do. - Others	Do.	——	$Y = 9.016X_1 - 13900$	0.1201
5	Do. - Total	Do.	——	$Y = 4099X_1 - 8022000$	0.9665
6	Ratio of vehicles types - Cars (%)	Do.	——	$Y = 1.236X_1 - 2362$	0.9920
7	Do. - Vans/Trucks (%)	Do.	——	$Y = -0.2316X_1 + 475$	0.8160
8	Do. - Buses (%)	Do.	——	$Y = -0.1466X_1 + 290$	0.9955
9	Do. - Others (%)	Do.	——	$Y = -0.8716X_1 + 1724$	0.9920
10	Ratio of car ownership (Vehicles/Person)	G D P per capita (£M/Person)	——	$Y = 0.0007086X_1 + 0.0002584$	0.9976
11	Do.	Average income per capita (£M/Person)	——	$Y = 0.0004274X_1 - 0.01815$	0.9760
12	Traffic volume by ferryboat (Vehicles/Year)	Year	——	$Y = 9621X_1 - 188000$	0.9276
13	Do.	Do.	Number of tourists	$Y = 5211X_1 + 0.1999X_2 - 10230000$	0.9349
14	Do.	Do.	Ratio of car ownership (Vehicles/Person)	$Y = -12290X_1 + 1742000X_2 + 23990000$	0.9968
15	Do.	Do.	G D P per capita (£M/Person)	$Y = -0.02558X_1 + 593.6X_2 - 72000$	0.9753
16	Tourists receipts (£M1,000/Year)	Number of tourists (Persons/Year)	——	$Y = 64.06X_1 - 1026000$	0.9981
17	Do.	Year	——	$Y = 1405X_1 - 2758000$	0.9568
18	G D P per capita (£M/Person)	Do.	——	$Y = 17.66X_1 - 34560$	0.9827
19	Average income per capita (£M/Person)	Do.	——	$Y = 27.51X_1 - 53770$	0.9437
20	Do.	G D P per capita (£M/Person)	——	$Y = 1.596X_1 + 54.42$	0.9845
21	Industrial production (£M1,000/Year)	Year	——	$Y = 4707X_1 - 9226000$	0.9884
22	Do.	G.D.P. per capita (£M/Person)	——	$Y = 263.9X_1 - 15850$	0.9963
23	*Agricultural production (£M1,000/Year)	Year	——	$Y = 102.3X_1 - 198500$	0.6601
24	Landings of fish (£M1,000/Year)	Do.	——	$Y = 13.04X_1 - 25310$	0.8470
25	**Number of exported (£M1,000/Year)	Do.	——	$Y = 1660X_1 - 3254000$	0.9826
26	** Do.	G D P per capita (£M/Person)	——	$Y = 90.94X_1 - 5105$	0.9675
27	**Number of imported (£M1,000/Year)	Year	——	$Y = 5055X_1 - 9896000$	0.9625
28	** Do.	G D P per capita (£M/Person)	——	$Y = 286.6X_1 - 6174$	0.9810
29	Number of employees (Persons)	Year	——	$Y = 2360X_1 - 4548000$	0.9876
30	Number of unemployees (Persons)	Do.	——	$Y = -434.3X_1 + 869100$	0.6836
31	Resident population (Persons)	Do.	——	$Y = 71.4X_1 + 181700$	0.0521

Remarks:
* Exclude stockbreeding
** Exclude service

Fig. 5-2



ITEM \ YEAR	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
CARS	19472	20494	22057	24540	27422	31518	37189	41768	45389	47281
VANS / TRUCKS	5833	6251	6577	7113	7855	8673	9845	10714	10627	10792
BUSES	616	616	616	615	615	623	623	621	622	622
OTHERS	3871	3841	3822	3785	3577	3641	4238	4044	3682	3605
TOTAL	29792	31202	33072	36053	39469	44455	51895	57147	60320	62300

SOURCE ANNUAL ABSTRACT OF STATISTICS

Fig. 5-2 LINK ROAD BETWEEN MALTA AND GOZO ISLANDS

NUMBER OF REGISTERED VEHICLES

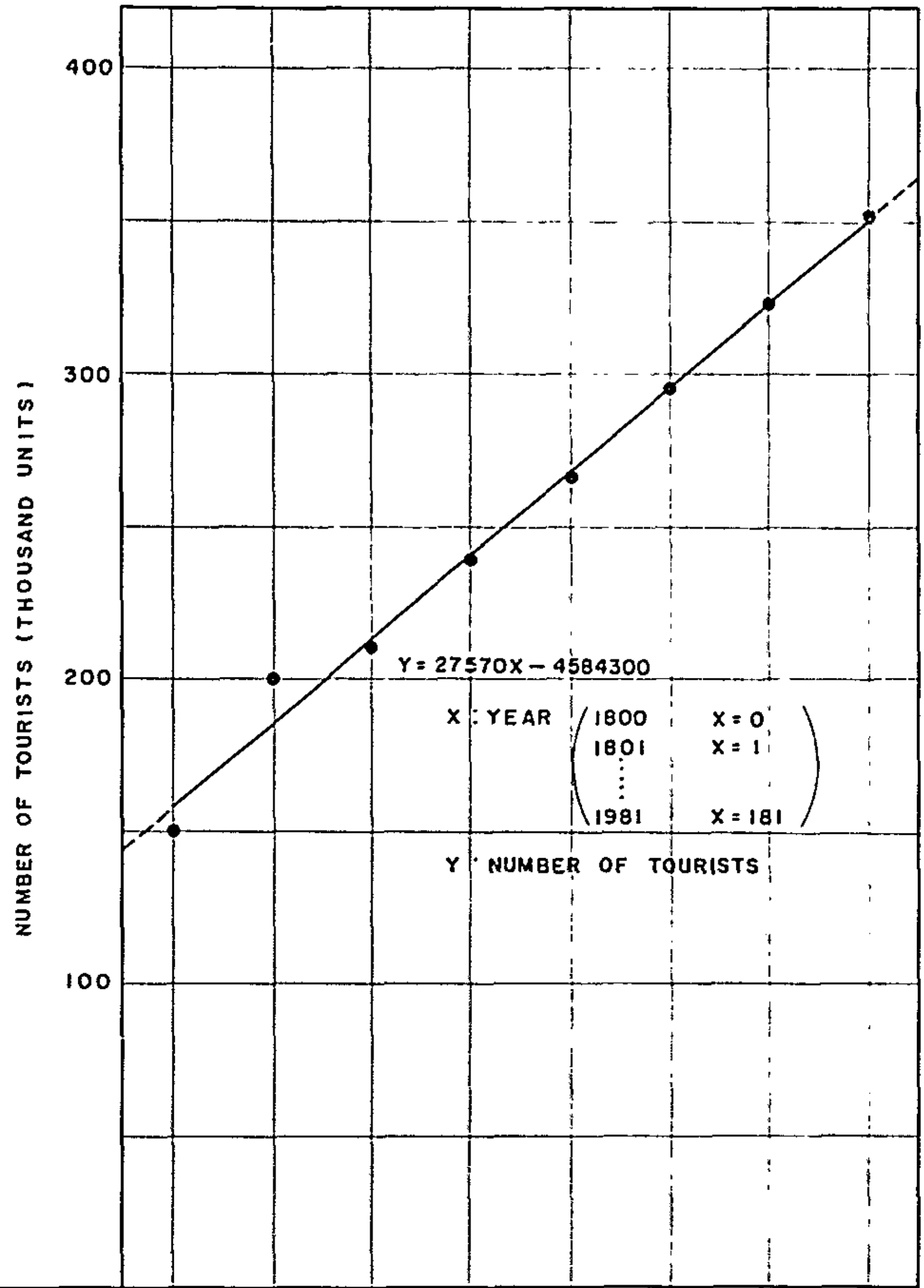
Fig. 5-3

ITEM \ YEAR	1842	1851	1861	1871	1881	1891	1901	1911	1921	1931	1948	1957	1967	1971
MALTA AND GOZO	114	123	134	142	150	165	185	212	212	242	306	320	314	325
MALTA	101	109	119	124	132	146	165	189	190	218	278	292	288	300
GOZO	14	15	15	17	18	19	20	23	23	24	28	28	26	25

Fig. 5-3 LINK ROAD BETWEEN MALTA AND GOZO ISLANDS

TREND OF POPULATION

Fig. 5-4



YEAR	1972	1973	1974	1975	1976	1977	1978	1979
NUMBER OF TOURISTS	149000	200000	211000	239000	267000	295000	323000	352000

SOURCE MINISTRY OF TRADE, INDUSTRY, AGRICULTURE, AND TOURISM

Fig. 5-4

LINK ROAD BETWEEN MALTA AND GOZO ISLANDS

FORECAST OF TOURISTS TO MALTA

Table 5-4 CORRILATION MATRIX AMONG THE ECONOMIC FACTORS

No.	Item		1	2	3	4	5	6	7	8	9	10	11	12
1	Year (1963 - 1971)		1.0000											
2	Number of owned vehicles	- Cars	0.9782	1.0000										
3	Do.	- Vans/Trucks	0.9841	0.9894	1.0000									
4	Do.	- Buses	0.7789	0.8073	0.8184	1.0000								
5	Do.	- Others	0.1201	0.2109	0.2554	0.3291	1.0000							
6	Do.	- Total	0.9665	0.9956	0.9861	0.8351	0.2730	1.0000						
7	Ratio of vehicle types	- Cars	0.9920	0.9859	0.9779	0.7862	0.0770	0.9719	1.0000					
8	Do.	- Vans/Trucks	-0.8160	-0.8984	-0.8281	-0.6931	-0.1504	-0.9001	-0.8655	1.0000				
9	Do.	- Buses	-0.9955	-0.9826	-0.9920	-0.8128	-0.1873	-0.9762	-0.9887	0.8204	1.0000			
10	Do.	- Others	-0.9920	-0.9595	-0.9673	-0.7663	-0.0211	-0.9404	-0.9894	0.7862	0.9845	1.0000		
11	Traffic volume by ferryboat	(Vehicles/Year)	0.9276	0.9820	0.9669	0.8177	0.3378	0.9896	0.9375	-0.9105	-0.9404	-0.8935	1.0000	
12	Number of tourists	(Persons/Year)	0.9640	0.9580	0.9789	0.8706	0.2936	0.9570	0.9554	-0.7778	-0.9819	-0.9507	0.9254	1.0000
13	Tourist receipts	(LM1,000/Year)	0.9568	0.9584	0.9754	0.8906	0.2866	0.9580	0.9538	-0.7904	-0.9762	-0.9456	0.9298	0.9981
14	G D P per capita	(LM/Year)	0.9827	0.9973	0.9915	0.7876	0.1965	0.9922	0.9871	-0.8815	-0.9855	-0.9662	0.9751	0.9541
15	Ratio of car ownership	(Vehicles/Persons)	0.9854	0.9982	0.9954	0.8108	0.2271	0.9943	0.9867	-0.8742	-0.9905	-0.9665	0.9761	0.9692
16	Average income per capita	(LM/Persons)	0.9437	0.9848	0.9606	0.7497	0.1821	0.9817	0.9590	-0.9237	-0.9432	-0.9220	0.9829	0.8972
17	Resident population	(Persons)	0.0521	0.2551	0.1841	0.2572	0.3940	0.2783	0.1306	-0.4916	-0.0938	-0 0157	0.3956	0.1287
18	Number of employees	(Persons)	0.9876	0.9869	0.9932	0.8219	0.2270	0.9801	0.9857	-0.8383	-0.9960	-0.9739	0.9519	0.9881
19	Agricultural production	(LM1,000/Year)	0.6601	0.6265	0.6798	0.5951	0.3086	0.6023	0.6484	-0.4039	-0.6915	-0.6682	0.5635	0.7814
20	Industrial production	(Do.)	0.9884	0.9945	0.9984	0.8155	0.2196	0.9904	0.9860	-0.8497	-0.9933	-0.9727	0.9697	0.9728
21	Landings of fish	(Do.)	0.8470	0.8505	0.7996	0.5085	-0.1823	0.8243	0.8640	-0.8350	-0.8064	-0.8422	0.8104	0.6997
22	Number of exported	(Do.)	0.9826	0.9681	0.9681	0.8402	0.1788	0.9702	0.9760	-0.8372	-0.9861	-0.9651	0.9273	0.9644
23	Number of imported	(Do.)	0.9625	0.9825	0.9919	0.8589	0.3363	0.9902	0.9558	-0.8360	-0.9778	-0.9362	0.9790	0.9741
24	Number of unemployees	(Persons)	-0.6836	-0.6857	-0.7529	-0.8233	-0.4099	-0.6947	-0.6751	0.4363	0.7328	0.6939	-0.6763	-0.8270

No.	Item		13	14	15	16	17	18	19	20	21	22	23	24
13	Tourist receipts	(LM1,000/Year)	1.0000											
14	G D P per capita	(LM/Year)	0.9519	1.0000										
15	Ratio of car ownership	(Vehicles/Persons)	0.9672	0.9976	1.0000									
16	Average income per capita	(LM/Persons)	0.8994	0.9845	0.9760	1.0000								
17	Resident population	(Persons)	0.1680	0.2223	0.2125	0.3395	1.0000							
18	Number of employees	(Persons)	0.9849	0.9858	0.9930	0 9456	0.1542	1.0000						
19	Agricultural production	(LM1,000/Year)	0.7767	0.6177	0.6503	0 5021	-0.0086	0.7265	1.0000					
20	Industrial production	(Do.)	0.9701	0.9963	0.9984	0 9703	0.1855	0.9931	0.6542	1 0000				
21	Landings of fish	(Do.)	0.6975	0.8519	0.8341	0.8914	0.1426	0.7898	0.2586	0 8261	1.0000			
22	Number of exported	(Do.)	0.9594	0.9675	0.9748	0.9279	0.0621	0.9772	0.6265	0.9747	0.8083	1.0000		
23	Number of imported	(Do.)	0.9733	0.9810	0.9875	0.9570	0.2417	0.9805	0.6444	0.9894	0.7676	0 9642	1 0000	
24	Number of unemployees	(Persons)	-0.8363	-0.6859	-0.7070	-0.5979	-0.1727	-0.7534	-0.8293	-0 7259	-0.2518	-0 6794	-0 7611	1 0000

5.3 Forecast for Traffic Demand

5.3.1 Outline

A generally accepted practice for the forecast of future traffic demand consists of obtaining the correlation between the current economic and industrial status and the current traffic volume as well as studying the future development plans and land use plans on the correlation found. This methodology is applied for the estimation of the future traffic demand in Malta.

To our regret, however, nothing about the figures that would substantiate the demand forecast was available to us because of various reasons, except for a rough idea of development plan and land use plan for Malta.

For this reason, we have had to look into "Outline of Development Plan for Malta, 1973 - 1980", published in Aug., 1973. For the estimation of traffic volume, there are many ways, and the way to be picked up is largely dependent on the quality and quantity of basic information available.

In consideration of such data as high correlation between the current ferry-using traffic volume and the number of tourists to Malta, the principal component analysis is applied to the forecast of future traffic demand so as to comprehensively embrace the conditions of industries and economics that now prevail in Malta.

The principal component analysis, which will be explained later, deals with the following economic and industrial factors in which secular change is considered.

Number of owned vehicles (cars, vans, trucks, busses and others); ratios of specific types of vehicles to total (cars, vans, trucks, busses and others); ratio of vehicle ownership; number of tourists, tourist receipts GDP per capita; average income per capita; resident population; number of employees; number of the unemployed; agricultural production; industrial production; marine output production; amount imported; amount exported. As already discussed, various economic indices are required for the stochastic analysis of the future originating traffic volume between Malta and Gozo.

However, the forecast values of these indices are available only from "Outline of Development Plan for Malta, 1973 - 1980" and to a very limited extent, from a few other materials.

Accordingly, the values of economic indices over the years up to 1979 are estimated by applying the progressive pattern before 1972 to the period from 1972 to 1979.

The values of the economic indices from the year 1979 onward are evaluated with the 1979 values referred to in the development plan as a control point and in consideration of the progressive pattern in the past on condition that they will increase in an arithmetic series.

Since it is foreseen, however, that the industrial development in Malta, particularly such water-dependent enterprises as agriculture, extractive industries, and tourism (as accounted by the number of hotels), will be largely dependent on the future availability of water supply, it would not follow the past progressive pattern simply, but saturate in some future days.

Considering these and other various factors, the future figures of agricultural production, industrial production, number of tourists, GDP per capita, etc. are estimated in direct correlation with future water supply.

In this way, the originating the traffic volume is forecast based on the past pattern of economic indices or on their estimated values.

Like the originating traffic volume, the generated traffic volume is determined by the principal component analysis.

The estimated values of the economic indices, which serve as a basis for its stochastics, are based upon the following assumptions.

If a bridge is available between Malta and Gozo, it is considered that the differences in all aspects of standards between Malta and Gozo, which now prevail to be equivalent to 25 years, will be leveled off in some 15 years.

As of 1972, for example, 120 thousand persons, accounting for some 38 per cent of a total population of about 318 thousand in Malta, were hived in the inner harbour region including Valletta. The income level of the people in this region is above the national average, but the bridge construction will have an impact to decentralize the cultural, industrial and economic activities. In this context, the average income level in Gozo is expected to emulate that in Malta.

Those economic factors, which will be subject most in their development patterns to the impact of bridge installation, include:

> Number of tourists → tourist receipts; GDP per capita; average income per capita → number of owned vehicles; agricultural production; industrial production; number of employees; amount exported; and amount imported.

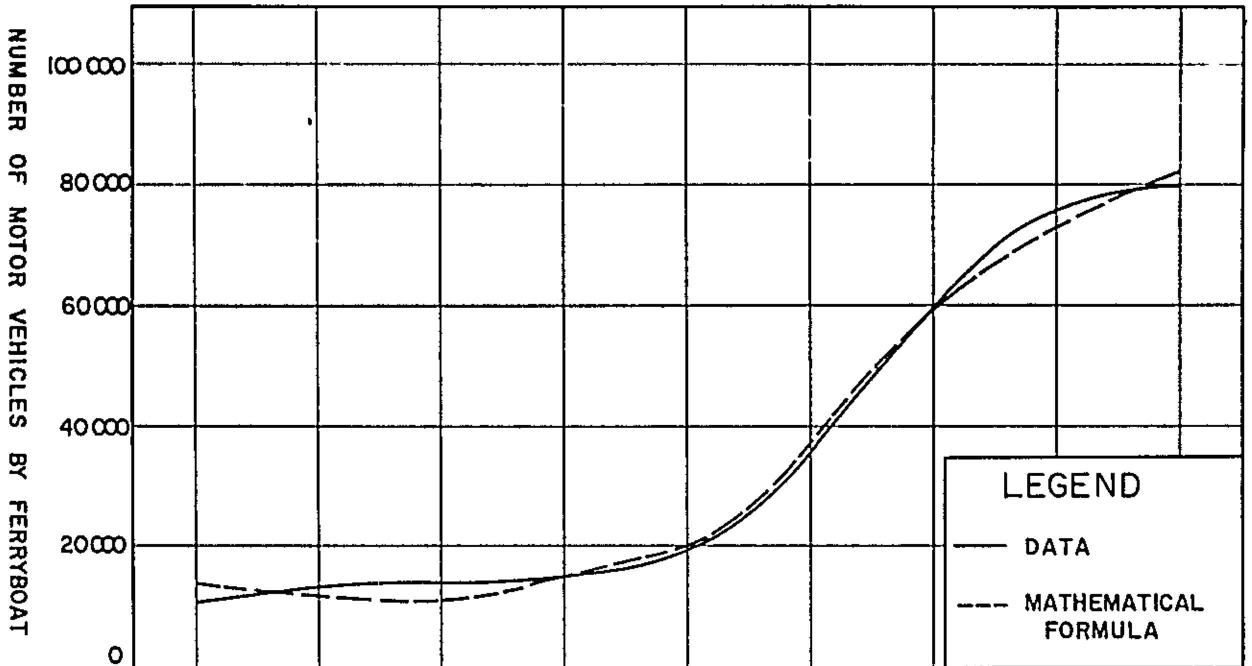
In the meantime, improvement of ferry systems will possibly allure additional increase in the traffic volume. However, the improvement plan for the ferry system is left quite uncertain to us, and such subordinate factor is discarded from the discussions here. The future traffic volume with which to assess the economic impacts is limited to the orginating one and the one expected to be generated by the construction of a bridge

The effect of bridge construction on the developments are believed to become strong more and more in deeper future, and the appraisal of the economic impacts of the bridge seems to be not of no use. For this reason, the traffic volume is estimated to cover it far up to the year 2010, were it ever so incredible.

5.3.2 Methodology for the Forecast of Traffic Demand

The future originating traffic volume and the generated traffic volume by the construction of a bridge between Malta and Gozo are estimated by the principal compo-

Fig. 5-5



ITEM \ YEAR	1963	1964	1965	1966	1967	1968	1969	1970	1971
DATA	10550	12980	14050	14890	19220	35520	59110	76340	79660
MATHEMATICAL FORMULA	13720	11820	10740	15150	19750	37250	59160	73120	81620

Fig. 5-5 LINK ROAD BETWEEN MALTA AND GOZO ISLANDS

NUMBER OF MOTOR VEHICLES BY FERRYBOAT
(RELATION BETWEEN PAST DATA AND MATHEMATICAL FORMULA)

nent analysis. The principal component analysis is one of the most fundamental techniques in the multivariate statistical analysis, and is able to reduce, into a few, independent abstract values, a volume of information comprising a good deal number of inter-related characteristic values.

In applying the factorial design method, it is of prime importance to carefully pick up economic factors (variates) which show high correlation with the traffic volume borne by ferries operating between Malta and Gozo.

The general equations for the factorial design method are given below.

$$f(x) = y_1 + y_2 + y_3 + \cdots\cdots + y_n = \sum_{i=1}^{n} y_i \quad \cdots\cdots 5\cdot1)$$

$$y_1 = a_{11}x_1 + a_{12}x_2 + \cdots\cdots + a_{1n}x_n = \sum_{i=1}^{n} a_{1i}x_i \quad \cdots\cdots 5\cdot2)$$

$$y_2 = a_{21}x_1 + a_{22}x_2 + \cdots\cdots + a_{2n}x_n = \sum_{i=1}^{n} a_{2i}x_i \quad \cdots\cdots 5\cdot3)$$

$$\vdots$$

$$y_n = a_{n1}x_1 + a_{n2}x_2 + \cdots\cdots + a_{nn}x_n = \sum_{i=1}^{n} a_{ni}x_i \quad \cdots\cdots 5\cdot4)$$

$$\sum_{i=1}^{n} a_{1i}^2 = 1, \ \sum_{i=1}^{n} a_{2i}^2 = 1, \cdots\cdots, \quad \sum_{i=1}^{n} a_{ni}^2 = 1 \quad \cdots\cdots 5\cdot5)$$

$$(n = 21)$$

Where, $f(x)$: Traffic volume by autos using ferryboats running between Malta and Gozo, vehicles/year

y_1 : No. 1 factor

y_2 : No. 2 factor

⋮ ⋮

y_n : No. n factor

x_1 : Number of owned vehicles (Cars)

x_2 : Number of owned vehicles (Vans and Trucks)

x_3 : Number of owned vehicles (Busses)

x_4 : Number of owned vehicles (Others)

x_5 : Car ratio to total number of vehicles

x_6 : Van and truck ratio to total number of vehicles

x_7 : Bus ratio to total number of vehicles

x_8 : Ratio of other vehicles to total number of vehicles

x_9 : Ratio of vehicle ownership (Vehicles/person)

x_{10} : Resident population (Persons)

x_{11} : Number of employees

x_{12} : Number of unemployees of business

x_{13} : GDP per capita (ŁM/man. year)

x_{14} : Average income per capita (1, 000 ŁM/year)

x_{15} : Number of tourists (Persons/year)

x_{16} : Tourist receipts (1, 000 ŁM/year)

x_{17} : Agricultural production (1, 000 ŁM/year)

x_{18} : Industrial production (1, 000 ŁM/year)

x_{19} : Landings of fish (1, 000 ŁM/year)

x_{20} : Amount exported (1, 000 ŁM/year)

x_{21} : Amount imported (1, 000 ŁM/year)

$a_{11} \sim a_{nn}$: Coefficients of respective economic factors

When the principal component analysis using equations 5. 1) through is used for obtaining the regression of the traffic volume of autos using ferries over the period from 1963 to 1971 in its correlation with the economic factors during the same period, the auto traffic volume can be mathematically expressed by the dotted line appearing in Fig. 5-5.

This theoretical value is given by Eq. 5. 1.

Fig. 5-5 justifies the theoretical expression as it closely follows the given data.

Following Eq. 5. 1, let us now evaluate the originating traffic volume in the future.

The economic and industrial factors in the future which serve as input data for Eq. 5.1 are determined by passing the past pattern in an arithmetic series on the years ahead of 1979 with the values specified for the year 1979 in the Development Plan for Malta as control points.

In addition to the auto traffic using ferries, there are ferry passengers taking busses up to ferry port for commutation between Malta and Gozo. For this reason, the correlation in the past of the person trip data can vassed at site and the auto traffic volume is studied and the evaluated correlation is applied to the forecast auto traffic volume for the assessment of the future traffic volume of non-auto passengers.

Once a bridge is constructed between Malta and Gozo, interisland bus routes will be developed, and those who are at present commuting without their own cars between Malta and Gozo are expected to take the interisland busses instead of ferries.

5.3.3 Traffic Volume in the Future

The originating traffic volume (vehicles/year) and the generated traffic volume (vehicles/year), assessed as to types of vehicles and years (1975 to 2010) by the method described under para. 5.3.2, appear in the bottom row in each bracket in Table 5-5.

Monthly statistics of the traffic volume of vehicles using ferryboats show that in the summer, when the sightseeing is at its best, the traffic volume attains a peak in August accounting for some 17 per cent of the yearly total volume. (See Fig. 5-6)

The values in the middle row in each bracket in Table 5-5 denote the monthly maximum traffic volumes (vehicles/month) obtained on the basis of monthly peak rates.

The values in the top row in each bracket in the same table show the peak-hour traffic volumes (vehicles/hr) in the peak months with the peak rate set at one-tenth, traffic volume in holidays at twice as large as in ordinary days, and with one month comprising 30 days.

The values in Table 5-1 are plotted in Fig. 5-7.

According to Table 5-5, the year 2010 is expected to have a yearly traffic volume of 450 thousand vehicles or a hourly peak traffic volume of 510 vehicles.

The hourly peak traffic volume in 2010 and the traffic capacity of the bridge volume in 2010 and the traffic capacity of the bridge are studied by comparison as follows.

Let us determine the traffic capacity of the bridge to begin with, provided that the structural requirements of the road are as per the *preliminary survey report*.

Structural requirements : - (in accordance with Japanese standards)

Design speed	:	60 kg/hr
Lane width	:	3.25 m x 2 lanes
Side allowance (on each side)	:	0.75 m
Ratio of large-sized vehicles	:	15% (estimated)

Correction factors : -

Lane width : 0.94; side clearance: 0.81; ratio of large-sized vehicles: 0.89; roadside conditions: 0.90; design level: 0.75

Basic traffic capacity (total of ups and downs by 2-way 2-lane road)

: 2,500 vehicles/hr

Permissible traffic capacity : 2,500 x 0.94 x 0.81 x 0.89 x 0.90 = 1,520 vehicles/hr

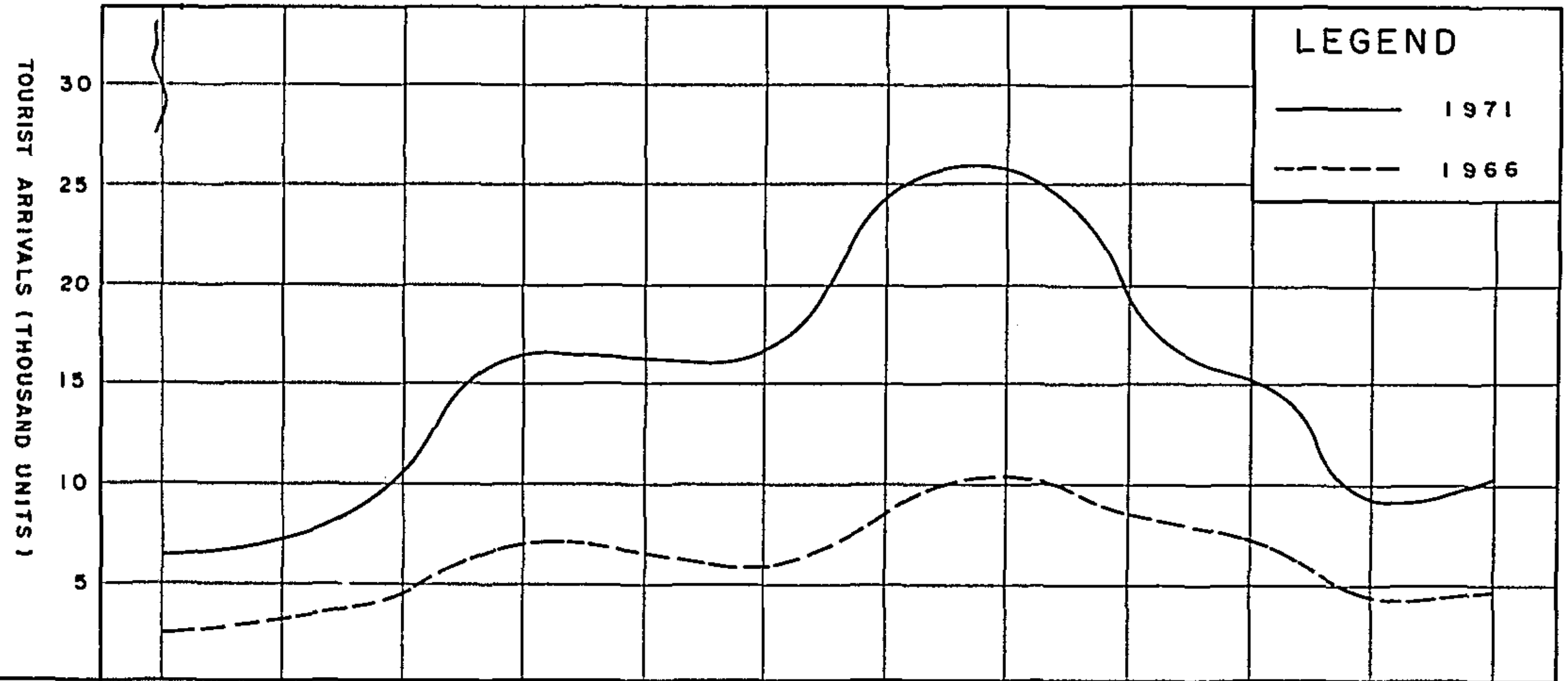
Design traffic volume : 1,520 x 0.75 = 1,140 vehicles/hr

Design standard traffic volume : 11,000 vehicles/day

The design traffic capacity of the 2-lane bridge is 1,140 vehicles/hr as given above, which is far above the hourly peak traffic volume of 510 vehicles/hr expected in 2010.

It is therefore concluded that a bridge with 2 lanes will do for the future traffic demand.

Fig. 5-6



YEAR \ MONTH		JAN.	FEB.	MAR.	APR.	MAY.	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.
TOURIST	1966	2426	3091	4374	7124	6577	5931	8436	10260	8437	7333	4265	4635
ARRIVALS	1971	6538	7352	10769	16471	16315	16583	24441	25703	19438	15402	9281	10411

SOURCE MINISTRY OF TRADE, INDUSTRY, AGRICULTURE, AND TOURISM

Fig. 5-6 LINK ROAD BETWEEN MALTA AND GOZO ISLANDS

MONTHLY CHANGES OF TOURIST ARRIVALS IN 1966,1971

Table 5 - 5 FUTURE TRAFFIC VOLUME BY VEHICLE TYPES

(Units: Thousand Vehicles)

Vehicle type / Item / Year	Cars		Vans/Trucks		Buses		Others		Total				
	Origi-nated traffic	Gen-erated traffic	* Origi-nated traffic	Gen-erated traffic	Di-verted traffic	Gen-erated traffic	Origi-nated traffic	Gen-erated traffic	** Origi-nated traffic	Di-verted traffic	Sub total	Gen-erated traffic	Total
1975	0.09		0.02		0.01		0.00		0.10	0.02	0.12		0.12
	13.2		3.3		1.8		0.3		15.1	3.4	18.5		18.5
	77.8		19.2		10.3		1.8		89.0	20.1	109.1		109.1
1980	0.12		0.03		0.02		0.00		0.14	0.03	0.17		0.17
	18.4		4.5		2.4		0.4		21.1	4.7	25.8		25.8
	108.4		26.6		14.2		2.6		124.0	27.8	151.8		151.8
1985	0.15	0.02	0.04	0.00	0.02	0.00	0.00	0.00	0.18	0.04	0.22	0.02	0.24
	23.0	2.7	5.7	0.3	3.0	0.4	0.5	0.1	26.4	5.9	32.3	3.5	35.8
	135.5	16.0	33.4	1.9	17.8	2.1	3.2	0.4	155.0	34.9	189.9	20.4	210.3
1990	0.18	0.04	0.05	0.01	0.02	0.01	0.00	0.00	0.21	0.05	0.26	0.05	0.31
	27.6	5.5	6.8	0.7	3.6	0.7	0.6	0.1	31.6	7.1	38.7	6.9	45.7
	162.6	32.1	40.1	3.9	21.4	4.1	3.8	0.7	186.0	41.9	227.9	40.8	268.7
1995	0.21	0.06	0.05	0.01	0.03	0.01	0.01	0.00	0.24	0.06	0.30	0.07	0.37
	31.7	8.2	7.8	1.0	4.2	1.1	0.7	0.2	36.2	8.2	44.4	10.4	54.8
	186.2	48.1	45.8	5.8	24.6	6.2	4.4	1.1	213.0	48.0	261.0	61.2	322.2
2000	0.24	0.06	0.06	0.01	0.03	0.01	0.01	0.00	0.28	0.06	0.34	0.08	0.42
	36.3	9.4	8.9	1.1	4.8	1.2	0.9	0.2	41.5	9.3	50.8	11.9	62.7
	213.3	55.1	52.5	6.6	28.2	7.1	5.0	1.3	244.0	55.0	299.0	70.1	369.1
2005	0.17	0.07	0.07	0.01	0.04	0.01	0.01	0.00	0.31	0.07	0.38	0.09	0.46
	40.1	10.4	9.9	1.2	5.3	1.3	1.0	0.2	45.9	10.3	56.2	13.2	69.4
	236.0	61.0	58.1	7.3	31.1	7.9	5.6	1.4	270.0	60.8	330.8	77.6	408.4
2010	0.30	0.08	0.07	0.01	0.04	0.01	0.01	0.00	0.34	0.07	0.41	0.10	0.51
	44.3	11.4	10.9	1.4	5.8	1.5	1.0	0.3	50.7	11.4	62.1	14.6	76.6
	260.6	67.3	64.1	8.1	34.3	8.7	6.1	1.5	298.0	67.1	365.1	85.6	450.7

Remarks: * Include diverted traffic.
** Traffic volume by ferryboat.
Upper Column: A Peak hourly traffic volume (B ÷ 30 × 2 × 0.1)
Middle Column: B Peak monthly traffic volume (C × 0.17)
Lower Column: C Annual traffic volume

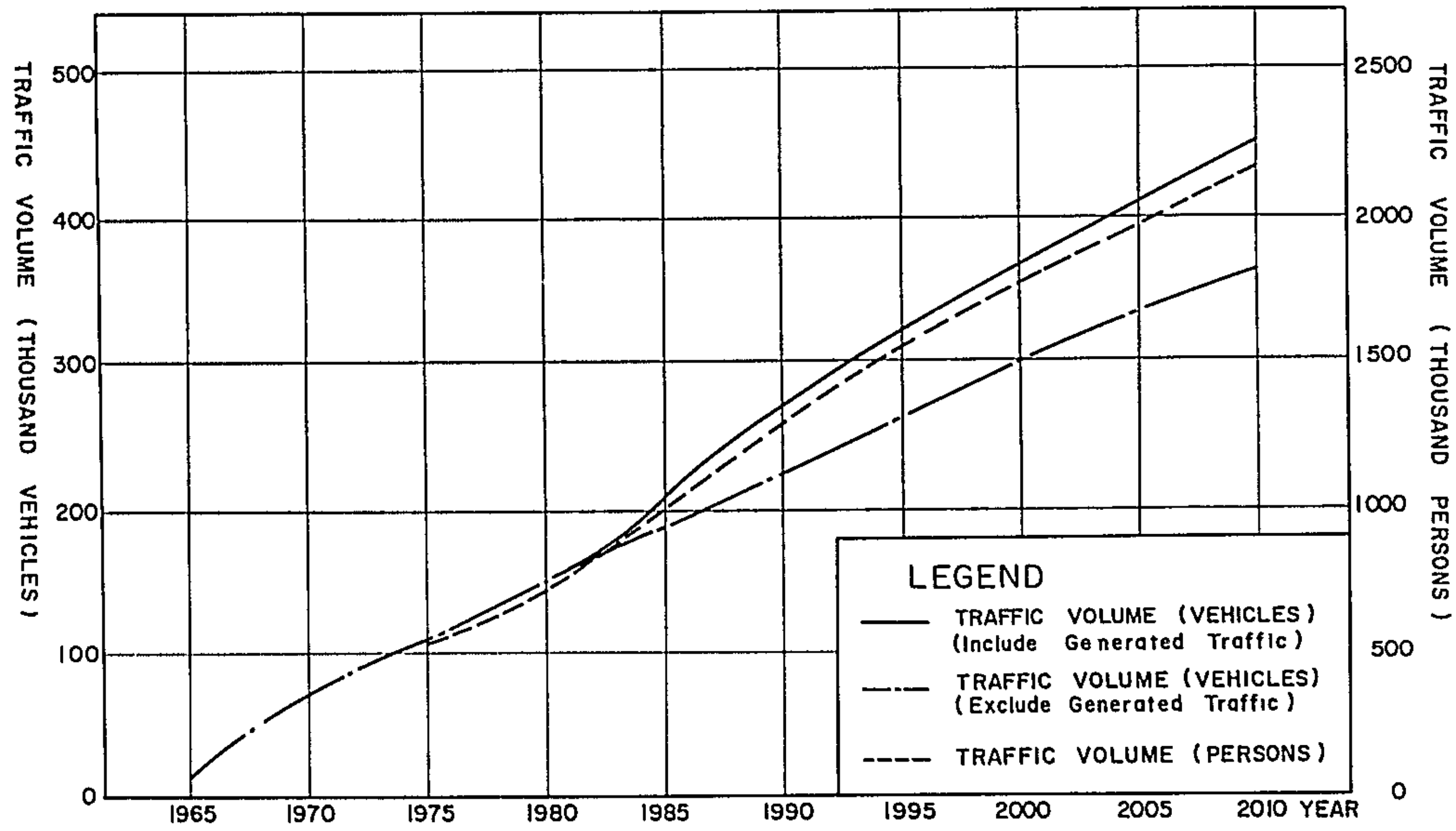
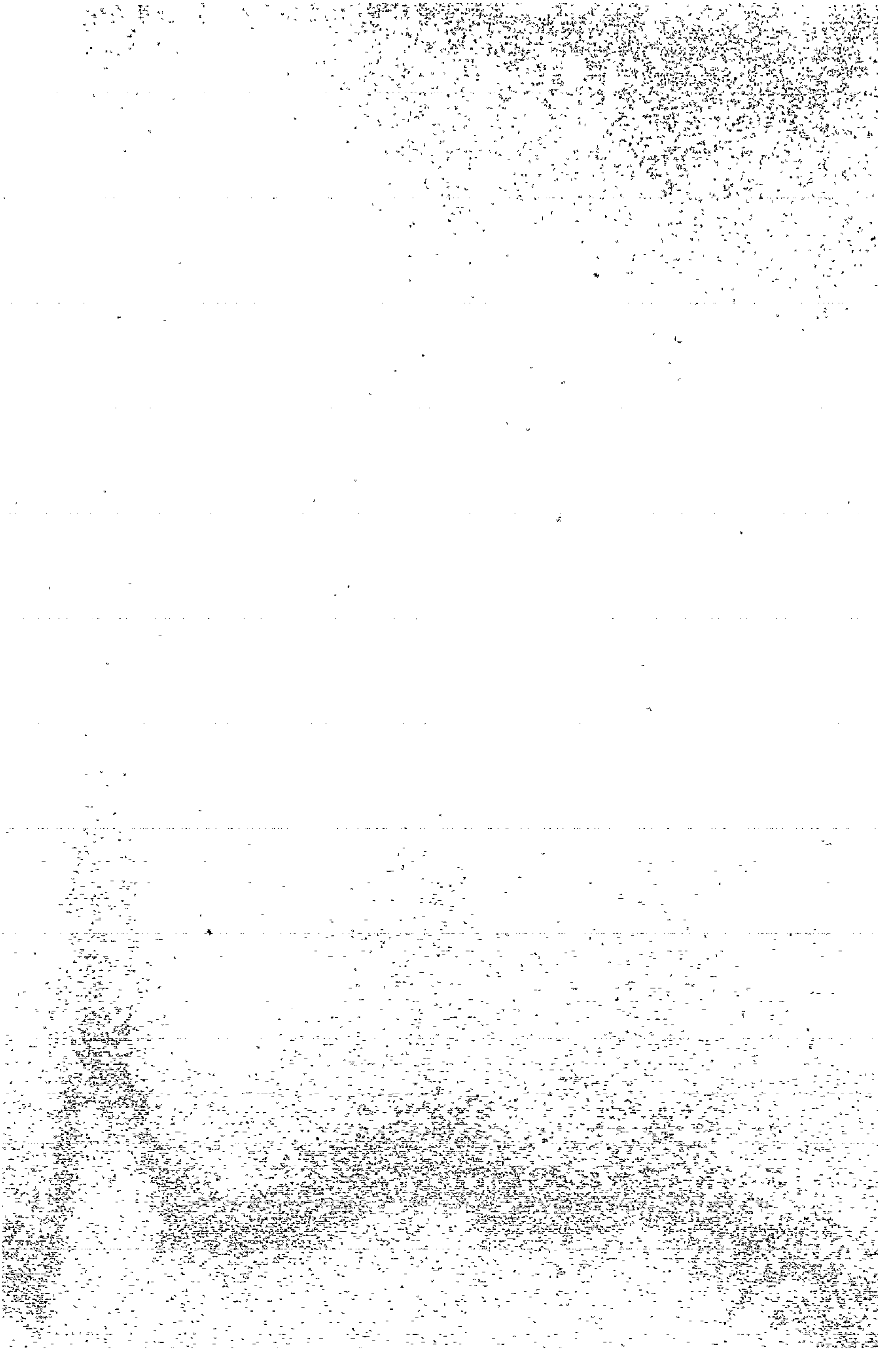


Fig. 5-7

Fig. 5-7	LINK ROAD BETWEEN MALTA AND GOZO ISLANDS
	FUTURE TRAFFIC VOLUME BETWEEN MALTA AND GOZO

CHAPTER 6

BRIDGE PLAN



CHAPTER VI BRIDGE PLAN

6.1 Outline

Based on the traffic demand forecast in Chap. V and the depth contours, quality of the bottom strata, geology, oceanographical phenomena, meteorology and topography (scale: 1/2, 500) obtained during the final survey, the present chapter will discuss the technical feasibility of constructing a link road and a bridge between Malta and Gozo with Comino as a pontoon, together with other various problems relating to engineering specifications, construction schedule and construction costs, and also will summarize the essentials of the link road and bridge construction plan.

Plan views and profiles of the projected site are shown in Figs. 6-1, 2, 3 and 4.

6.2 Link Road Plan

6.2.1 Route Location

The route location conducted at site revealed no particular obstacles that may hinder the route plan. The ground condition was also found generally acceptable. The problems are therefore simplified from the outset. For the selection of a route, we were only required to consider how the horizontal and vertical control points be secured for the purpose of satisfying mainly structural requirements and how to connect channel bridges to the selected ground routes.

Generally, the efforts were used to make most of the existing roads, and those which are found defective in alignment were corrected to meet the design standards applied for the construction plan. New road construction on the existing roads is advantageous in that their degree of utilization is high, that the construction work will be easy, and in that transit functions will not be marred even when the construction work is carried out in several stages.

With reference to the proposed site, the route is selected as shown in Figs. 6-1, 2, 3 and 4.

Principal control points and intervals are as follows.

(1) Malta Island

Proposed junction (Stao) with the Malta trunk road: approx. 830 m from the trunk road to the shoreline of South Comino Channel.

(2) Comino Island

Approx. 3, 200 m

(3) Gozo Island

Approx. 650 m from the shoreline to the existing road

Fig. 6-1

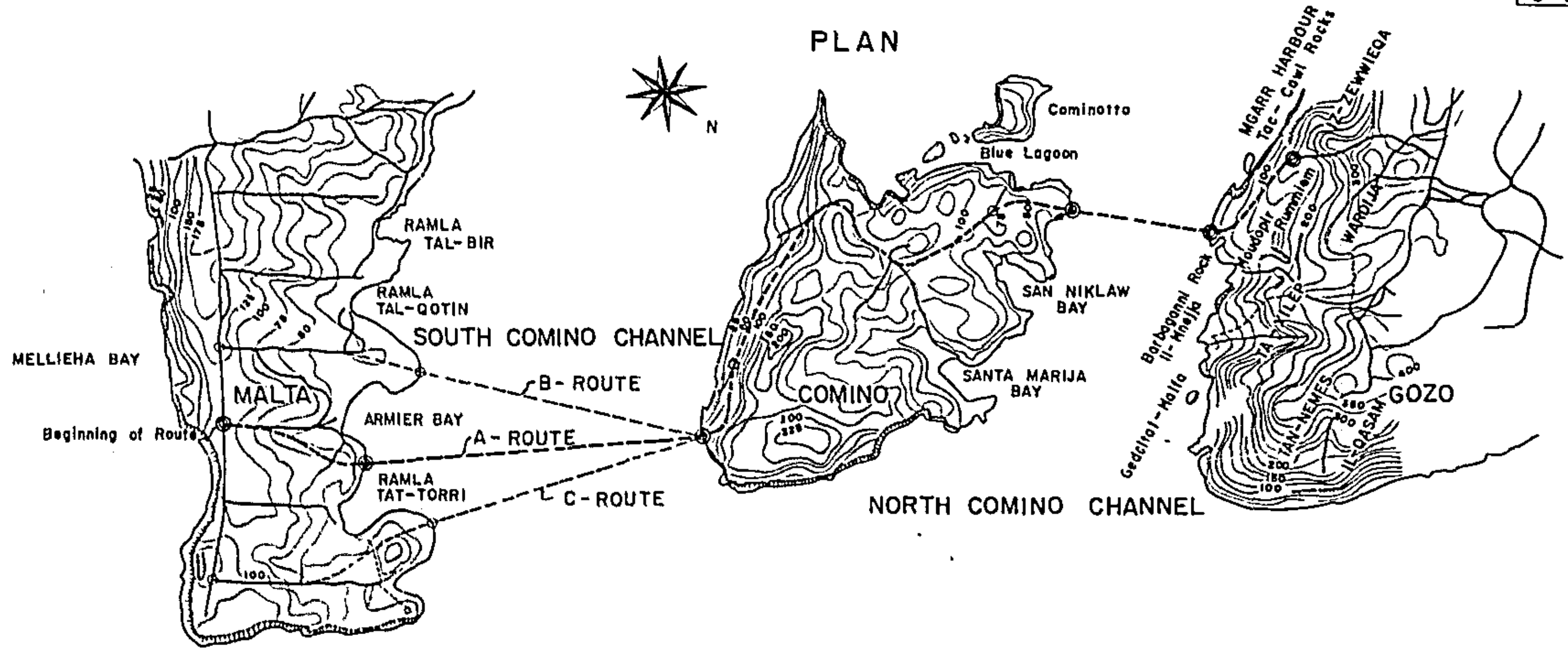
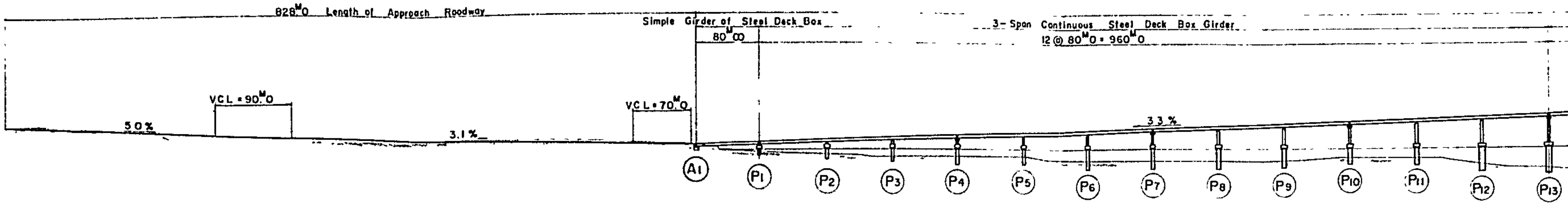
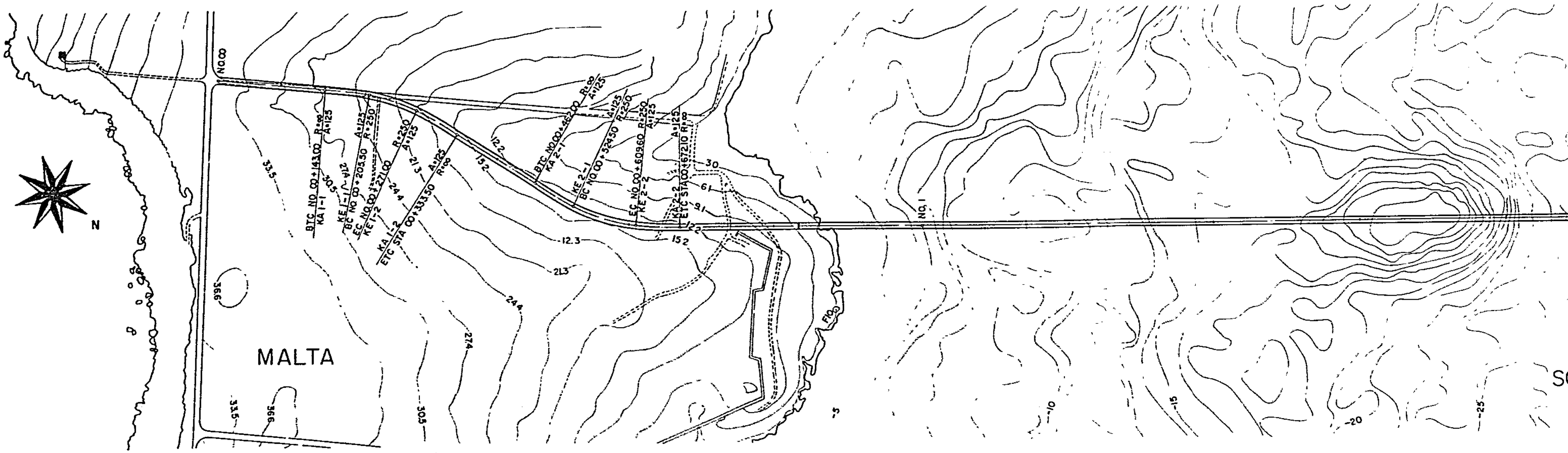


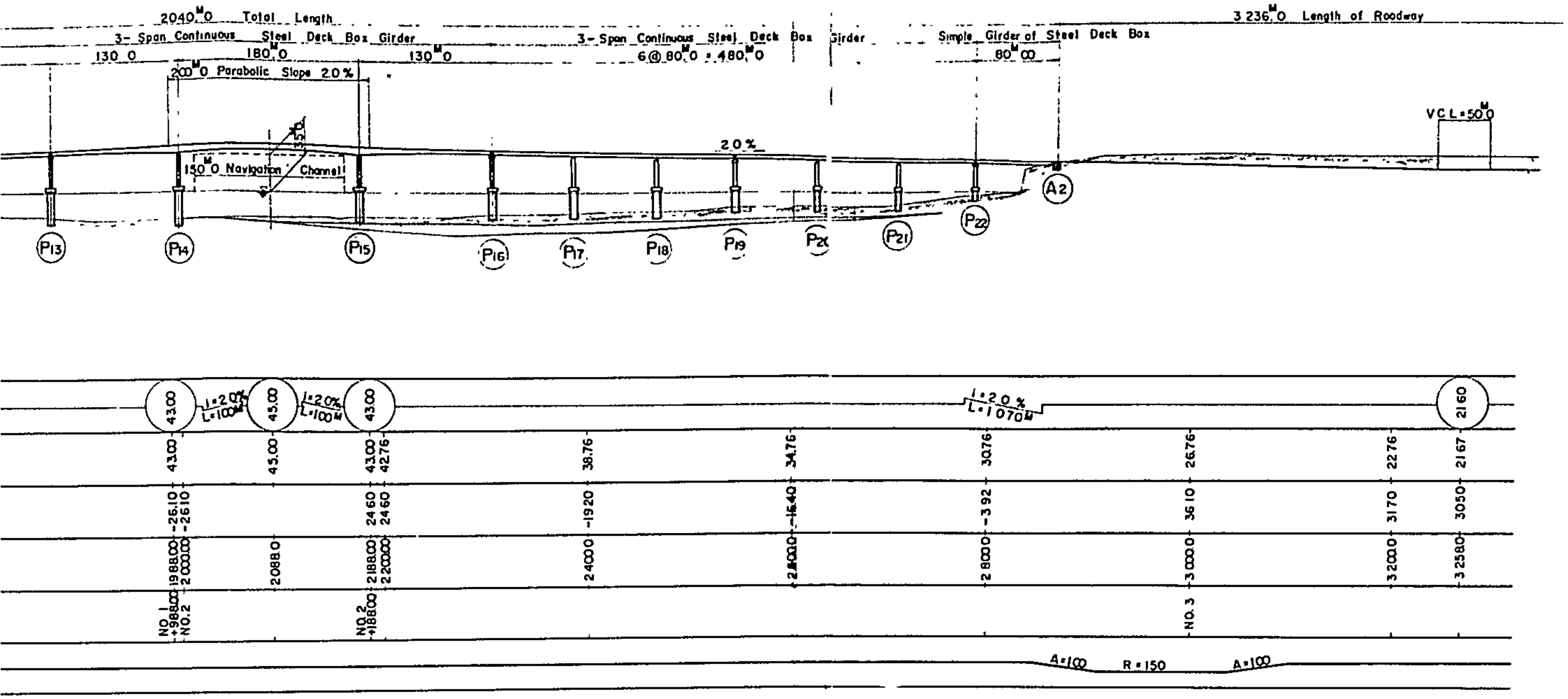
Fig. 6-1	LINK ROAD BETWEEN MALTA AND GOZO ISLANDS LOCATION MAP



GRADE	33.63	i=5.0% L=300M	18.53		i=3.1% L=488M	3.40				i=3.3% L=1200M	
PROPOSIDE HEIGHT	33.63	23.53	19.44	15.43	9.23	3.46 3.86	10.40	17.00	23.60	30.20	36.80
GROUND HEIGHT	33.53	26.80	17.00	13.29		7.60 7.60	-6.90	-9.80	-15.15	-12.70	-19.00
ACCUMULATIVE DISTANCE	0.0	200.0	300.0	400.0	600.0	788.0 800.0	1000.0	1200.0	1400.0	1600.0	1800.0
STATION	NO.0		NO.0 +300.0			NO.0 +788.0	NO.1				
CURVE BAND		A=125 R=250	A=125		A=125 R=250	A=125					



PROFILE



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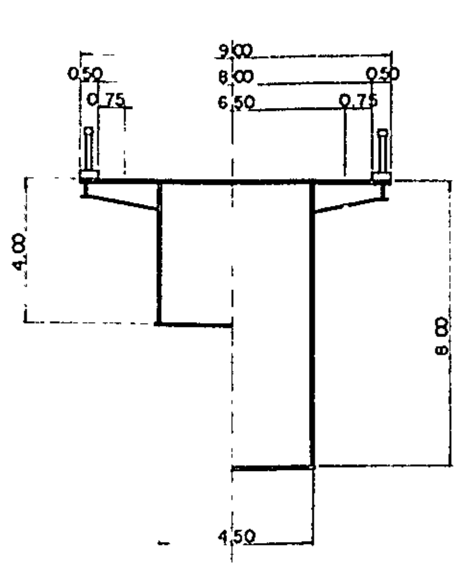
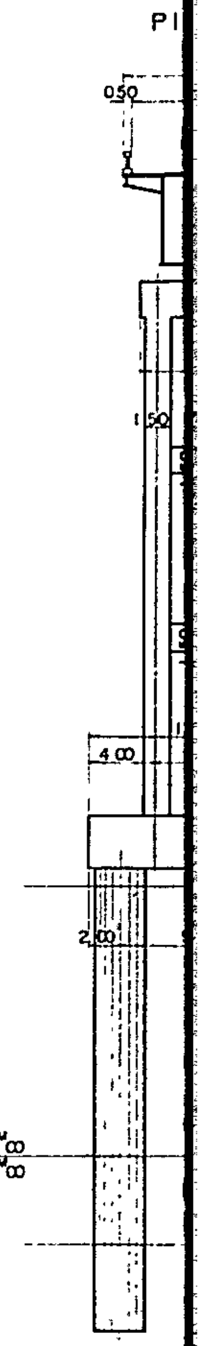
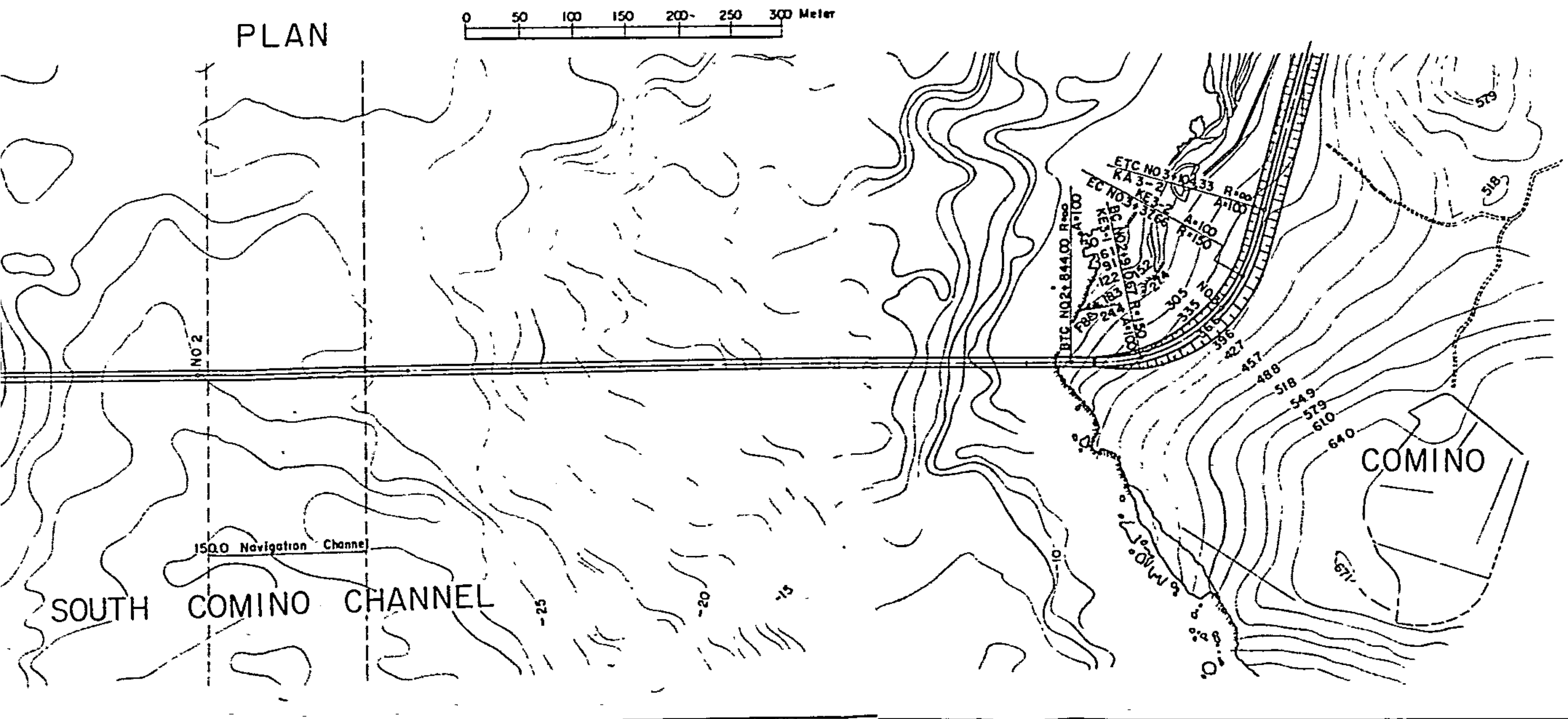
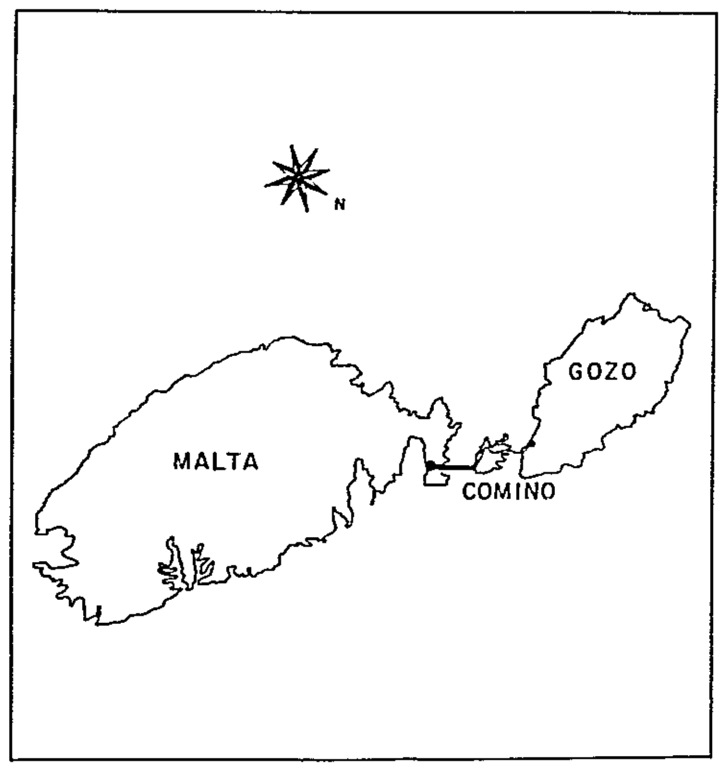


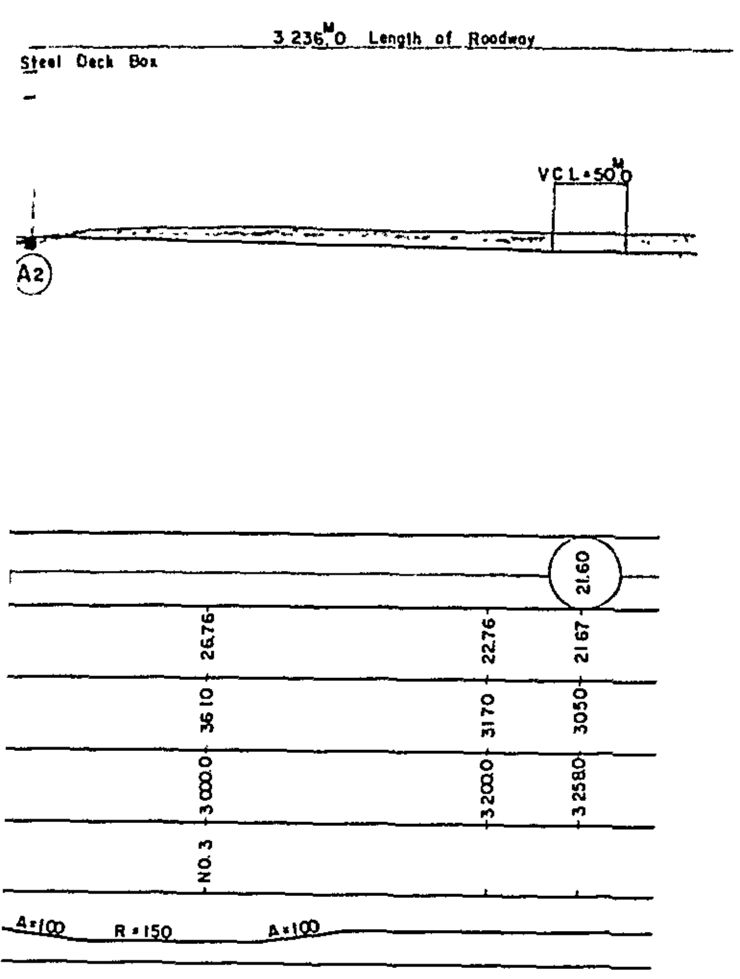


PLAN





All dimensions are shown in m.



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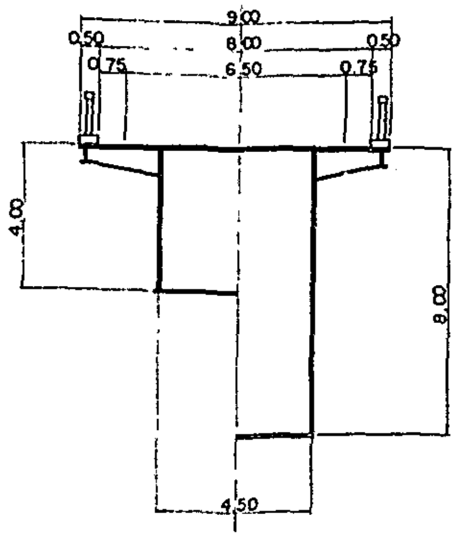

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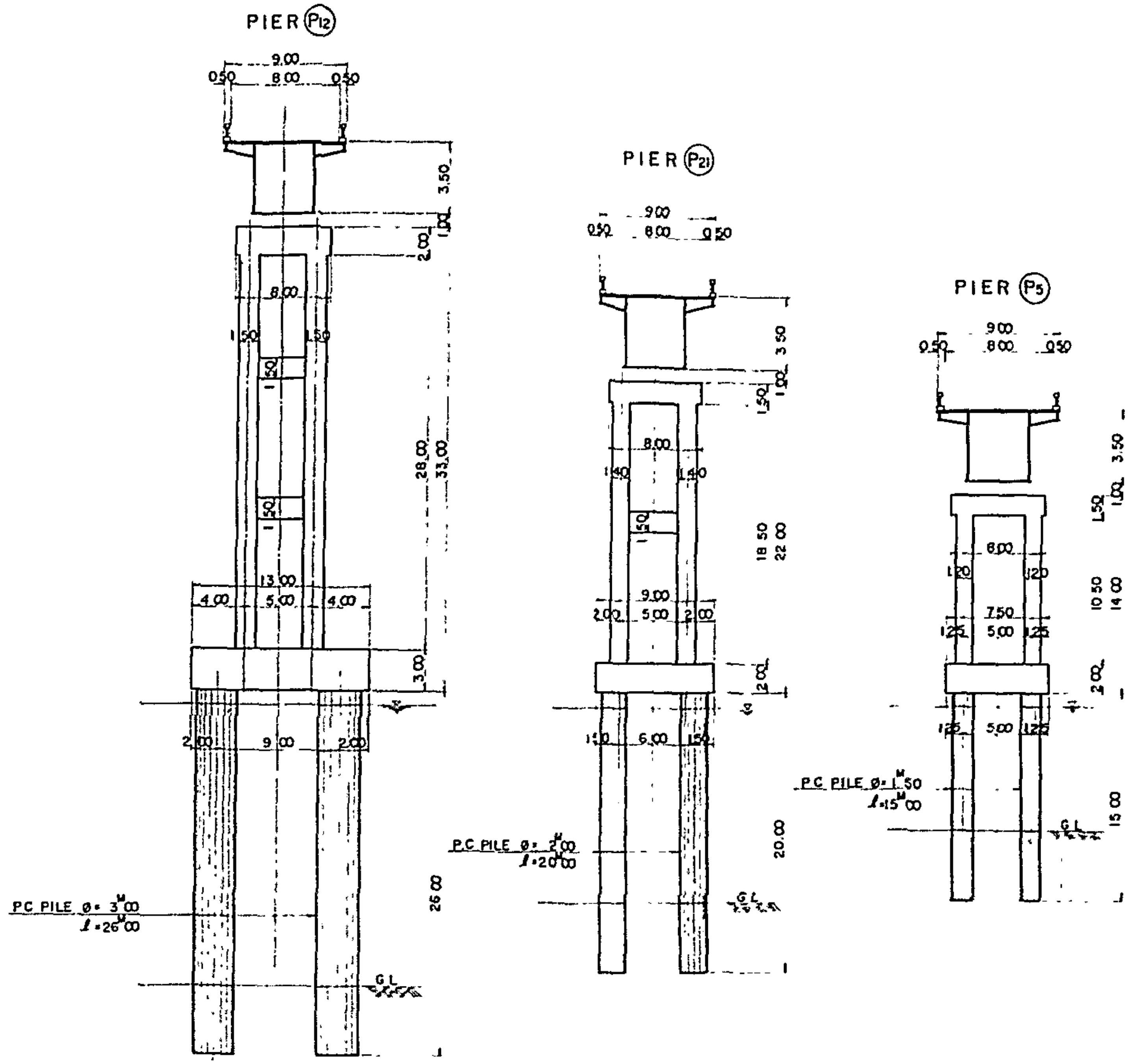
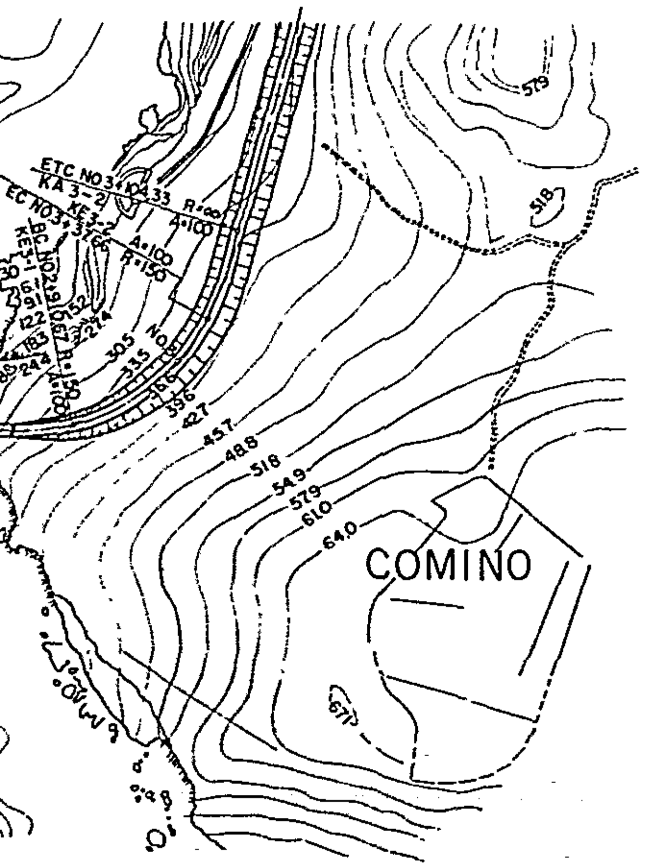
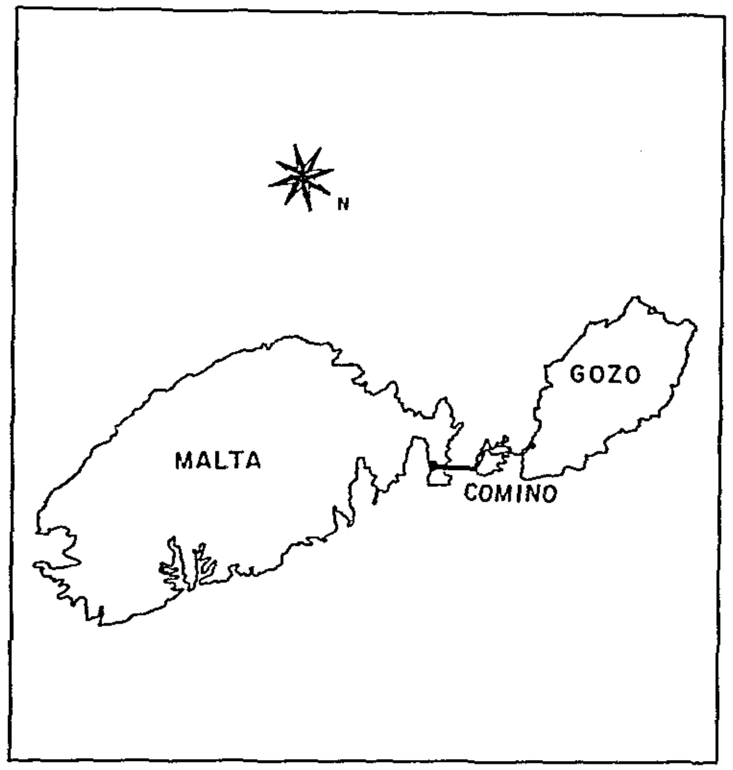






All dimensions are shown in m.

Fig. 6-2	LINK ROAD BETWEEN MALTA AND GOZO ISLANDS
	SOUTH BRIDGE (MALTA - COMINO)

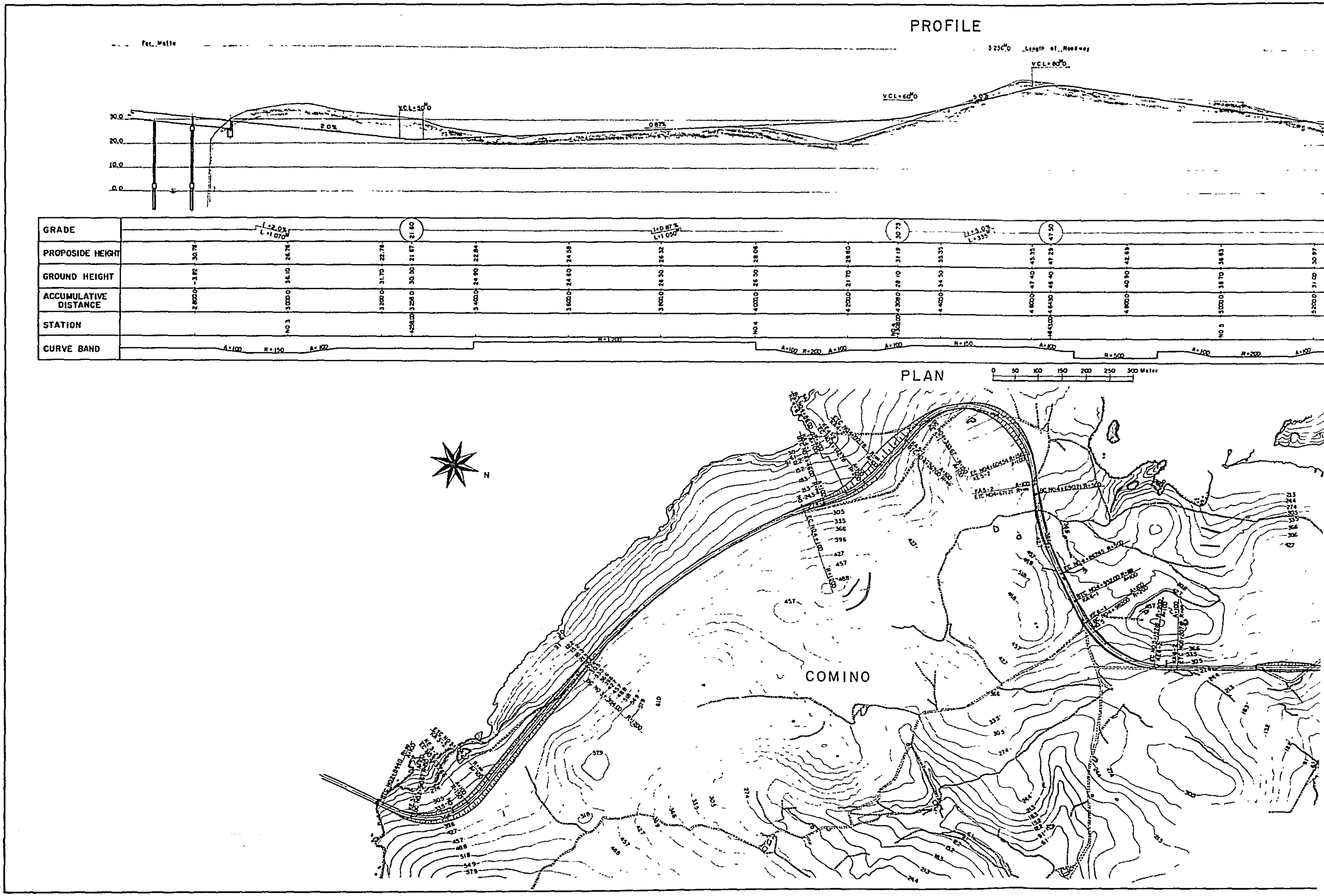
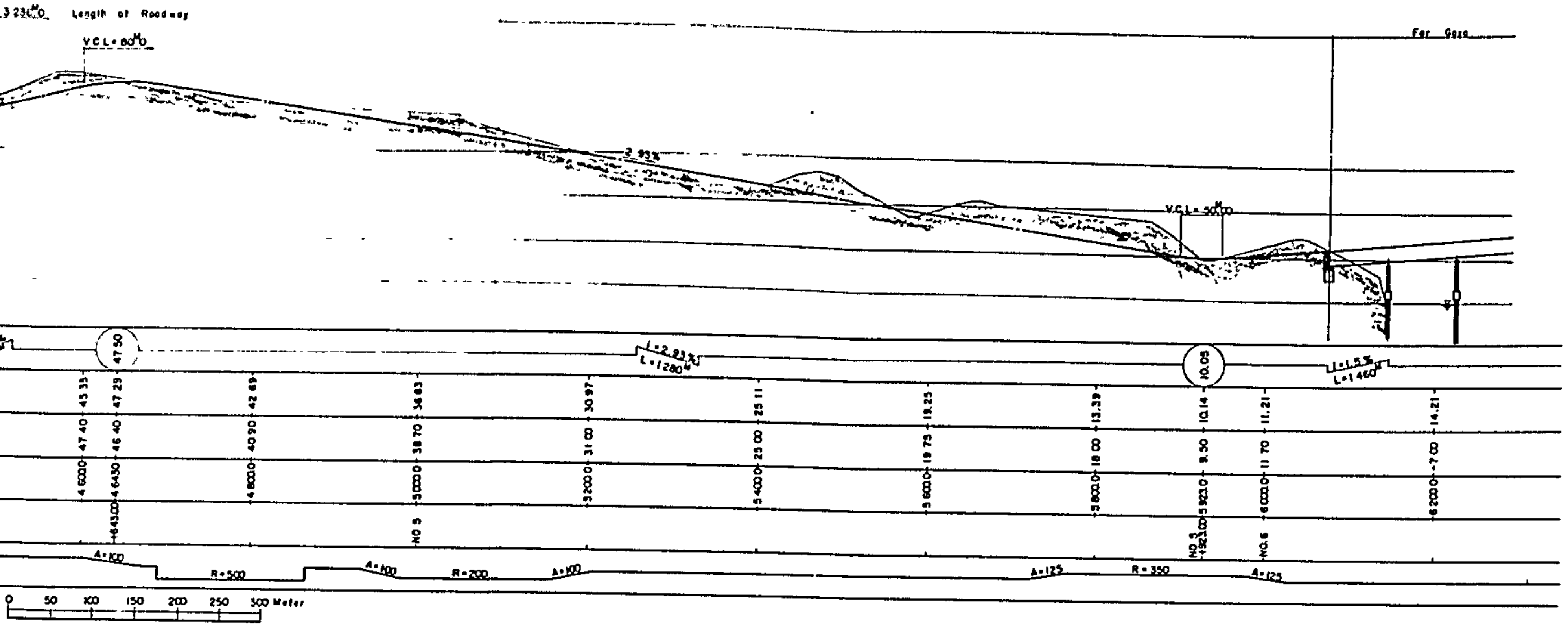
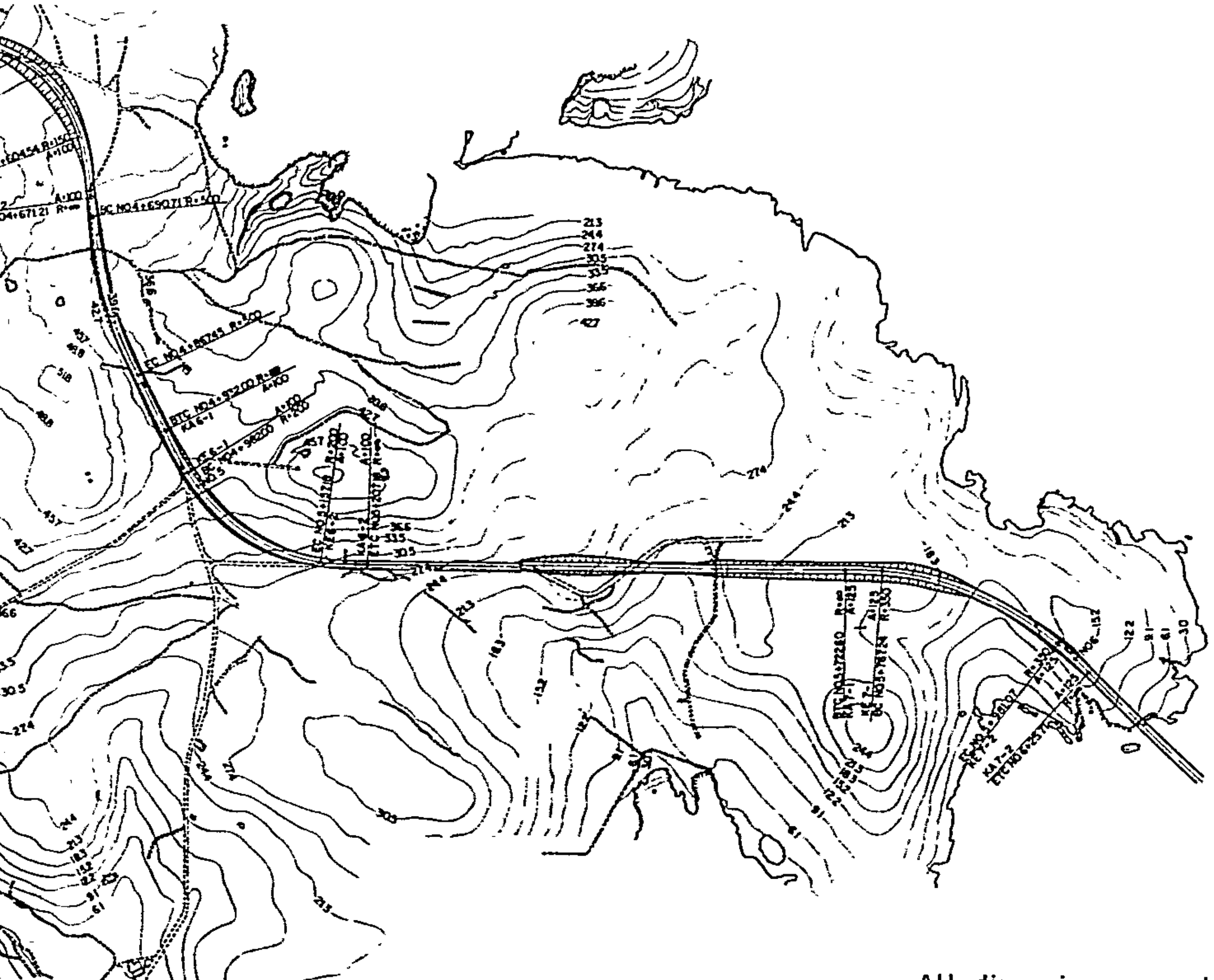

PROFILE
3 230.0 Length of Roadway
V.C.L = 80.0
V.C.L = 60.0
V.C.L = 30.0
2.0%
0.87%
5.0%
30.0
20.0
10.0
0.0
GRADE
i = 2.0%
L = 1 070
21.60
i = 0.87%
L = 1 050
30.75
i = 5.0%
L = 335
47.50
PROPOSIDE HEIGHT
GROUND HEIGHT
ACCUMULATIVE DISTANCE
STATION
NO 3
NO 4
NO 5
CURVE BAND
A = 100
R = 150
R = 1 200
R = 200
R = 500
PLAN
0 50 100 150 200 250 300 Meter
N
COMINO

Fig. 6-3





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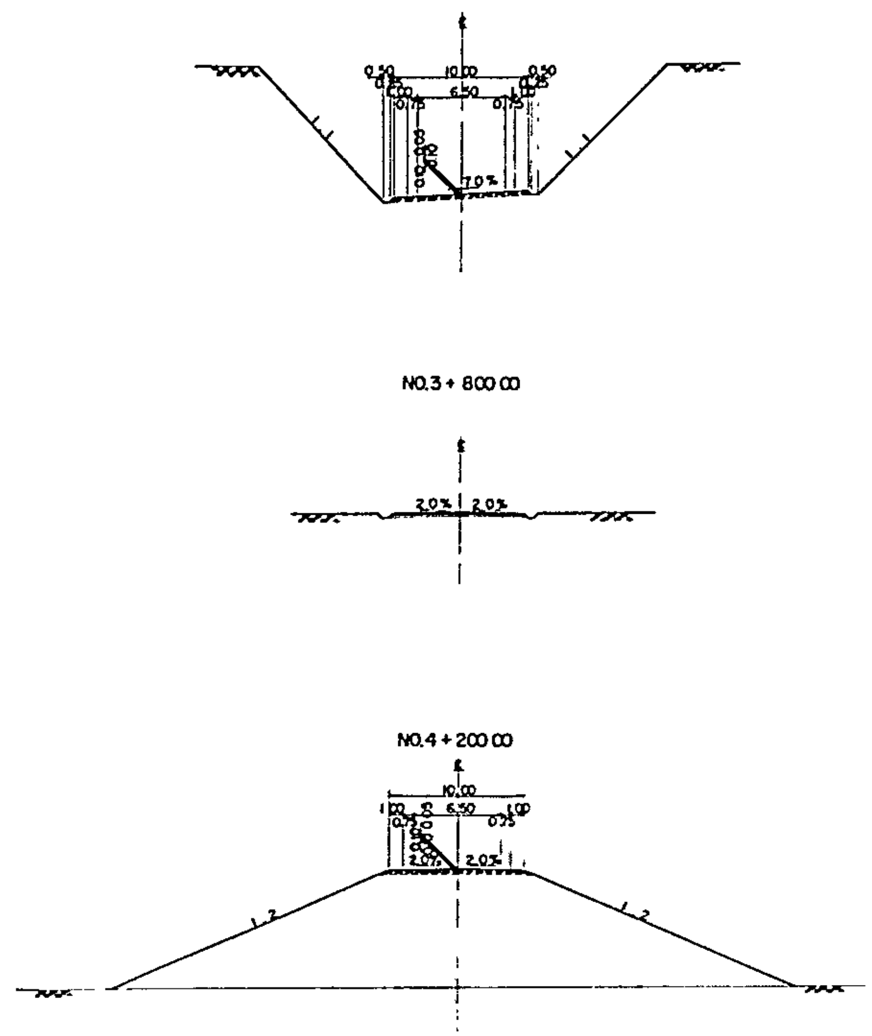
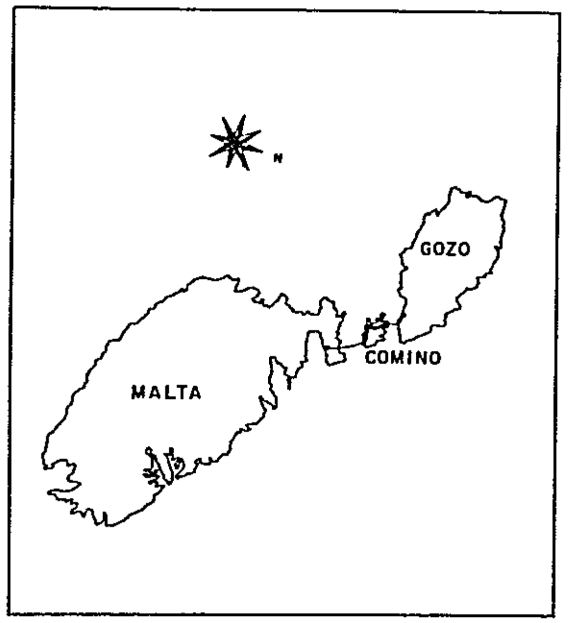
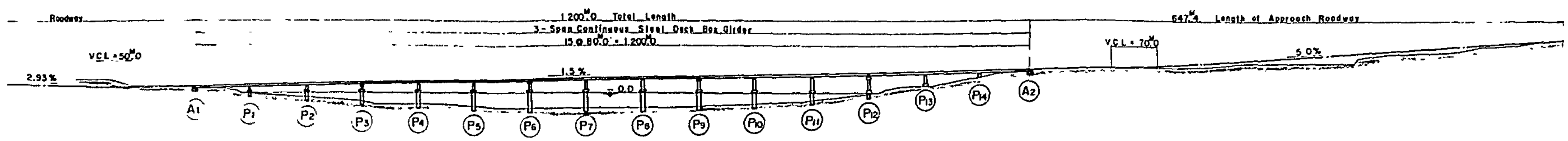




All dimensions are shown in m.

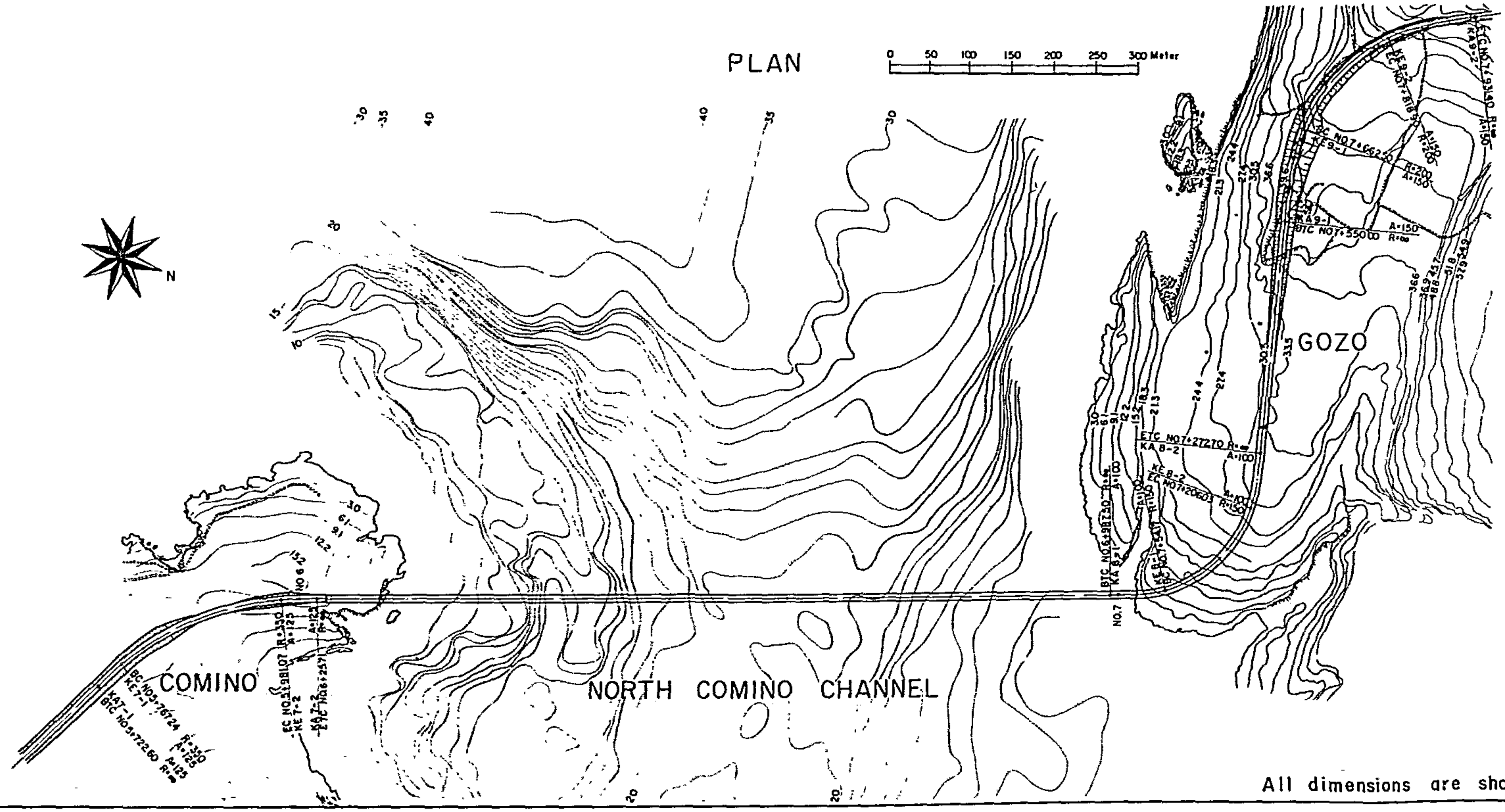
Fig. 6-3	LINK ROAD BETWEEN MALTA AND GOZO ISLANDS
	LINK ROAD IN COMINO

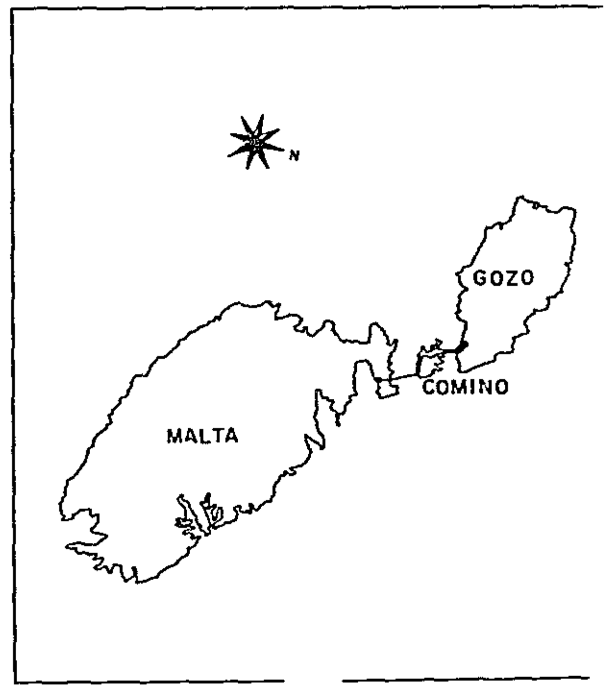
PROFILE



GRADE	i=2.93% L=1280 M	(10.03)					i=1.5% L=1460 M			(31.95)		i=5.0% L=568.4 M		(60.37)
PROPOSIDE HEIGHT	13.39	10.14	11.21	14.21	17.21	20.21	23.21	26.21	29.21	32.52	33.83	42.80	52.80	60.37
GROUND HEIGHT	18.00	9.50	11.70	-7.00	-15.60	-19.70	-15.80	-3.00	28.00	28.50	28.55	32.43	45.80	60.50
ACCUMULATIVE DISTANCE	5600.0	5923.0	6000.0	6200.0	6400.0	6600.0	6800.0	7000.0	7200.0	7383.0	7400.0	7600.0	7800.0	7951.40
STATION		NO.5 +923.00	NO 6					NO 7		NO.7 +383.00				
CURVE BAND	R=350		A=125					A=100	R=150 A=100			A=150	R=200	A=150

PLAN



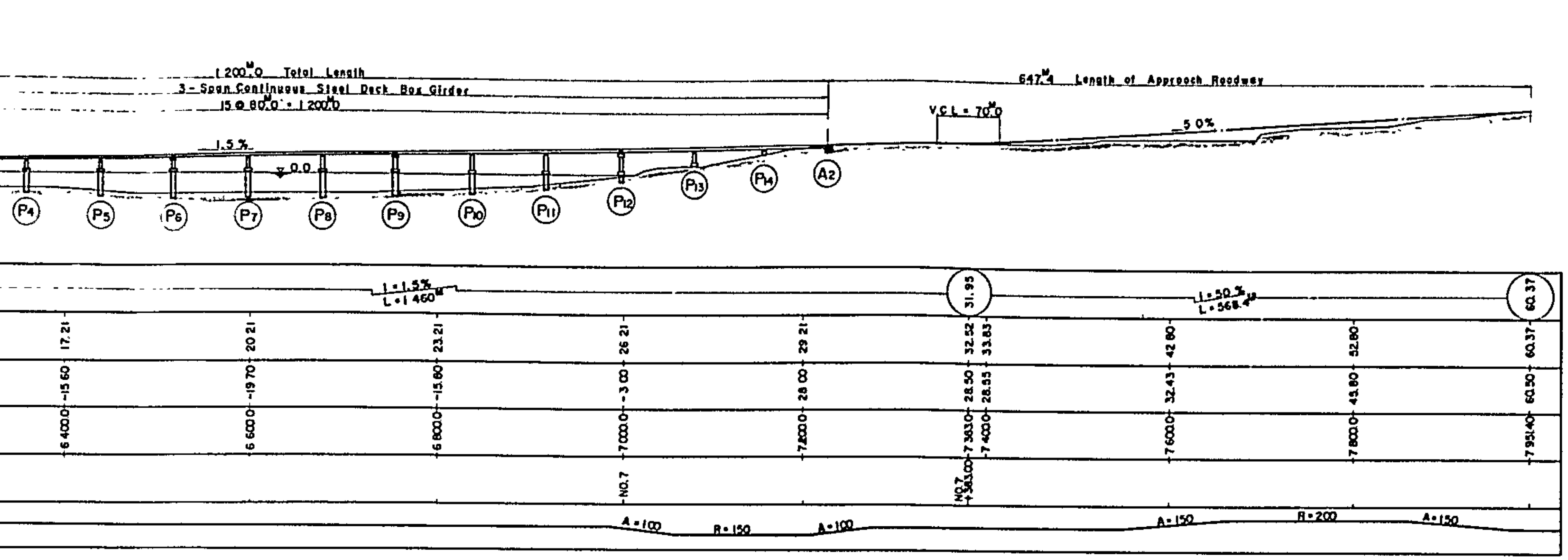


All dimensions are shown in m.

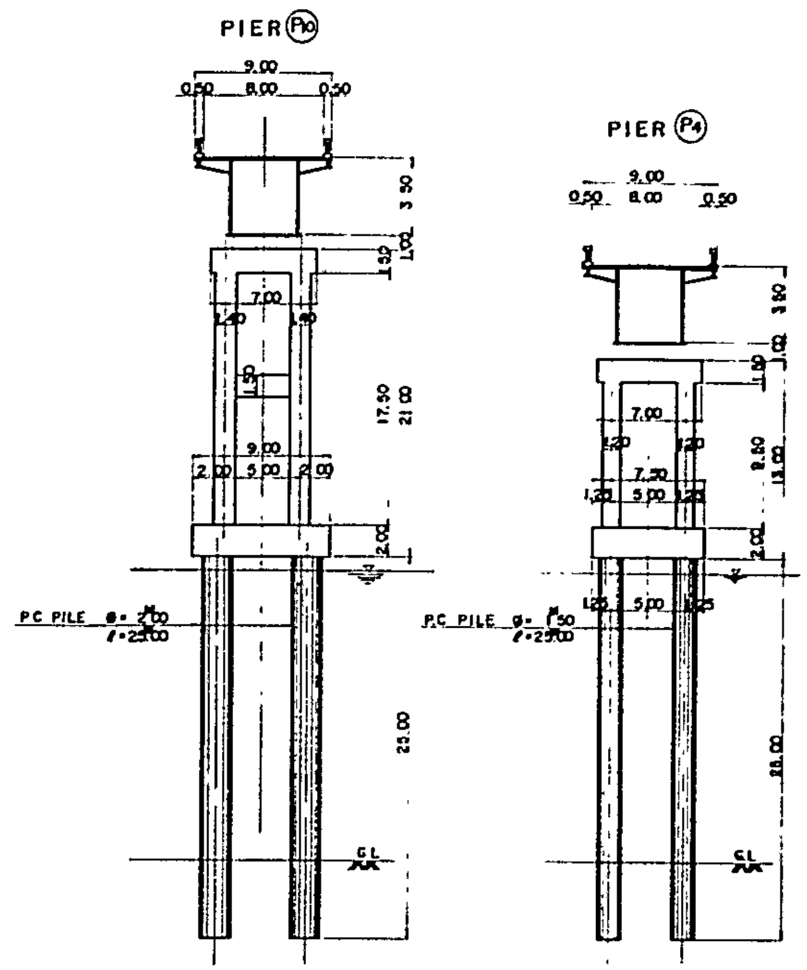
Fig. 6—4	LINK R…
	NO…

Fig. 6-4

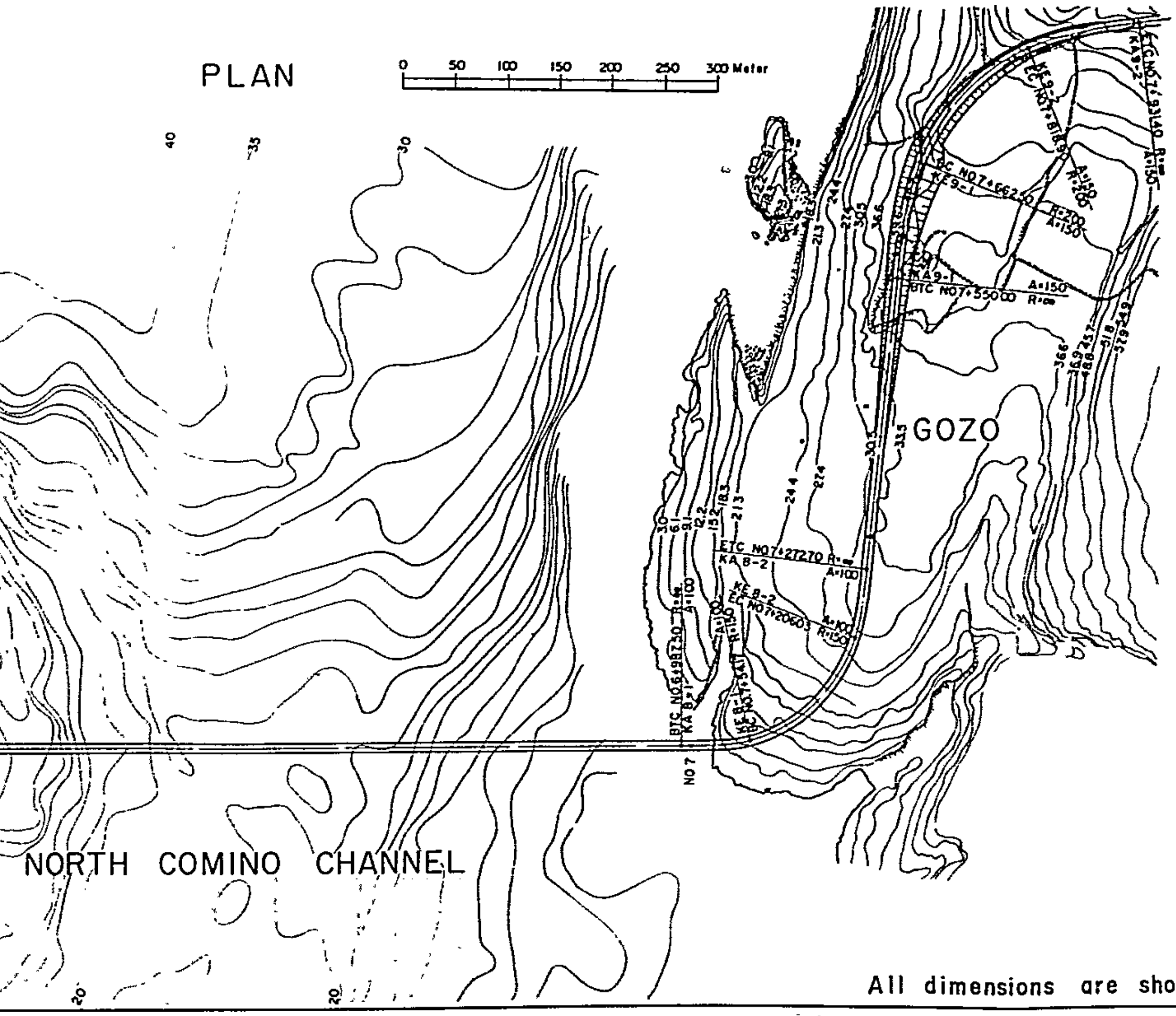
PROFILE

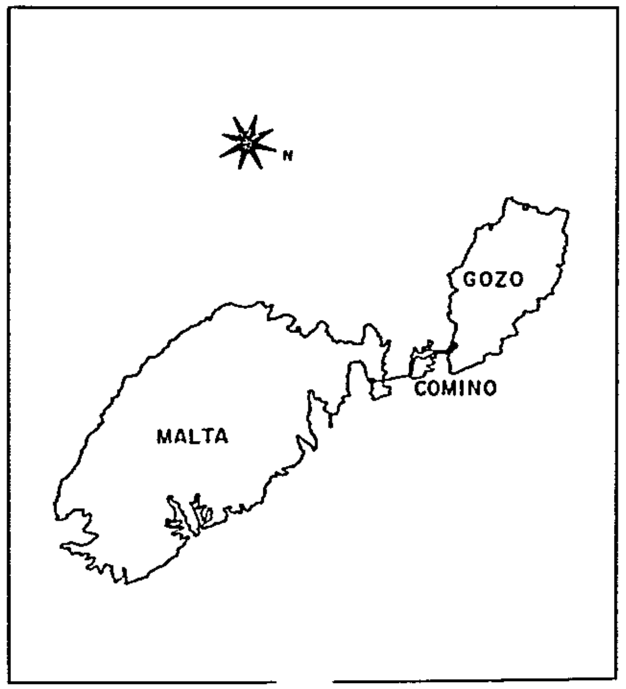


CROSS SECTION



PLAN





All dimensions are shown in m.

Fig. 6-4	LINK ROAD BETWEEN MALTA AND GOZO ISLANDS
	NORTH BRIDGE (COMINO - GOZO)

6.2.2 Structural Standards for Road

As per para. 1.1.1.

6.2.3 Location Plan

As already described in the outline, the roadway to be built newly will be run along the existing roads, and its rectilinear sections and curved sections will be combined according to the structural standards.

6.2.4 Profile Projection

All the existing roads are free of rivers, culverts, and other artificial structures to come across. Like the location plan, the grade patterns are determined for cuts and fills of earth to level off the roadway as far as possible and with due consideration given to the existing road conditions.

6.2.5 Cross Section

A typical cross section of the road is shown in Fig. 6-4 in which is given a two-lane road having an overall width of 6.5 m, a shoulder width of 1.75 m, a transverse grade of 1.5 per cent, a slope of cut of 1 : 1 and a slope of fill of 1 : 2, a superlayer for the traffic lane of 5 cm, an upper road bed of 10 cm, and a lower roadbed of 10 cm. The height of fill is less than 3 m as standard, and the fill materials are not alien ones, but surplus to be created by excavating the side ditches. In order to protect the road, the side ditches will be prepared 2 m apart from the farthest end of the side slope.

6.2.6 Earthwork Plan

While the existing roads are on the grade, the planned road will have side ditches and will be filled some 30 cm above the grade. Also on the cutting formation complete runoff ditch should be provided.

In the mountaneous regions, the grading may be controlled so as to balance the volume of earthworks required in order to make cuts and fills meet in the shortest haul of transport.

As the right of way belong to the public domain, any particular restraints are not imposed on the road construction.

It is desirable to keep the inclination of the side slope as moderate as possible, and slope protection will be satisfactory if its inclination is 1 : 1 for the cut part and 1 : 2 for the fill part and if protective planting is made.

For the earth-moving work, bulldozers, carryallscrapers, motorscrapers, tired rollers, graders, shovels, dump trucks, etc. will be economically combined for efficient work.

The volume of cuts and fills and the area of pavement are as listed below.

Table 6-1 LIST OF MATERIALS

	Road in Malta	Road in Comino	Road in Gozo
Cuts	24, 500 m^3	154, 900 m^3	6, 600 m^3
Fills	5, 700 m^3	42, 000 m^3	8, 200 m^3
Pavement	6, 620 m^2	25, 280 m^2	5, 800 m^2

6.3 Bridge Construction Plan

6.3.1 Introduction

The type, spanning and principal dimensions of this bridge were more elaborately designed so as to suit to the proposed site, these had been proposed on the preliminary survey report.

The navigation clearance in the channel, which is the most ruling factor in the construction of the bridge, has been determined to accommodate the request from the specialists of ports and harbours that the Comino Channels should provide ample height and width for the largest vessels which are supposed to navigate through this bridge.

As a consequence, the maximum height of the proposed bridge is set 40 m above the sea level.

The route which is taken up under the present plan is as shown in Fig. 6-1.3, which has been determined after closely examining the distances across the channels, navigational conditions, depth contours, the quality of the bottom stratun, subsea geology, approach to the existing roads, etc. The aggregate length of the route is as follows.

South Comino Channel	North Comino Channel
2, 040 m	1, 200 m

Since the piers are always endangered with the collision with vessels, they should be provided with adequate protections, but are discarded from the present discussion.

6.3.2 Channel Conditions

For the most part, the water depths are in the range of -20 m to -30 m. The seabed is composed of five different strata. Coralline limestone which is exposed over a wide area provides a good bearing foundation for the bridge piers. While north-east tidal current is prevailing in the North Comino Channel, south-west current is predominant in the South Comino Channel. The maximum velocity of both currents is in the range of 0.4 to 0.6 m/sec. (0.8 to 1.2 knots). The tide is of the semi-diurnal nature; high water and low water are developed twice every day, and the maximum tidal range is about 20 cm. Malta and its neighboring islands are favoured with the typical Mediterranean climate. Namely, it is hot and dry in the summer and mild and wet in the winter. In the May-August period, it is hard to see rainfalls. The rainy season there is from September to April, and the annual rainfalls are approximately 590 mm. The prevailing wind is a comfortable north-west breeze. Around vernal and autumnal equinox days, a strong wind blows in the north-western direction. In the summer, a south-west strong wind batters at the islands. According to the observations conducted at the Luga Airport, the average wind velocity over the ten years from 1958 to 1967 was more than 22 Knots (11.4 m/sec.). It is therefore inferred that the waves might have been about 4 m in height.

As regards the navigation clearance, the following are proposed by the experts of ports and harbours for accommodating the vessels using the South Comino Channel.

1) There are no vessels which use the Comino Channels, other than those plying in and out regularly or irregularly and yachts.

2) The largest vessels running on the Comino Channels are the following ferry-boats.

   The Jyland (27.4 m in height and 12.8 m in width)

   The Calypso (35.1 m in height and 152.4 m in width)

As a consequence, the minimum clearance has been set with reference to the Calypso.

6.3.3 Fundamentals for Design Considerations

1) Fundamentals for Bridge Construction Plan

Number of lanes : 2

Assuming that the traffic volume is 1,250 vehicles per hour per lane, 2,500 vehicles can be carried in an hour on the two lanes (1,250 vehicles/hr/lane).

2) Structural Standards for Road

As per para. 1.1.1.

3) Basic Requirements for Engineering and Construction Work

i) A waterway having a navigation clearance of some 35 m above the sea level and a width of 150 m will be provided in the South Comino Channel.

ii) The North Comino Channel will be closed to vessels.

iii) Structural engineering standards

The loads, structural specifications and materials used will be in accordance with relevant Japanese standards and regulations.

The principal loads and the strengths of principal materials are shown on Tables 6-2 and -3.

As regards the earthquakes, Mary Abela reported about 30 cases the Maltese islands had experienced since 1537. Also, Herbert P.T. Hyok stated in his paper, "Geology of the Maltese Islands," that some earthquakes caused disasters, but that fatal hazards were not caused yet.

Except the above two, we could not obtain any information about the degrees of earthquake damages or the magnitude of individual earthquakes. However, we have taken up the coefficient of horizontal seismic force of 0.1 for the structural design.

Table 6-2 PRINCIPAL LOADS

Principal loads	Dead load Live load Shock	TL-20 (uniform load, 350 kg/m^2) Concentrated load, 5,000 kg/m
Subordinate loads	Wind load Influence of temperature change	
Special loads	Construction loads Wave pressures Others	

For the calculation of the wind load, the average wind velocity of 22 knots observed at the Luga Airport over the 10-year period from 1958 to 1967 is employed.

1 knot = 1,852 m/hr/0.5144 m/sec.

0.5144 x 22 = 11.3 m/sec.

The wind pressure can be given by the following equation.

$$P = 1/2 \cdot \rho \cdot v^2 \cdot A \cdot C_D$$

Where, ρ : air density, 0.125 kg/sec^2/m^4

v : design wind velocity, 11.3 x 1.4 = 16 m/sec.

(Value, 1.4, is a horizontal length compensation factor)

C_D: drag coefficient, 1.6

A : effective area of projection to perpendicular, m^2

Hence, the wind pressure per m^2 becomes as follows.

$$P = 1/2 \times 0.125 \times 16^2 \times 1.6 = 25.6 \text{ kg/m}^2 = 30 \text{ kg/m}^2$$

Table 6-3 MATERIAL STRENGTHS

Concrete, compressive strength	σca = 70 kg/cm^2
Iron cord, tensile strength	σsa = 1,800 kg/cm^2
Steel, tensile strength	σsa = 2,800 kg/cm^2

Conditions for Construction Work

The commissioning is scheduled for the fiscal 1981, and the period of 5 to 6 months before commissioning is set out for the finishing work, and all the civil engineering work will have been completed until that time.

A way of Estimating the Construction Costs

Amount of work done and construction costs will be calculated for each of principal works (superstructure, abutments, piers and anchoring, etc.). The estimation will begin in the fiscal 1974, and will cover all the costs including those for surveys, detailed engineering, taxes and reserves.

6.3.4 Outline of the Considerations for the Selection of Route

1) South Comino Channel

It is natural that the route should be selected to minimize the construction cost. To make the shortest path between Malta and Gozo by making use of the existing trunk roads and to cross the shallowest waters are the answer so long as the economics is concerned.

With this in mind, three routes, A, B and C (see Figs. 6-5 and -6) are examined with reference to the structural specifications, navigation clearance and spanning proposed in the preliminary survey.

Route A which wades through the shallowest path is about 10 m below-below sea level up to some 800 m from Malta Island, and has some 700 m of section which ranges in depth from 20 to 26 m and for which work will involve much difficulty.

Route B and C measures some 1,000 m for this deep section or some 300 m longer than Route A, and will make the construction work difficult as much.

In the meantime, the design height and length of the bridge are just the same for the three routes on the Comino side, while on Malta side Route C is lower and shorter than any other as seen in the shore approach and profile grade. However, Route C requires a longer extension from the existing trunk road than Route A, and into the bargain is expected to involve difficulties in approaching because of poor alignment and overtax cut and fill work.

The three proposals are compared in Table 6-4; Route C requires steels and concrete less than any other, and Routes B and C have longer length of the piles for 26 m deep section which is considered to involve dangerous sea work.

Table 6-4 COMPARISON OF MATERIALS REQUIREMENTS BY ROUTE

	Steel	Concrete	Pile length	Aggregate road length
Route A	7,485	4,630 m^3	484 m	828 m
Route B	7,223	4,680 m^3	596 m	1,328 m
Route C	6,961	4,130 m^3	678 m	1,228 m

Fig. 6-5

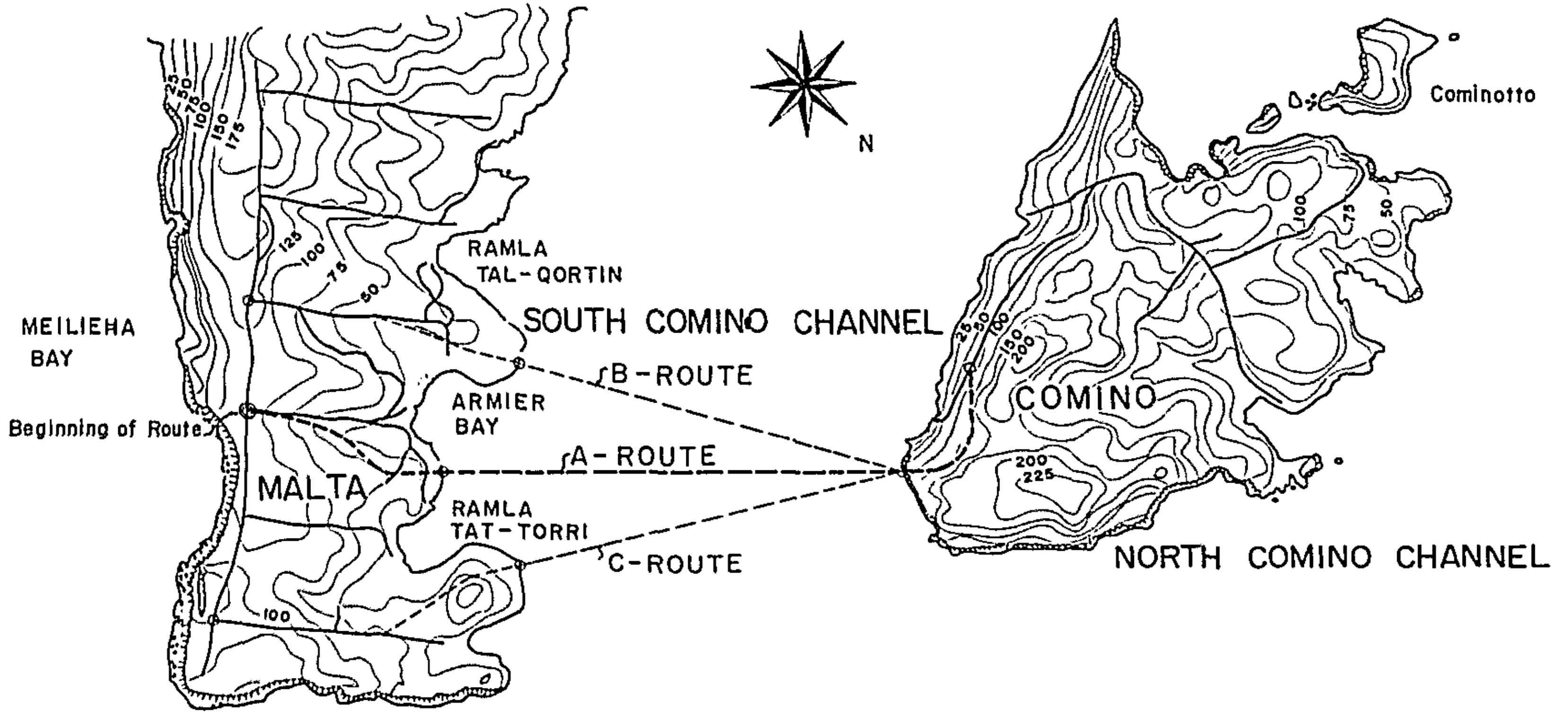


Fig. 6-5	LINK ROAD BETWEEN MALTA AND GOZO ISLANDS LOCATION MAP OF SOUTH BRIDGE

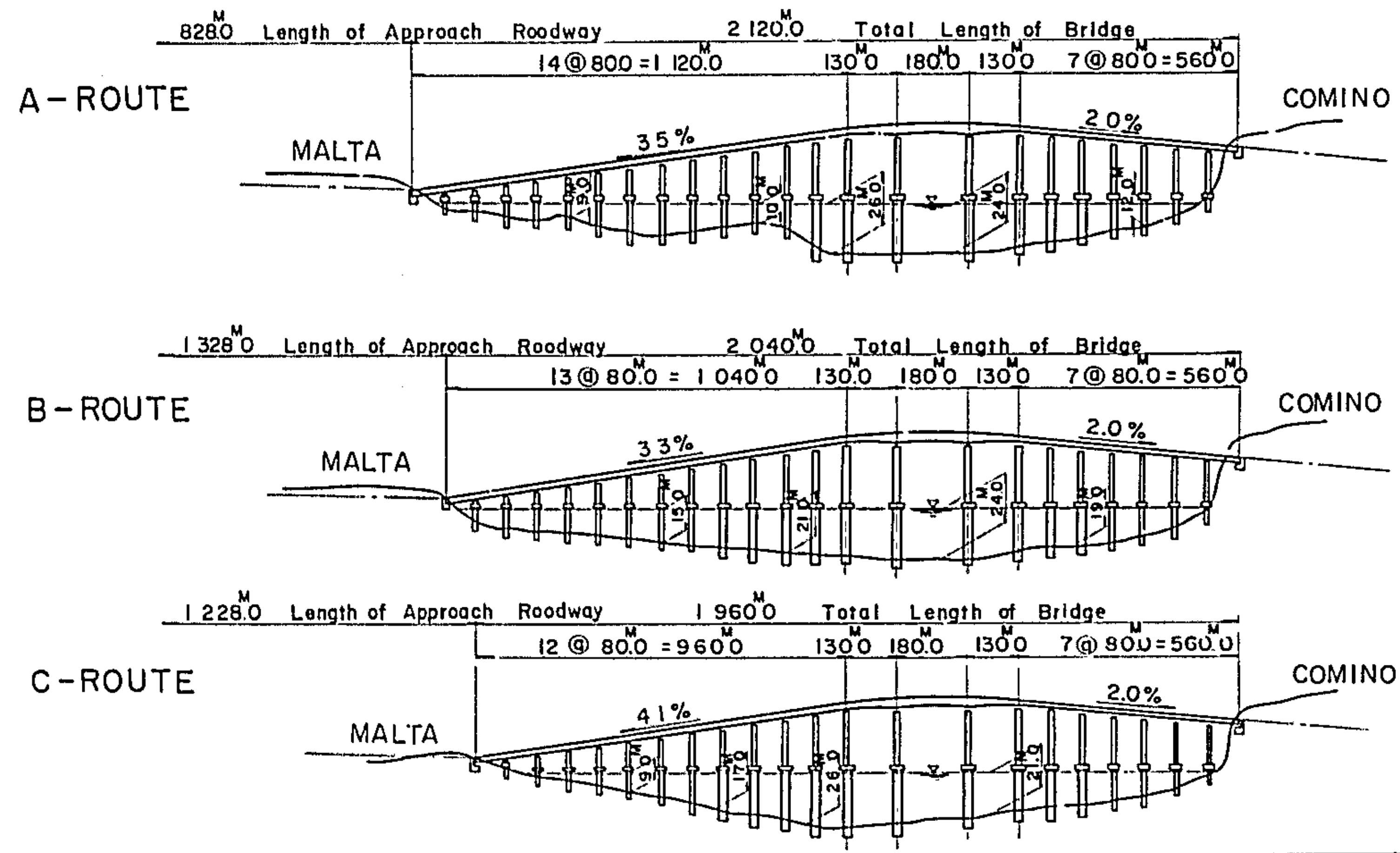


Fig. 6-6

Fig. 6-6 LINK ROAD BETWEEN MALTA AND GOZO ISLANDS

PROFILES OF A, B AND C - ROUTE

From the above data, the construction costs are roughly estimated as follows. The conclusion is that Route A is most economical. Route A is also likely to be better than any other from the viewpoint of connection with the existing road on the Malta side.

We have judged for Route A and have considered that Route A should cross the shallowest path according to the depth contour diagram obtained. The location of Route A is almost the same as given by the preliminary survey report.

Table 6-5 COST COMPARISON (in £M)

	Superstructure	Substructure	Road	Total
Route A	4,455,000 (33.41)	738,000 (5.54)	49,000 (0.37)	5,242,000 (39.32)
Route B	4,434,000 (33.27)	823,000 (6.17)	106,000 (0.80)	5,363,000 (40.26)
Route C	4,387,000 (32.90)	792,000 (5.94)	98,000 (0.74)	5,277,000 (39.58)

(Values parenthesized in 100 million yen)

Discussed in the ensuing paragraphs is Route A.

2) North Comino Channel

The route that can connect the Comino and Gozo in the shortest path in the shallowest waters without hindering the junction between the bridges and the planned roads on Comino is shown in Figs. 6-1 and -3.

If the alternative route is setted on the westward of the route the water depth grows, while another alternative on the eastward make the connection between the route and existing trunk road difficult. Accordingly, the comparison between the selected route and alternative routes is omitted.

6.3.5 Studies on the Type of Structure and the Section

1) Examination on Spanning

In the South Comino Channel, the central span should be longer than 150 m for the purpose of providing the vessels with their way of run. For this reason, the following structure is selected for the bridge.

The central part of the bridge structure is a 3-span steel deck type continuous box girder (spanning: 130 m - 180 m - 130 m), and the side parts are also of the same structure but spanned at an interval of 80 m.

The piers used are classified as to the depth of water as follows.

Depth of Water	Height of Pier	Anchoring Length
10 m	10 m	12 m
15 m	20 m	20 m
25 m	30 m	30 m

The estimates of the construction costs are compared in Fig. 6-7 with reference to the pier height and anchoring length vs. span length. For the water depths of 10 m and 15 m, the costs for the substructure are smaller than those for the superstructure, and the total costs are almost constant in the range of 60 m to 80 m in span.

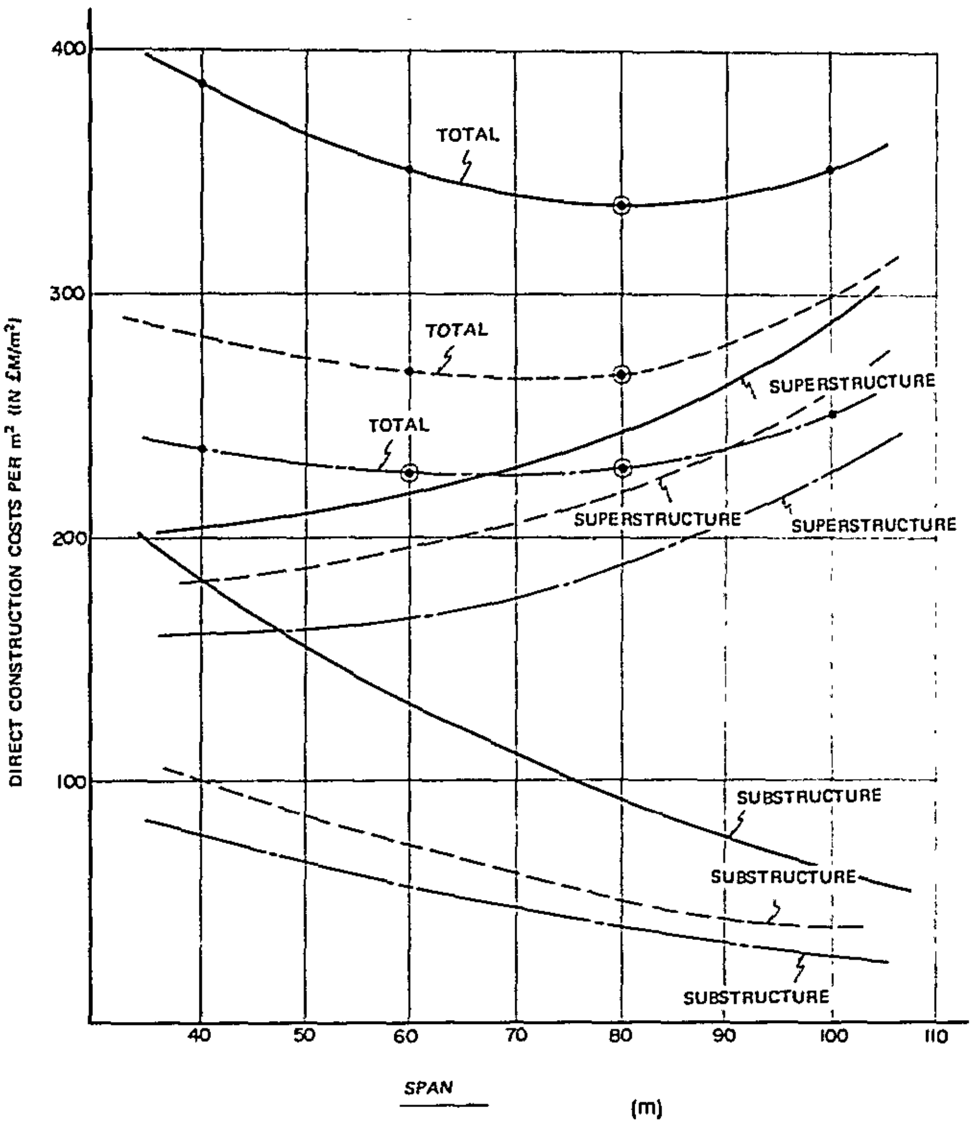
For a water depth of 25 m where the construction costs are expected largely affected, the costs for the substructure dwarf those for the superstructure, and in this case the economic span is 80 m.

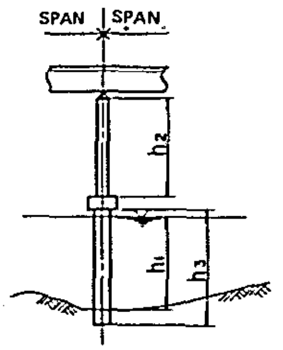
Considering that the water depth of 25 m and the resultant pier height of 30 m would serve as the principal determinants of construction costs, and that the subsea work be minimized, the side span is set at 80 m.

2) Type of Superstructure

In the projects including channel work, it is usually practised to make longer the span of the superstructure in order to minimize the work volume of substructures which are liable to be endangered by many unknown factors. In the present project, the span of the central section must be more than 150 m because of the necessity of keeping the necessary waterway for the vessels.

The side sections are selected to be of the continuous type in consideration of the construction convenience and roadability. Upon computation of the principal sections, the 3-span continuous box girder and truss are compared for the following cases with reference to materials and construction methods.

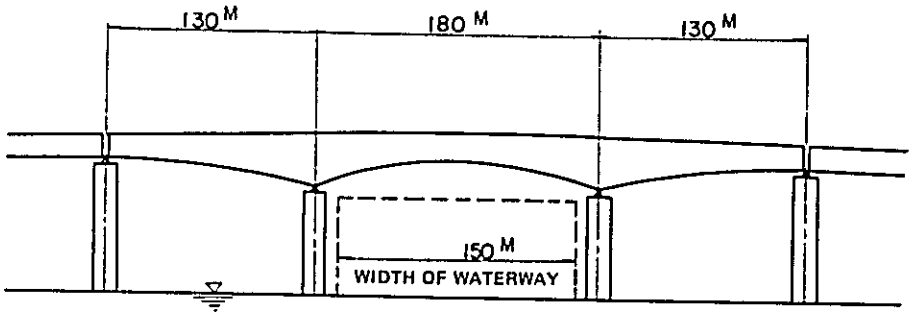




	Depth of Water (h1)	Height of Pier (h2)	Anchoring Length (h3)
— · —	10m	10m	1.5$^{\phi}$x 15m
- - - -	15m	20m	2.5$^{\phi}$x 20m
———	25m	30m	3.0$^{\phi}$x 30m

Fig. 6-7 COMPARISON OF CONSTRUCTION COSTS BY SPAN

CASE 1 CONTINUOUS STEEL BOX GIRDER (STEEL DECK FLOOR)



CENTRAL SPAN

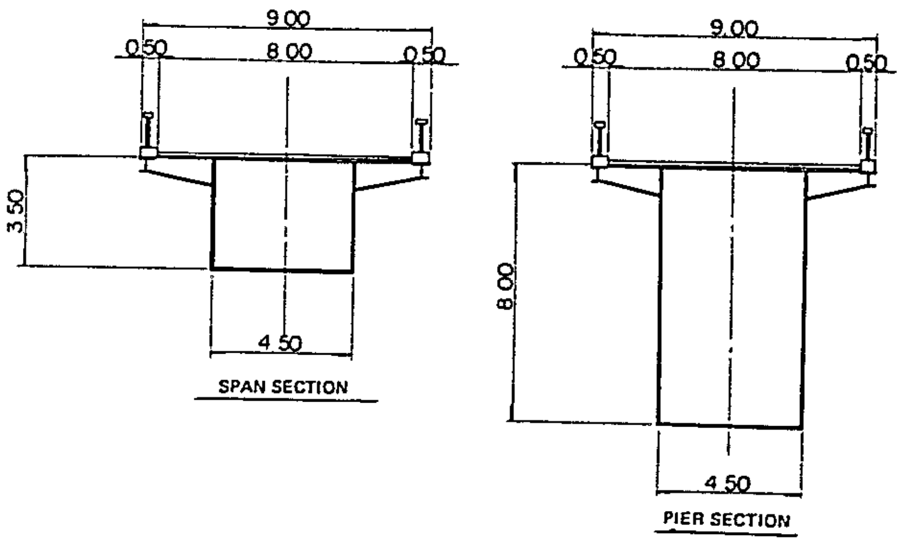
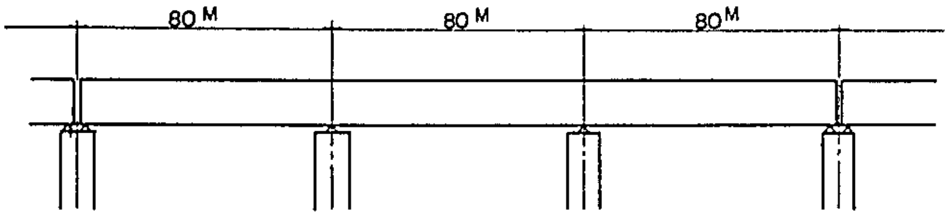


Fig. 6-8-(1) SECTION OF 3-SPAN CONTINUOUS STEEL DECK BOX GIRDER



SIDE SPAN

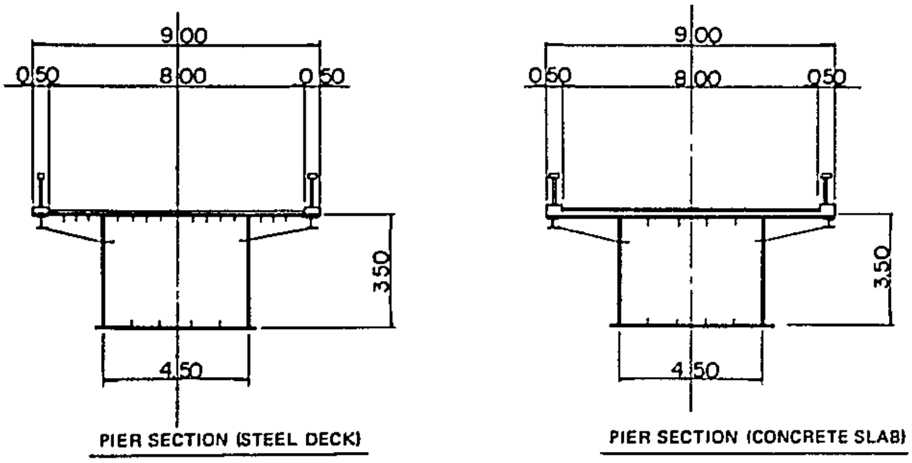


Fig. 6-8-(2) SECTION OF 3-SPAN CONTINUOUS STEEL DECK BOX GIRDER

CASE 2 CONTINUOUS TRUSS (CONCRETE SLAB)

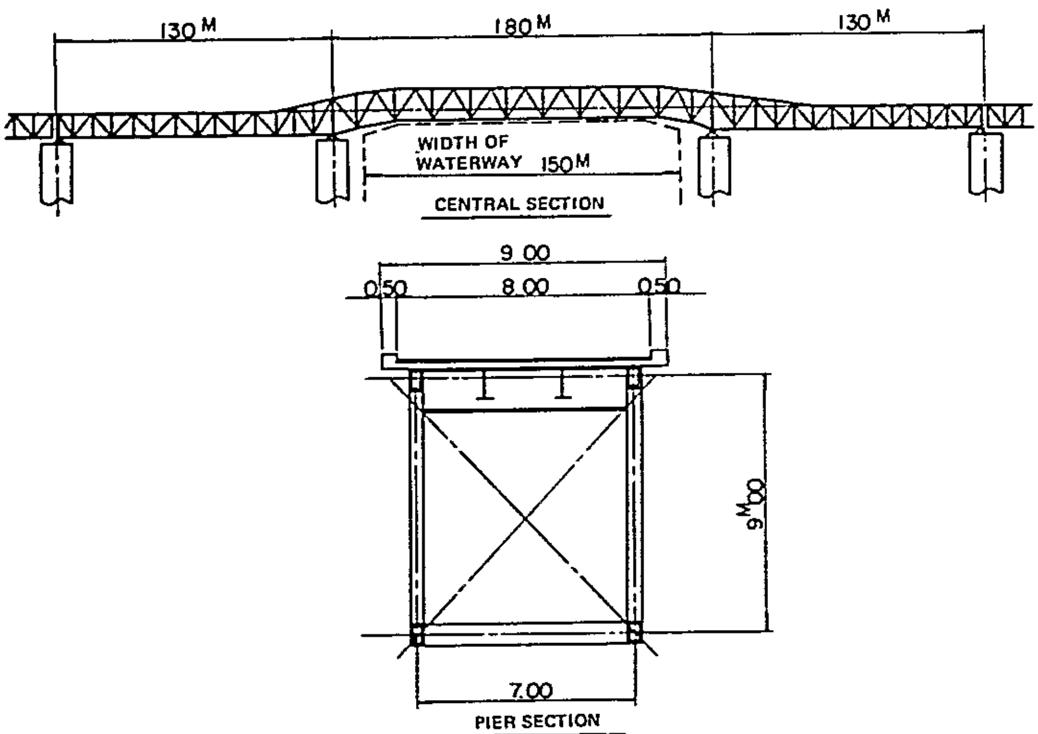
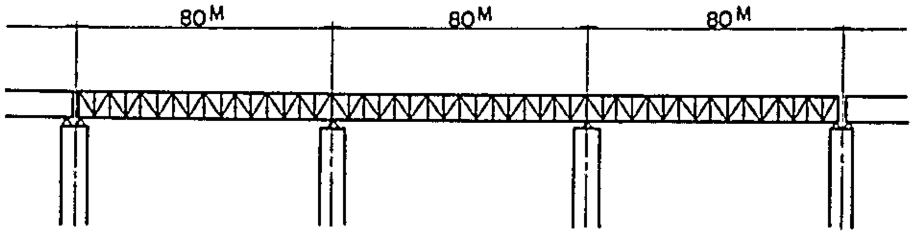


Fig. 6-9-(1) SECTIONAL VIEWS OF 3-SPAN CONTINUOUS TRUSS



SIDE SPAN

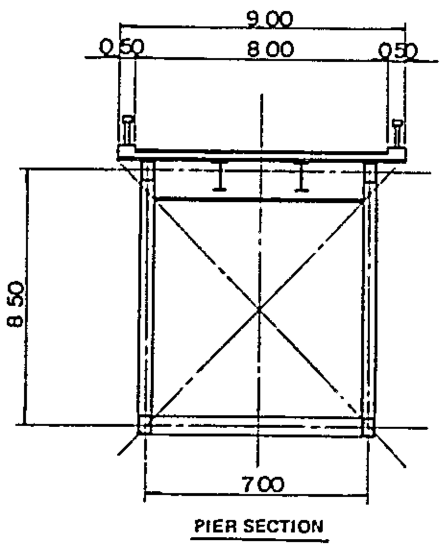
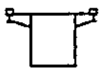


Fig. 6-9-(2) SECTIONAL VIEWS OF 3-SPAN CONTINUOUS TRUSS

Table 6-6

		Bending moment and axial force	Unit Stress	Section (cm)	Steel weight per m^2
Central Span Section	 Box girder steel deck plate	$M=23509.6^{tm}$	$\sigma c=1063\ kg/cm^2$ / $1200\ kg/cm^2$; $\sigma c=1858\ kg/cm^2$ / $2100\ kg/m^2$	1-U. Flg 900x2.6 2-Web. PL 800x2.8 1-L. Flg 480x1.6	560 kg/m^2
	 Truss concrete slab	$M=36054.9^{tm}$ $N=3004.6^{t}$	$\sigma t=2063\ kg/cm^2$ / $2100\ kg/cm^2$	1-PL 70 x 3.2 2-Web PL 80 x 2.4 1-PL 50 x 2.4	630 kg/m^2
			$\sigma c=1899\ kg/cm^2$ / $1900\ kg/cm^2$	1-R 70 x 3.2 2-Web PL 80 x 2.4 1-PL 50 x 2.8	
Side Span Section	 Box girder steel deck plate	$M=4873.7^{tm}$	$\sigma c=1135\ kg/cm^2 < 1200\ kg/cm^2$ $\sigma t=1995\ kg/cm^2 < 2100\ kg/cm^2$	1-U. Flg 480 x 2.4 2-Web. PL 350 x 1.4 1-L. Flg 480 x 1.0	380 kg/m^2
	 Concrete slab	$M=7140.9^{tm}$	$\sigma c=1860\ kg/cm^2 < 1900\ kg/cm^2$ $\sigma t=2060\ kg/cm^2 < 2100\ kg/cm^2$	1-U. Flg 480 x 2.0 2-Web. PL 350 x 1.4 1-L. Flg 480 x 1.7	395 kg/m^2
	 Truss concrete slab	$M=7315.6^{tm}$ $N=860.6^{t}$	$\sigma c=1830\ kg/cm^2 < 1900\ kg/cm^2$	1- PL 43 x 1.2 2-Web 50 x 1.0 1- PL 38 x 2.2	360 kg/m^2

As will be clear from Table 6-6, in the central span section, the box girder requires less steel than the truss alternative.

On the other hand, in the side span section, the situation is reversed. Also, the deck plate is better than the concrete slab. Although the above examination claims that the box girder be taken for the central span section and the truss structure for the side span sections, but in view of the construction practice the truss structure will unavoidably require the so-called staging method for all that the difficulties in installing stages at sea will add to the labourious work including transportation and handling of small members, production and machining, bolting and other miscellaneous labour-intensive jobs.

As regards the box girder, the use of the floating crane makes it possible to expedite transportation at sea and also to advantageously erect as-assembled large bridge blocks.

Since the truss structure is bound to use concrete slabs, molding work at sea, including timbering, concrete placing and separation of templates, will be very difficult.

For the above reasons, the 3-span continuous steel deck box girder has been considered for the present project.

3) Type of Substructure

It is needless to say that the assignment of the substructure is to communicate the loads of the superstructure to the foundation bedrock safely and uniformly.

Accordingly, the substructure should be one which can perfectly meet the bearing conditions presumed for the design of the superstructure. At the same time, it is required to withstand subsidence, waves and other external forces coming from the bedrock or variations and to ward them off the superstructure.

The coralline linestone forming the foundation of the proposed site is strong enough for the construction of bridge. For the substructure, therefore, the iron-reinforced concrete pier on precast prestressed concrete piles has been decided upon by taking into account the workability.

For the design of piers, the height of the pier is set at 10 m, 20 m and 30 m considering the following conditions. See Fig. 6-10.

(1) The upper beam is determined by taking into account the bearing conditions and workability of superstructure erection work.

(2) The loads acting upon the pier and pile include reaction of the superstructure, deadweight of pier, wind load, temperature effects and waves, and the section, but dimensions of them are determined with reference to axial force.

(3) The section is so designed as to be sturdy, especially against wave disturbances.

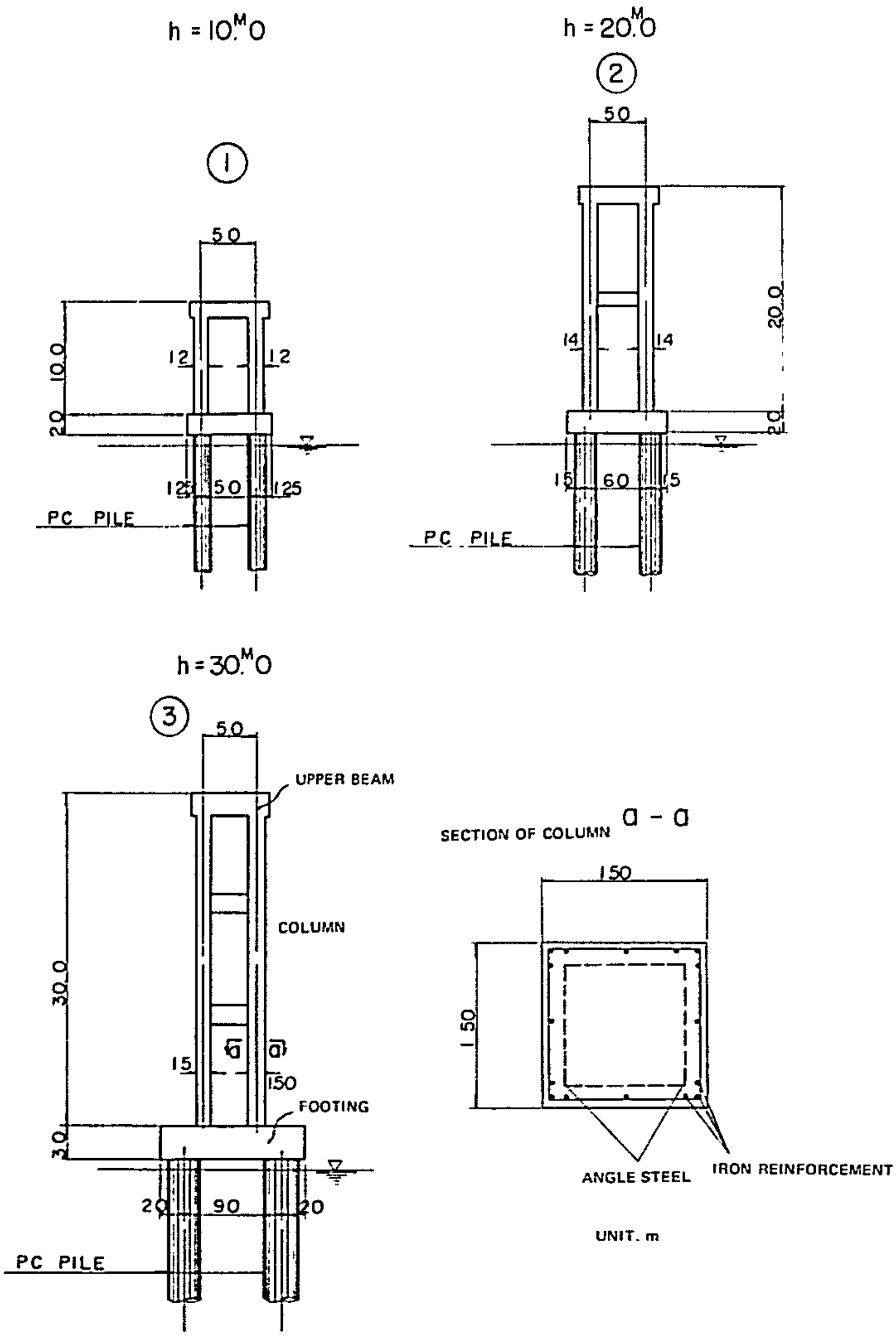


Fig. 6-10 SECTION OF PIER

6.3.6 Working Procedures and Construction Schedule

1) Working Conditions

Since the project involves sea works, practically all work including transportation of hands, materials and machinery, etc. cannot do without vessels. Besides, the work is susceptible to oceanographic conditions, and will possibly take extended time. In order to mitigate the sea work, a special construction port will be almost indispensable for accommodating a land construction yard and for harbouring construction vessels.

In the present project, therefore, a working base will be installed at Malta and Comino to prepare materials stock yards, plant facilities, prestressed concrete pile production yards, steel girder block assembling yards and accommodations for labourers.

2) Construction Procedures for the Substructure

The pier construction work is nothing but the subsea work, and unlike land work is accompanied by difficulties. It is therefore mandatory to elaborate on the working procedures and related conditions fully before entering upon the work. The most widely accepted method for the construction of the substructure is to erect the scaffolding first, to cut a ring-shaped hole by making use of a rotary cutter, and set precast prestressed concrete piles (Dia. : 1.5 m, 2.0 m or 3.0 m) in it, and then to place concrete into that cofferdam to form a pier. The next work is to place concrete on it and strangthen with iron reinforcements.

The resultant block is used as a timbering for the superstructure concrete placing.

3) Erection Method for the Superstructure

For the erection of the 3-span continuous steel deck box girder at sea, the following three methods are conceivable.

(1) Overhang construction by making use of erection truss
(2) Cantilever method using in combination a scaffolding
(3) Floating crane method for block erection

The method (1) is suitable at a place where the water depth is relatively small. But since the South Comino Channel is deep, the erection of the scaffolding is difficult.

In the method (2), a timbering is to be provided on the pier, and then one block of girder is erected on it. By making use of the girder block, an erection truss is then installed to sequentially sling and erect small girder blocks which are carried to the bridge site by deck barges. Erection of timbering and volumes of sea work because of divided blocks are demerits of this method.

In the method (3), large blocks of girder are lifted by means of floating cranes and towed by means of a tugboat *to the bridge site and directly assembled.*

Since the method (3) can reduce the sea work largely compared to other methods, it has been selected for the erection work. The erection work by this method is illustrated in Fig. 6-12. The erection is carried out in the numerical order, beginning from (1). *Unit block to be handled by this method* weighs some 230 tons and measures 90 m in length, and can be handled by a 250 ton crane boat.

The dimensions of the crane boat is shown below.

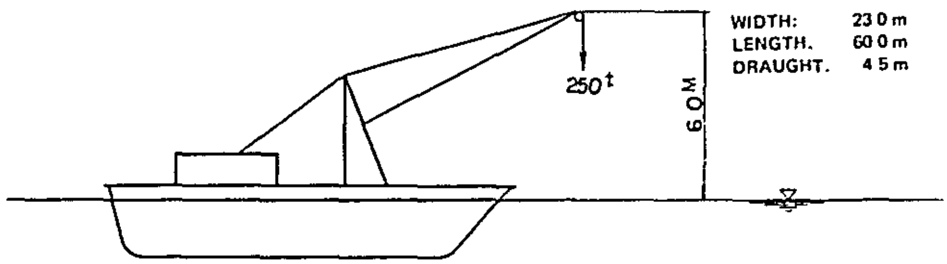


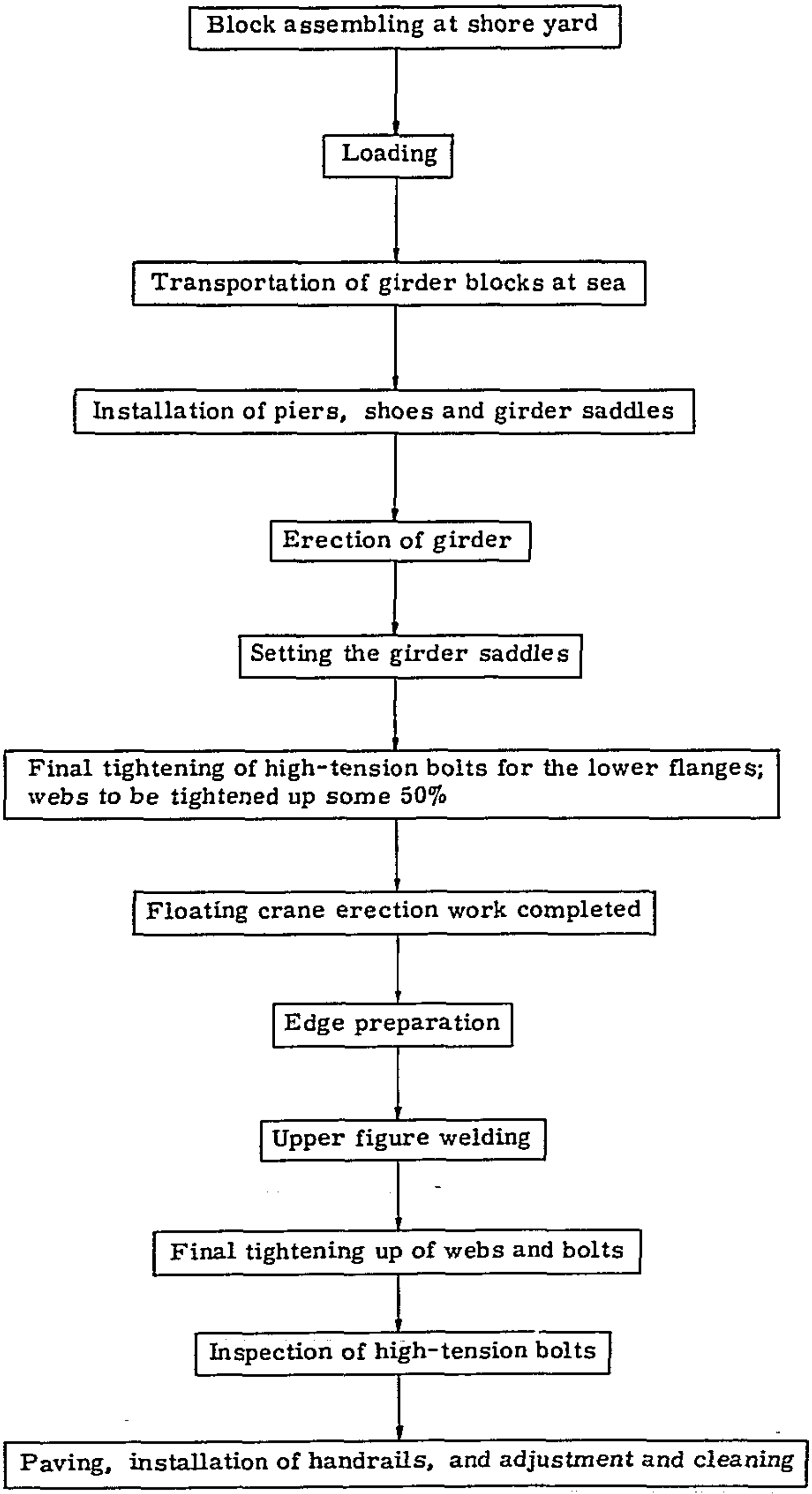
Fig. 6-11 250 - TON CRANE BOAT

Since the central section is spanned 130 m, 180 m and 130 m, bents will *be used supplementarily.*

Construction Schedules

For the route and type of bridge and *its construction method* determined as above, the direct construction schedules will be as set forth in Figs. 6-13 and -14. Namely, the South Bridge will take some 5 years, and the North Bridge some 4 years.

The erection sequence is as follows.



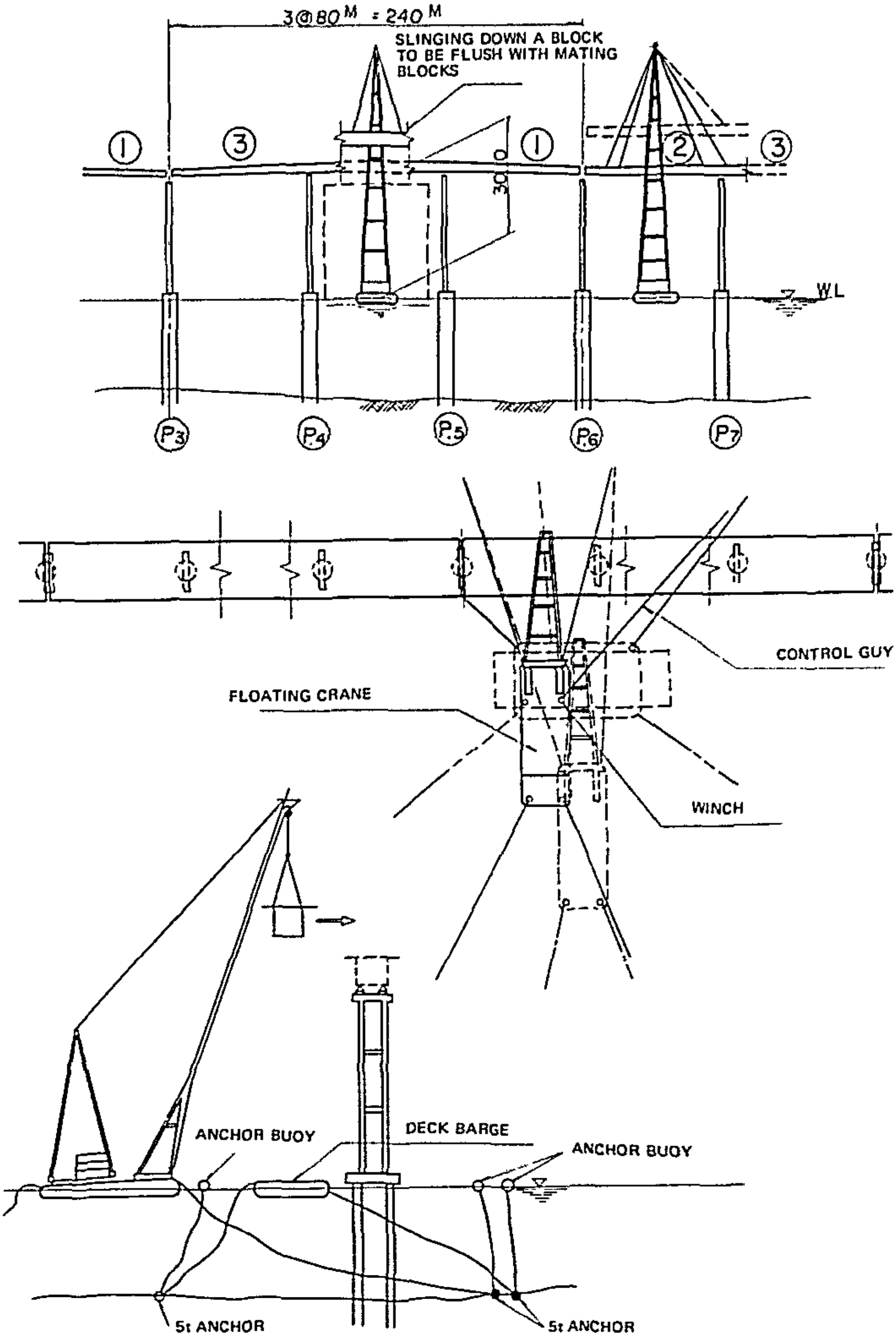


Fig. 6-12 ILLUSTRATION OF ERECTION METHOD

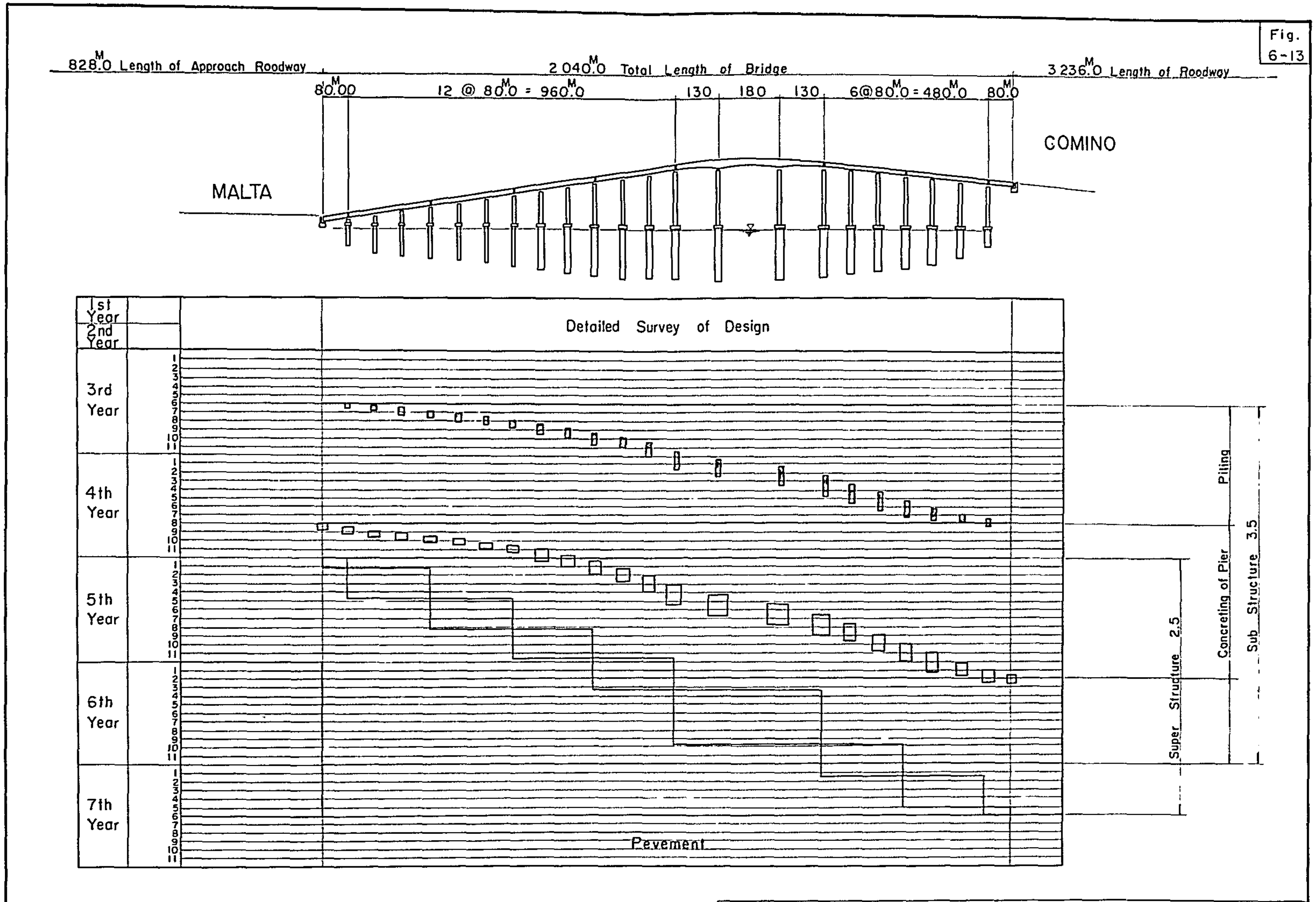


Fig. 6-13

LINK ROAD BETWEEN MALTA AND GOZO ISLANDS

WORK SCHEDULE OF SOUTH BRIDGE

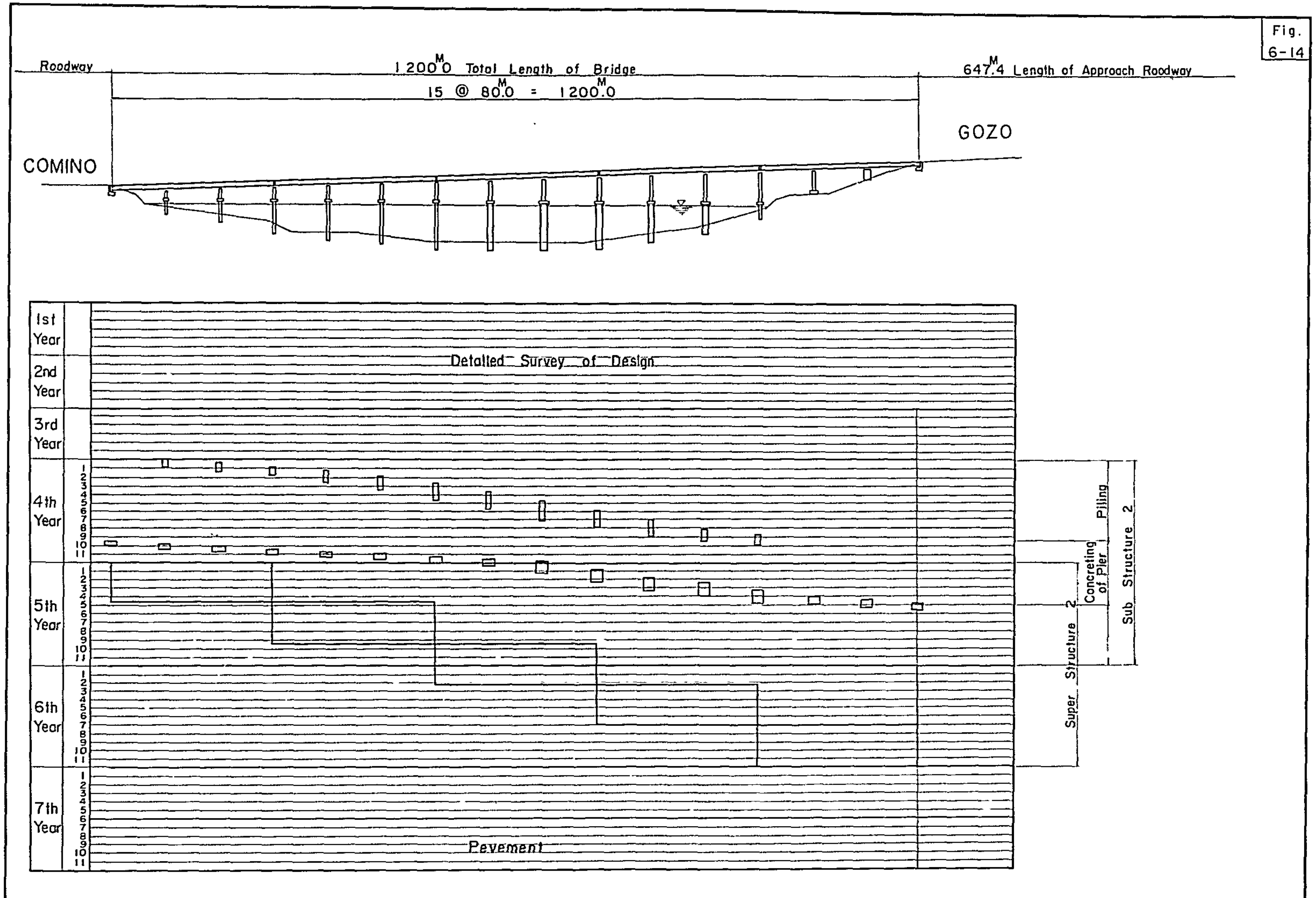


Fig. 6-14	LINK ROAD BETWEEN MALTA AND GOZO ISLANDS
	WORK SCHEDULE OF NORTH BRIDGE

6.4 Construction Costs

6.4.1 Construction Schedules

This project aiming at the connection of Malta and Gozo with a link road consists mainly of subsea civil engineering work which is very difficult compared to the land work, and its plans and working schedules should be made up by fully taking into account endemic climate conditions.

The direct construction work will take some 5 years, in addition to come 2 years to be allowed for the preparations such as geological survey, location and topographic surveys, detailed design, etc.

The work schedule is as shown below.

Table 6-7 Work Schedule

	1st year	2nd year	3rd year	4th year	5th year	6th year	7th year
Geological survey, field survey, detailed design and other preparations							
Malta approach road							Paving
Malta-Comino bridge				Substructure	Superstructure		Paving
Comino road							Paving
Comino-Gozo bridge				Substructure	Superstructure		Paving
Gozo approach road							Paving

6.4.2 Total Construction Costs

Table 6-8 TOTAL CONSTRUCTION COSTS 1₤M = ¥750 (in ¥100 million)

Item	Domestic funds	Foreign funds	Total	Remarks
A. Bridge construction	396,000 (2.97)	7,086,700 (53.15)	7,482,700 (56.12)	Design life: 50 years
B. Road construction	354,700 (2.66)	-	354,700 (2.66)	10 years
C. Sub total	750,700 (5.63)	7,086,700 (53.15)	7,837,400 (58.78)	
D. Detailed design, survey, etc.	-	235,100 (1.76)	235,100 (1.76)	C x 3%
E. Taxes	-	548,600 (4.10)	548,600 (4.10)	C x 7%
F. Reserves	150,100 (1.13)	1,417,300	1,567,400 (11.76)	C x 20%
Total	900,800 (6.76)	9,287,700 (69.64)	10,188,500 (76.40)	C + D + E + F

Operating and maintenance costs (domestic funds)

(0.41 million yen/year) 54,700₤M/year

Bridge construction costs: 5,612,000 thousand yen/3,180 x 8.0 = 220 thousand yen/m^2

3) Construction Costs by Section

The direct construction costs for the roads and bridges are as follows.

(1) Roads

Table 6-9 (1) THE DIRECT CONSTRUCTION COSTS FOR ROADS (₤M)

Section	Length	Unit Cost	Amount
Malta	828 m	60 ₤M/m (45,000 yen/m)	49,700 (37,300 thousand yen)
Comino	3,160 m	83 ₤M/m (62,200 yen/m)	262,300 (196,700 thousand yen)
Gozo	726 m	59 ₤M/m (44,100 yen/m)	42,700 (32,000 thousand yen)
Total	4,714 m		354,700 (266,000 thousand yen)

(Values parenthesized in yen)

(2) South Bridge

Table 6-9 (2) DIRECT CONSTRUCTION COSTS FOR SOUTH BRIDGE

(ŁM)

	Q'ty	Unit Cost	Amount
Superstructure: Steel	7,485 tons	595 ŁM/ton (446 thousand yen/ton)	4,455,000 (¥3.341 thousand mil.)
Substructure: Concrete	4,634.8m^3	95 ŁM/m^3 (71,200 yen/m^3)	440,000 (¥0.330 thousand mil.)
Foundation: PC pile	926.2 m	338 ŁM/m (263,700 yen/m)	313,000 (¥0.235 thousand mil.)
Total			5,208,000 (¥ 3,906 thousand mil.)

(Values parenthesized in yen)

(3) *North Bridge*

Table 6-9 DIRECT CONSTRUCTION COSTS FOR NORTH BRIDGE

(ŁM)

	Q'ty	Unit Cost	Amount
Superstructure: Steel	3,950 tons	512 ŁM/ton (384 thousand yen/ton)	2,024,000 (¥1.518 thousand mil.)
Substructure: Concrete	1,730 m^3	97 ŁM/m^3 (72,800 yen/m^3)	168,000 (¥0.126 thousand mil.)
Foundation: PC pile	462 m	179 ŁM/m (134,000 yen/m)	82,700 (¥0.062 thousand mil.)
Total			2,274,700 (¥1.706 thousand mil.)

(Values parenthesized in yen)

6.5 Problems Left for Future Study

6.5.1 Collection of Problems

Problems so far raised consequent upon the examination of the Malta-Comino-Gozo link road project are summarized below.

1) Interconnection with Existing Roads

The interconnection between the projected link road and the existing roads in Malta and Gozo should be coordinated with the future plan for Malta. In Comino, the link road is projected to run along the existing road, but its construction may have to be carried out in stages while using the existing roads.

2) Construction Schedule

In the present project, the bridge construction work is given priority over others. The inception of the road construction work for Malta, Comino and Gozo should be well coordinated with the bridge construction plan in order to fully exploit the existing roads.

3) Influence of the Piers on Navigation

Studies should be made on the degree of hazards of the marine piers on the navigation, definite methods of navigation control, protection of marine structures, etc.

4) Studies on the Environmental Effects

The proposed site is one of the most important resorts for Malta. Impacts of the construction of link road in the channels on the environment should be forecast, accordingly.

5) Safety Measures for the Construction Work

The project involves a variety of jobs at high places and at sea, and efforts should be made for technical and safety measures.

6.5.2 Structures

The structures are designed in accordance with the design standards now practiced in Japan and in consideration of the final survey findings including climatology, tidal conditions, waves, etc. The section of the substructure is designed to meet the bearing requirements of the superstructure.

As regards the earthquake, the coefficient of seismic horizontal force is set at Kh = 0.1, and the wind load is calculated with the design wind velocity at 30 m/sec.

6.5.3 Matters Concerning the Erection Work

The construction of a bridge having a maximum water depth of 26 m and a design height of 40 m above sea level is technically feasible. The South Comino Channel, however, is broad, and the work involved is all but marine one. It is therefore needed to provide safe scaffoldings stable against winds and waves.

CHAPTER 7

PLAN FOR RECONSTITUION AND AMPLIFICATION OF MARINE TRANSPORTATION FACILITIES

CHAPTER VII PLAN FOR RECONSTITUTION AND AMPLIFICATION OF MARINE TRANSPORTATION FACILITIES

7.1 Outline

The interisland traffic demand expected in fugure may be met to some extent by the efficient operation of the existing ferries, but when it will be beginning to exceed the ferry capacity, it could be borne by other traffic means such as motor vehicles running on the link rod bridge, etc.

With this in mind, the present chapter deals with the improved operations of the existing ferries for the time schedules, transportation capacity, yearly overhead costs, yearly operation costs and the number of berths required to meet the transportation demand, port and harbour construction costs and yearly expenditures of ports and harbours.

Also, the time schedules, transportation capacity and operation costs are determined in order to carry by the existing ferries the future traffic volume estimated in Chapt. V, and the number of berths and yearly operation costs for the scheduled operations are calculated.

The costs and expenditures determined in this way are used in Chap. VIII "Appraisal of the Project" in order to assess the economic feasibility of the present project. The results of computation and analysis in this chapter based on the data acquired in Malta reveal as in Table 7-3 that it is possible to convey 433 thousand vehicles a year if the existing three bottoms of ferry are plied 10 to 11 times a day.

As the originating traffic volume in 2010 is expected to be 298 thousand vehicles/year, the existing line-up of the ferries seems to afford the future traffic demand so far as they can be operated fully and efficiently.

7.2 Ferries

7.2.1 Improved Operation of the Existing Ferries

1) Transportation Capacity Per Bottom

As already set forth in Chap. V, the ferryboats now serving between Malta and Gozo are Minor Eagle (367 tons), Jylland (823 tons) and Calypso Land (1,960 tons).

With their gross tonnages regarded as 400 tons, 800 tons and 2,000 tons respectively, the transportation capacity per bottom is estimated in Table 7-1. Assuming that the overall length, longitudinal allowance and side allowance of a vehicle are 4.7 m, 0.30 m and 0.50 m, respectively, the space required by each vehicle is 12.0 m^2. If the load factor is set at 50 per cent, the average transportation capacity will be as indicated in Table 7-1.

Table 7-1 TRANSPORTATION CAPACITY PER BOTTOM

Item \ Type	Unit	400-ton	800-ton	2,000-ton
Deck space	m^2	300	500	900
Number of accommodated vehicles (12.0 m^2/car)	Vehicles	25	41	74
Average transportation capacity (load factor: 50%)	Vehicles	12	20	37

2) Ferry Services

The ferries now are plying 5 to 7 roundtrip a day. The available number of roundtrips and transportation capacity required to cover up the foreseeable increase in the traffic demand are calculated on condition that the existing three ferries are operated to the fullest extent.

The observations aboard the Calypso Land and pollings were collected and studied. The findings are: the journey between Malta and Gozo over a distance of some 3.2 sea miles (6 km) requires some 25 min. (incl. berthing and deberthing times), and the roll-in work requires guiding and chocking, consuming more time than the roll-off work.

According to these findings, it is assumed that the standard number of vehicles to be rolled in a minute is 5 while the standard number of vehicles to be rolled off is 10 per minute.

The passengers as a load of a ferry will be traded off in much less a time than the vehicles, and the time required for a single roundtrip is considered to be governed by the roll-in time of vehicles.

The service hours of the ferryboats are dependent on season, and the longest now practised is from 6:15 a.m. to 8:45 p.m. as shown in Table 5-1.

For the computation of the ferry services, the service hours are set to be 6:00 a.m. to 8:00 p.m. for the future. The possible numbers of daily roundtrips for the ferries are calculated and listed in Table 7-2 "Ferry Services."

Table 7-2 FERRY SERVICES

Item \ Type	Unit	400-ton	800-ton	2,000-ton
Distance	Sea miles (km)	3.2 (6)	3.2 (6)	3.2 (6)
Speed	KT	8	11	13
Trip time	min.	23	18	15
Turnround time	min.	15	18	24
Roll-in (5 vehicles/min.)	min.	3	5	9
Roll-off (10 vehicles/min.)	min.	2	3	5
Berthing and deberthing	min.	10	10	10
Roundtrip time	min.	76	72	78
Service hours: 6:00 to 20:00	hrs.	14	14	14
Number of roundtrips/ship. day	roundtrips/ship. day	11	11	10

3) Transportation Capacity

From Table 7-1 "Transportation capacity per bottom" and Table 7-2 "Ferry Services" and on the assumption that the ferry can be put in business for 300 days a year, the transportation capacity available will be as shown in Table 7-3 "Transportation capacity available by ferries."

Namely, it is readily found that the transportation of 433 thousand vehicles a year can be achieved only by the existing three ferries if they are operated fully.

Table 7-3 TRANSPORTATION CAPACITY AVAILABLE BY FERRIES

Item \ Type / Unit		400-ton	800-ton	2,000-ton	Total
Daily average	Vehicles	264	440	740	1,444
Peak day max.	Vehicles	528	880	1,480	2,888
Yearly average (300 days)	Thousand vehicles/year	79	132	222	433

4) Overhead Costs for Ferry Operation

i) *Ship costs (on a yearly basis)*

In Malta, there are no new ferries purchased recently. For this reason, the purchase data of the past are referenced in order to evaluate the ship costs for the ferries. The results are as listed in Table 7-4 "Yearly ship costs for ferries."

Table 7-4 YEARLY SHIP COSTS FOR FERRIES

Item \ Type / Unit		400-ton	800-ton	2,000-ton	Remarks
Construction cost	1,000 ₤M	200	400	1,000	500₤M/ton
Depreciation in 16 years	₤M	11,250	22,500	56,250	By straight line depreciation with salvave value at 10%
Interest rate, (8.0%)	₤M	8,800	17,600	44,000	Average value=55%of construction cost
Tax (1.4%)	₤M	770	1,540	3,850	Assessed value: half the average value
Insurance	₤M	1,500	3,000	7,500	0.75% of construction cost
Repair cost	₤M	5,000	10,000	25,000	2.5% of construction cost
Yearly overhead cost	₤M/year	27,320	54,640	136,600	Total yearly overhead cost for three ferries: 218,560

ii) Operating Costs

The aggregate yearly running mileage calculated from Table 7-2 and the data on the wages for seamen in Malta are used to calculate the operating costs for the ferries.

The results are given in Table 7-5.

Table 7-5 OPERATING COSTS FOR FERRIES

Item \ Type	Unit	400-ton	800-ton	2,000-ton	Total	Remarks
Fuel Cost	₤M	5,070	9,500	14,400	28,970	
Fuel consumption rate	lit/km	8	15	25	-	
Yearly haul	km	39,600	39,600	36,000	115,200	300 working days a year
Yearly fuel	kl	317	594	900	1,811	
Oil and greases	₤M	400	870	1,300	2,570	
Consumption rate	lit/km	0.05	0.11	0.18	-	
Yearly consumption	lit.	1,980	4,356	6,480	12,816	For the same hauls referred to fuel cost
Personnel Expenditures	₤M	13,860	20,790	20,790	55,440	
Crew	Persons	14	21	21	56	
Yearly operating cost	₤M/year	19,330	31,160	36,490	86,980	

7.2.2 Port and Harbour Facilities Indispensable for the Efficient Operation of the Existing Ferries

1) Number of Berths Required

i) Number of Berths Required

The berth availability time is calculated with the average utilization factor set at 60% for the 14 service hours from 6:00 am to 8:00 pm. Then, the results are combined with the time of occupancy per turnround in order to calculate the number of turnrounds for which the berths are available a day. Thus, the ratio of the daily maximum number of roundtrips to the number of turnrounds for which berths are available a day results in the number of berths required.

The number of berths required is calculated in the way above, and the results are shown on Table 7-6 "Number of berths required for ferries."

Table 7-6 NUMBER OF BERTHS REQUIRED FOR FERRIES

Items \ Type	Unit	400-ton	800-ton	2,000-ton	Remarks
Berth availability time	hours	8.4	8.4	8.4	Average utility factor: 60%; 14 hours served a day
Time of occupancy per turnround	min.	15	18	24	
Daily number of turnrounds for which berths are available	turn-rounds	33	28	21	
Daily maximum number of roundtrip	round-trips	11	11	10	
Number of berths required	berths	0.33	0.39	0.48	Daily maximum number of roundtrips/ number of turnrounds for which berths are available a day
Number of vehicles transported a year	thousand vehicles ./year	79	132	222	

ii) Yearly Number of Vehicles Transported vs. Number of Berths Required

As is clear from Table 7-6, only a single berth will do if only one out of three ferries is used. Even for any set of two out of three ferries, one berth is sufficient for the purposes. When three ferries are used at the same time, the required number of berths is 2.

Table 7-7 YEARLY TRANSPORTATION VS. NUMBER OF BERTHS REQUIRED

Item \ Type / Unit		400-ton	400-ton + 800-ton	400-ton + 800-ton + 2,000-ton
Vehicle transportation	thousand vehicles/year	79	211	433
Number of berths required	berth	1	1	2

2) Construction Costs

Marine facilities are now under construction in Mgarr Harbour of Gozo. The costs for them are presented in the Report by Messrs. Coode & partners, titled "GOZO-MGARR HARBOUR PROPOSED REMODELLING," and are used as a basis for the construction of a harbour in Malta, the scale of which is almost the same as that of Mgarr.

The construction costs estimated for Malta are given in Table 7-8.

Table 7-8 CONSTRUCTION COSTS FOR MARINE FACILITIES (£M)

Works involved \ Estimate	Higher Estimate	Lower Estimate
Reclamation and embankment	318,000	133,000
Breakwater	1,229,000	525,000
Reclamation	178,000	146,000
Quay (2 berths)	130,000	95,000
Others	203,000	102,000
Total	2,058,000	1,001,000

3) Yearly Costs for Port and Harbour Facilities

The yearly costs for the port and harbour facilities are calculated in two cases; one with breakwaters and the other without. The results are shown in Table 7-9.

Table 7-9 YEARLY COSTS FOR PORT AND HARBOUR FACILITIES (ŁM)

Item \ Estimate	Higher Estimate	Lower Estimate	Remarks
Reclamation costs	43,150	24,270	
Interests (8.0% per annum)	39,680	22,320	
Tax (1.4%)	3,470	1,950	Value assessable = Acquired value x 1/2
Depreciation costs	26,020	12,300	By straight-line depreciation with salvage value set at 10%
Quay (30 years)	3,900	2,850	
Breakwater (50 years)	22,120	9,450	
Interests	59,800	27,280	8.0%; average value, 55%
Quay	5,720	4,180	
Breakwater	54,080	23,100	
Taxes	10,460	4,770	1.4%, average value
Quay	1,000	730	
Breakwater	9,460	4,040	
Maintenance and repair costs	13,590	6,200	1% of construction cost
Quay	1,300	950	
Breakwater	12,290	5,250	
Others	40,600	20,400	Depreciation in 5 years
Total	193,620	95,220	
Case without breakwaters	71,420	42,680	"Others" prorated with construction cost

4) Total Cost

The ship costs, operating costs, port and harbour costs and yearly costs for the port and harbour facilities per compiled in Table 7-10.

Table 7-10 TOTAL COST

Item \ Type / Unit	Unit	400-ton	800-ton	2,000-ton	Total
Yearly ship costs	₤M/year	27,320	54,640	136,600	218,560
Yearly operating costs	₤M/year	19,330	31,160	36,490	86,980
Port and harbour construction costs	₤M	Higher Estimate		Lower Estimate	
		2,058,000		1,001,000	
Yearly costs for the port and harbour facilities w/breakwaters	₤M/year	193,620		95,220	
ditto, but w/o breakwaters	₤M /year	71,420		42,680	

7.2.3 Operating Costs for the Future Traffic Demand

Here are estimated the yearly operating costs for the ferries to carry the accrual traffic volume in the future which has been estimated in Chap. V.

As already discussed, the future traffic demand can be fully met by amplifying the services of the existing three ferries. For this reason, the services are set to satisfy the traffic volumes of the years 1980, 1955 and 2010, and the corresponding yearly operating costs are also estimated as shown in Tables 7-11, -12 and -13.

Table 7-11 YEARLY OPERATING COSTS FOR FERRY SERVICES TO MEET THE FUTURE TRAFFIC DEMAND (Traffic Volume for 1980: 130 Thousand Vehicles/Year)

Item \ Type	Unit	400-ton	800-ton	2,000-ton	Total	Remarks
Average transportation (Load factor: 50%)	Vehicles	12	20	37		
Haul	Km	6	6	6		One-way
Number of round-trips per ferry per day	Round-trips/ day, ferry	4	3	3	10	
Yearly average transportation capacity (300 days)	Thousand vehicles/ year	28	36	66	130	Estimated at 130 thousand vehicles/year
Fuel costs	£M	1, 840	2, 590	4, 320	8, 750	
Fuel consumption cost	l/km	8	15	25		
Yearly total haul	Km	14, 400	10, 800	10, 800		300 working days a year
Yearly total fuel requirement	Kl	115	162	270		
Costs for oils and greases	£M	140	240	390	770	
Consumption rate	l/Km	0.05	0.11	0.18		
Yearly total requirement	lit.	720	1, 188	1, 944		
Personnel costs	£M	13, 860	20, 790	20, 790	55, 440	
Crew	persons	14	21	21		
Yearly operating cost	£M/year	15, 840	23, 620	25, 500	64, 960	

Table 7-12 YEARLY OPERATING COSTS FOR FERRY SERVICES TO MEET THE FUTURE TRAFFIC DEMAND (Traffic Volume for 1995: 213 Thousand Vehicles/Year)

Item	Unit \ Type	400-ton	800-ton	2,000-ton	Total	Remarks
Average transportation (Load factor: 50%)	Vehicles	12	20	37		
Haul	Km	6	6	6		One-way
Number of round-trips per ferry per day	Round-trips/day, ferry	6	6	5	17	
Yearly average transportation capacity (300 days)	Thousand vehicles/year	43	72	111	226	Estimated at 213 thousand vehicles/year
Fuel costs	£M	2,760	5,180	7,200	15,140	
Fuel consumption cost	l/Km	8	15	25		
Yearly total haul	Km	21,600	21,600	18,000		300 working days a year
Yearly total fuel requirement	Kl	173	324	450		
Costs for oils and greases	£M	220	480	650	1,350	
Consumption rate	l/Km	0.05	0.11	0.18		
Yearly total requirement	lit.	1,080	2,376	3,240		
Personnel costs	£M	13,860	20,790	20,790	55,440	
Crew	persons	14	21	21		
Yearly operating costs	£M/year	16,840	26,450	28,640	71,930	

Table 7-13 YEARLY OPERATING COSTS FOR THE FERRY SERVICES TO MEET THE FUTURE TRAFFIC DEMAND (Traffic Volume for 2010: 298 Thousand Vehicles/year)

Item \ Type	Unit	400-ton	800-ton	2,000-ton	Total	Remarks
Average transportation (Load factor: 50%)	Vehicles	12	20	37		
Haul	Km	6	6	6		One-way
Number of round-trips per ferry per day	Round-trips/day. ferry	9	9	7	25	
Yearly average transportation capacity (300 days)	Thousand vehicles/ year	64	108	155	327	Estimated at 298 thousand vehicles/year
Fuel costs	₤M	4, 150	7, 780	10, 080	22, 010	
Fuel consumption cost	1/Km	8	15	25		
Yearly total haul	Km	32, 400	32, 400	25, 200		300 working days a year
Yearly total fuel requirement	Kl	259	486	630		
Costs for oils and greases	₤M	320	710	910	1, 940	
Consumption rate	1/Km	0.05	0.11	0.18		
Yearly total requirement	lit.	1, 620	3, 564	4, 536		
Personnel costs	₤M	13, 860	20, 790	20, 790	55, 440	
Crew	persons	14	21	21		
Yearly operating cost	₤M/year	18, 330	29, 280	31, 780	79, 390	

CHAPTER 8

APPRAISAL OF THE PROJECT

CHAPTER VIII APPRAISAL OF THE PROJECT

8.1 Benefits

8.1.1 Kinds of Benefits

The construction of a bridge will bring about benefits and advantages to Malta. Among other things, the nine items listed in Fig. 8-1, "Probable Benefits," are most beneficial. These are crudely divided into two (A and B below) as to the future traffic volume (originating traffic volume + generated traffic volume).

A) Costs and expenditures for the operation of ferries, boats and other vessels and ancillary facilities which can be superseded by the construction of a bridge.

B) Saving of transit time for passengers, drivers and cargoes and increased life of vehicles, both accruing from the construction of a bridge.

In the developing countries, where the productivity of labour is very low, the time benefits are often neglected, but in Malta which has made a rapid progress to send up the labour value, time is really money.

Item A can be subdivided into the following five.

A.1) Construction costs for new ferries which would become necessary to absorb the future increase in traffic volume.
As already discussed in para. 5.1, "Status quo in traffic," the transport by ferries between Malta and Gozo has been increasingly preponderating in recent years. Should the traffic volume exceed the ferry capacity in future, additional ferries would be required. If however there is bridge, such investment might be appropriated for other purposes.

A.2) Costs for expansion of the berths and wharves necessary for the traffic volume expected to increase in future.
As described in para. 7.2, the port and harbour facilities now available for the existing ferries are as follows.
In Gozo, the construction of a new rubble-mound type breakwater and a dolphin quay is under way in Mgarr Port. They would be enough for the time being to cope with traffic demand. Available in Malta, however, is only a vertical dolphin quay. In fact, there is not so much as a breakwater. Although Marfa Point serves as a natural breakwater to some extent, it has provided itself of little use as the ferry operation is sometimes compelled to anchor for some 10 days a month in the cold season. In the Mainland Malta, the port and harbour facilities are so meagre at present, and should be fortified with adequate quays and breakwaters to see the traffic volume

increasing year after year.
If however a bridge is available, these additional investments are saved, and can be appropriated for other purposes.

A.3) Maintenance and other overhead costs for ferries
If a bridge is available, the ferries are not required to serve between Malta and Gozo, dispensing with their maintenance and other overhead costs.

A.4) Maintenance and other overhead costs for small vessels
The vessels other than ferries which now are engaged in the transport between Malta and Gozo are quite unknown to us as to their scope of services. So far as we know, there are three 40-ton vessels and three 30-ton vessels turning round once a day between Malta and Gozo. For this reason, the maintenance and other overhead costs of half the number of these small vessels are taken up as a saving. As regards the small vessels, which are quite different in scale and in other various aspects from the ferry, their services may be viable when dealing with some specific commodities.
As a consequence, it is assumed that their services would be half substituted by the bridge.

A.5) Difference in costs between ferry-using vehicle transport to which frequent stop, start and acceleration are incidental and free-running bridge transport
The vehicles relying on ferries now require frequent start, stop and acceleration until they are aboard, consuming fuel and overtaxing themselves as much. On the other hand, the bridge requires a running cost over its entire length, including approach roads. This difference of costs should be taken into account for economic assessment.

On the other hand, the item B) can be subdivided into the following four.

B.1) Time benefits for passengers
At present, the seafarers of the ferries shuttling a haul of some 4.5 nautical miles require about 30 min. plus a turnround time of approximately 30 min. for loading and unloading cargoes and rolling in and off vehicles at each terminal port. Namely, a total of 1 hr is unavoidably necessitated for a one-way trip. But this will be curtailed to some 12 min. if a bridge is constructed between Malta and Gozo, on condition that the average running speed of vehicles is 30 miles an hour (48 km/hr). This kind of time economy may be sometimes a great advantage to the passengers taking buses, taxis and other vehicles.

B.2) Time benefits for cargo transport
The same concept as above holds also true to the cargoes carried by trucks,

vans, etc. In addition, wharfages and warehouse charges are expected to be mitigated, and such perishables as agricultural and marine products can be transported without damaging their freshness, thus maintaining their commercial values high.

B.3) Time benefits for drivers

If the time for trip is cut, the driver can appropriate the resulting surplus time for other purposes.

B.4) Time benefits for vehicles (as reduced to pecuniary value from the number of vehicles into which the total delay time is converted based on service life of vehicle)

Ferry traffic takes longer time than bridge traffic does. This difference is the grim evidence that the traffic volume will increase on the bridge between Malta and Gozo since the vehicles should be operated to the full for their life length.

The curtailment of travel time by bridge will require a less number of vehicles than by ferry when considered on a fixed time basis.

Thus, the reduction of total delay time and of the number of vehicles calculated from the service life of vehicle assumes an entry for benefits.

These nine varieties of benefits are brought about by the construction of bridge. Other benefits including the resultant promotion of tourism development, enhancement of reputation of Malta as a sightseeing land, and predictable increase in tourism revenues.

Accurate appraisal of these benefits is hard to come by, and is discarded from the present considerations.

(1) Effects on the development of sightseeing resources

(1-1) The bridge construction will go a long way toward the development of sightseeing resources with which Gozo and Comino Islands are well endowed, have Malta win fame for her eminence as a resort, increase tourists, and thrust up national revenues.

(1-2) Those potential customers who have never been to Gozo Island because of lack of communications, will be encouraged to come, stay long, contributing much toward raising the tourism revenues in Malta.

(2) Effects on the development of industries

(2-1) Agriculture:

The agricultural development in Gozo will be promoted. Increased stability of production and delivery and improvement in freshness and quality of products will enhance the marketability and international commercial viability of the agricultural products.

(2-2) Manufacturing industry:

Gozo will be given fitness for industrial development. Ample manpower available there will push forward the development of extractive industries. Particularly, manufacturing industry will find itself, and its products will qualify for marketability and international competition.

(2-3) Increased opportunities of employment:

Industrial and economic development will increase the chance of employment and will decrease unemployment.

(2-4) Effective use of land:

Population will begin to disperse, and the land utilization in Gozo will be improved. Also, the value of land in Gozo will rise.

(3) Effects on the rationalization of marketing:

Rationalization of marketing will reduce costs such as for ullage, damage, packaging, etc., and will expedite the development of Gozo as a whole.

(4) Procurement of the readiness of transportation:

Ready availability of traffic means will give a drive to the development of industry, economy and culture. Also, the link road will minimize the disasters and will provide an emergency breakthrough.

(5) Dissemination of education, culture and medical services:

Gozoites will also benefit from various such welfare facilities.

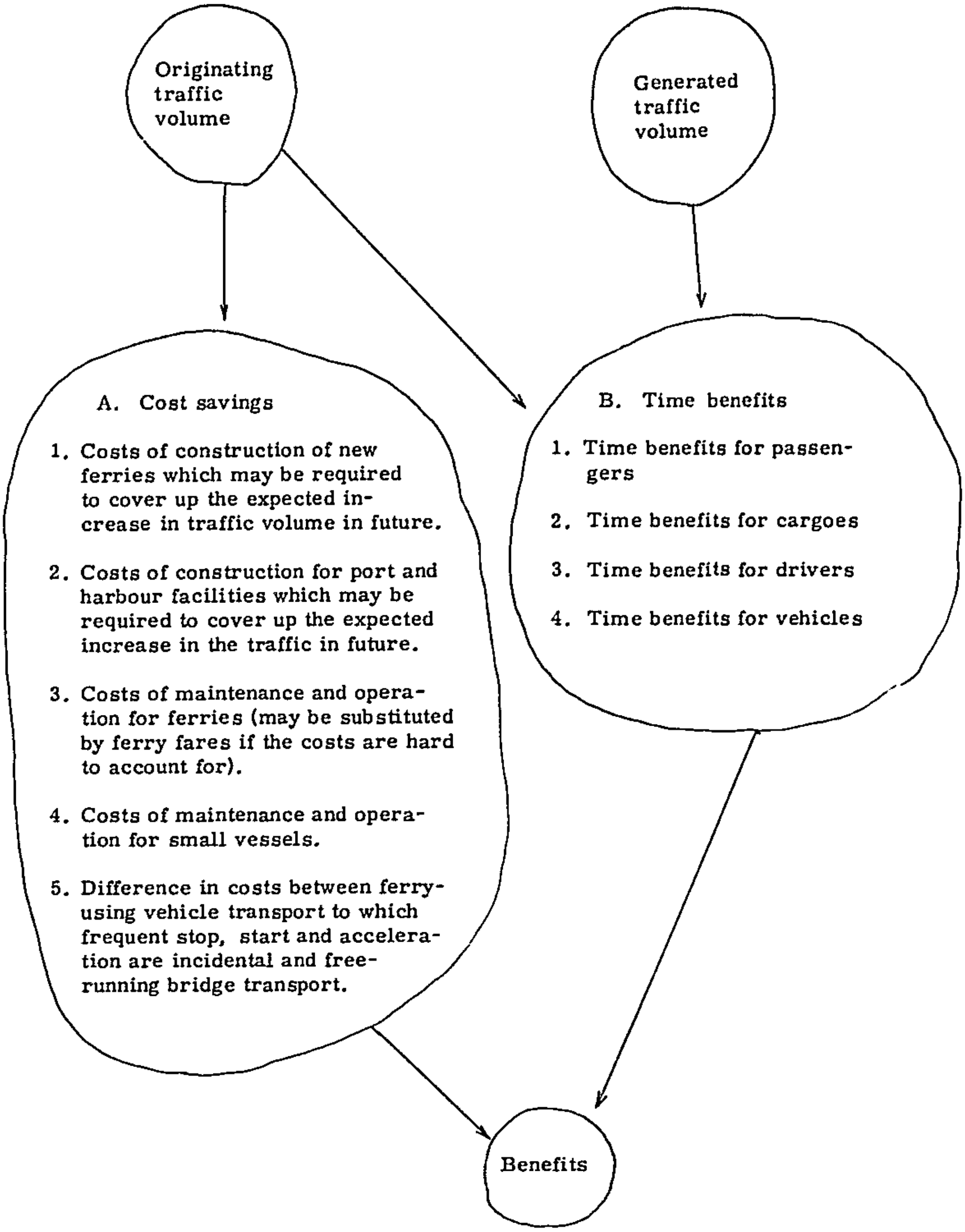


Fig.	GOZO LINKING BRIDGE PROJECT
8-1	KINDS OF BENEFITS CONCEIVABLE

8.1.2 Specific Benefit Cost and Its Concept

1) Specific Time Benefit Cost

i) Vehicles

It is assumed that in Malta the economic life of vehicles under normal operating conditions, that is, the total available time per vehicle, is 4,000 hrs for cars and vans, 7,000 hrs for buses and trucks and 4,000 hrs for others.

The annual time saving by type of vehicles can be obtained by multiplying the annual traffic volume by the travel time difference between ferry and bridge.

By dividing the total saving time by the total available time, the annual time saving can be reduced to the number of vehicles, which is then multiplied by vehicle capital cost to obtain the total vehicle capital cost due to time delay. Table 8-1 lists capital costs per vehicle by type.

Table 8-1 VEHICLE CAPITAL COSTS

Type	Capital Cost (£M/vehicle)
Car	1,200
Van	1,200
Truck	2,000
Bus	4,000
* Others	300

Note: *incl. motor cycles.

ii) Drivers

The following estimate refers to drivers and assistant drivers of buses and trucks.

Table 8-2 HOURLY COSTS OF DRIVERS AND ASSISTANT DRIVERS

Drivers and Assistant Drivers	Hourly Costs, £M/hr.
Driver	0.34
Assistant driver	0.24

Note: Refer to Economic Activities in 1967.

iii) Passengers

Table 8-3 HOURLY COSTS

Type of Vehicle	Hourly Costs, ŁM/vehicle, hr.
Car, Van	0.44
Bus	5.11
* Others	0.34

Note: * incl. motor cycles.

Hourly cost per employe can be expressed by the following formula.

$$\text{Hourly cost} = \frac{\text{Gross annual income of employes}}{\text{Gross annual working time}}$$

$$= 0.284 \text{ ŁM/man·hr.}$$

As regards car, van and others, hourly-costs are calculated by multiplying the hourly cost per employe by the average number of passengers which is set at 1.55 persons/vehicle and 1.2 persons/vehicle, respectively.

For bus, the average number of passengers is set at 36 persons/bus, of which half are considered employes. Namely, hourly bus cost is calculated by the hourly cost per employe by half the number of passengers, in that the benefit computation is limited to the employed only.

iv) Cargoes

For want to adequate materials pertaining to hourly costs for the transportation of cargoes, it is assumed that the cost of cargoes per ton per hr is half the running cost. Assuming that the running speed is 30 miles/hr, the average load is 3 tons/truck and 0.3 tons/van, hourly cost per vehicle is calculated as follows.

Table 8-4 HOURLY COSTS FOR CARGOES

Type of Vehicle	Hourly Cost, ŁM/vehicle. hr.
Truck	0.14
Van	0.01

2) Specific Running Benefit Cost

The bridge, if constructed, will force the vehicles to run a distance of some 9.5 km more than by ferries.

Discussed here is the benefit arising from the difference between bridge-using running costs and the ferry-using costs in which extra costs for frequent idling, start and stop are included.

Specific benefit costs per trip between Malta and Gozo are as follows.

Table 8-5 SPECIFIC RUNNING BENEFIT COSTS

Type of Vehicle	Specific Running Benefit Cost, ₤M/vehicle. trip
Car	-0.051
Van, Truck	-0.072
Bus	-0.096
Others	-0.016

As is clear from Table 8-5, the specific running benefit cost turns negative because the bridge-using traffic requires more cost.

8.1.3 Benefit Calculation

As regard the benefits taken up in para. 8.1.1 "Kinds of benefits," pecuniary values are calculated for cases 1, 2 and 3 and cases 4, 5 and 6 (see Table 8-13) for reference only. The results are given in Table 8-6 through 8-11. Of the values, those appearing in the upper bracket are in 100 ₤M, and those in the lower bracket are in ¥ million. Since floating system is applied, the exchange rate is set at ¥750 to ₤M for the convenience. Since it is undesirable that the change in the exchange rate changes the economic appraisal, considerations are given so that both costs and benefits may be assessed on a domestic currency basis.

The most largest among the benefits is the "costs of maintenance and operation for the ferries dispensed with by bridge construction," which accounts for 45 to 62 percent of the total, followed by the "costs of construction and maintenance for the port and harbour facilities spared by the construction of bridge," which also accounts for 14 to 36 per cent.

The time benefits given in item B) account for 10 to 34 per cent of total, a comparatively small value.

Namely, the costs dispensed with by the construction of bridge given in item A) occupy a majority and are considered important. The costs of construction for bridge are examined in two cases; higher estimate and lower estimate.

Unit: Upper bracket: 100 £M
Lower bracket: ¥ million
Bridge toll : Free
Costs for port and harbour - Higher Estimate

Table 8-6 A COMPREHENSIVE LIST OF YEARLY BENEFITS (Case 1)

Benefits		FY / Quality of Traffic	1981			1995			2010		
			Accrual traffic volume	Developable traffic volume	Total	Accrual traffic volume	Developable traffic volume	Total	Accrual traffic volume	Developable traffic volume	Total
A. Saved Costs	1. Costs of construction and maintenance for the port and harbour facilities necessary to meet the expected demand increase in traffic volume in future		*2,072		*2,072	1,666		1,666	1,666		1,666
			*155.4		*155.4	125.0		125.0	125.0		125.0
	2. *Costs for maintenance and operation of ferries (If these are hard to assess, ferry fares are to be considered instead)*		2,835		2,835	2,905		2,905	2,980		2,980
			212.6		212.6	217.9		217.9	223.5		223.5
	3. Costs of maintenance and operation for small vessels		1		1	-1		-1	-3		-3
			0.1		0.1	-0.1		-0.1	-0.2		-0.2
	4. Difference between costs of ferry-using traffic accompanying frequent start, stop and acceleration and costs of running on the bridge.		-87		-87	-151	-18	-169	-210	-24	-234
			-6.5		-6.5	-11.3	-1.4	-12.7	-15.8	-1.8	-17.6
B. Time Economy	1. Time economy for passengers		559		559	965	124	1,089	1,343	172	1,515
			41.9		41.9	72.4	9.3	81.7	100.7	12.9	113.6
	2. Time economy for cargoes		13		13	23	1	24	32	2	34
			1.0		1.0	1.7	0.1	1.8	2.4	0.2	2.6
	3. Time economy for drivers		33		33	56	11	67	79	16	95
			2.5		2.5	4.2	0.8	5.0	5.9	1.2	7.1
	4. Time economy for vehicles		183		183	315	45	360	440	65	505
			13.7		13.7	23.6	3.5	27.0	33.0	4.9	37.9
C. Tollage revenue	1. If the bridge is available for charges										
	Total		5,609		5,609	5,778	163	5,941	6,327	231	6,558
			420.7		420.7	433.4	12.2	445.6	474.5	17.3	491.9

Note: Values with an asterisk refer to the five years after 1981, and for the years ahead of 1986, the same value as in 1995 is applied.

Table 8-7 A COMPREHENSIVE LIST OF YEARLY BENEFITS (Case 2)

Unit: Upper bracket: 100 LM
Lower bracket: ¥ million
Bridge toll : Free
Costs for port and harbour - Lower Estimate

Benefits \ Quality of Traffic / FY		1981 Accrual traffic volume	1981 Developable traffic volume	1981 Total	1995 Accrual traffic volume	1995 Developable traffic volume	1995 Total	2010 Accrual traffic volume	2010 Developable traffic volume	2010 Total
A. Saved Costs	1. Costs of construction and maintenance *for the port and harbour facilities* necessary to meet the expected demand increase in traffic volume in future	*1,014 * 76.1		*1,014 * 76.1	810 60.8		810 60.8	810 60.8		810 60.8
	2. Costs for maintenance and operation of ferries (if these are hard to assess, ferry fares are to be considered instead)	2,835 212.6		2,835 212.6	2,905 217.9		2,905 217.9	2,980 223.5		2,980 223.5
	3. Costs of maintenance and operation for small vessels	1 0.1		1 0.1	-1 -0.1		-1 -0.1	-3 -0.2		-3 -0.2
	4. Difference between costs of ferry-using traffic accompanying frequent start, stop and acceleration and costs of *running on the bridge.*	-87 -6.5		-87 -6.5	-151 -11.3	-18 -1.4	-169 -12.7	-210 -15.8	-24 -1.8	-234 -17.6
B. Time Economy	1. Time economy for passengers	559 41.9		559 41.9	965 72.4	124 9.3	1,089 81.7	1,343 100.7	172 12.9	1,515 113.6
	2. Time economy for cargoes	13 1.0		13 1.0	23 1.7	1 0.1	24 1.8	32 2.4	2 0.2	34 2.6
	3. Time economy for drivers	33 2.5		33 2.5	56 4.2	11 0.8	67 5.0	79 5.9	16 1.2	95 7.1
	4. Time economy for vehicles	183 13.7		183 13.7	315 23.6	45 3.5	360 27.0	440 33.0	65 4.9	505 37.9
C. Tollage revenue	1. *If the bridge is available for charges*									
Total		4,551 341.3		4,551 341.3	4,922 369.2	163 12.2	5,085 381.4	5,471 410.3	231 17.3	5,702 427.7

Note: Values with an asterisk refer to the five years after 1981, and for the years ahead of 1986, *the same value as in 1995 is applied.*

Table 8-8 A COMPREHENSIVE LIST OF YEARLY BENEFITS (Case 3)

Unit: Upper bracket: 100 LM
Lower bracket: ¥ million
Bridge toll : Free
Costs for port and harbour: Nil

Benefits \ Quality of Traffic \ FY		1981 Accrual traffic volume	1981 Developable traffic volume	1981 Total	1995 Accrual traffic volume	1995 Developable traffic volume	1995 Total	2010 Accrual traffic volume	2010 Developable traffic volume	2010 Total
A. Saved Costs	1. Costs of construction and maintenance for the port and harbour facilities necessary to meet the expected demand increase in traffic volume in future.									
	2. Costs for maintenance and operation of ferries (if these are hard to assess, ferry fares are to be considered instead)	2,835		2,835	2,905		2,905	2,980		2,980
		212.6		212.6	217.9		217.9	223.5		223.5
	3. Costs of maintenance and operation for small vessels	1		1	-1		-1	-3		-3
		0.1		0.1	-0.1		-0.1	-0.2		-0.2
	4. Difference between costs of ferry-using traffic accompanying frequent start, stop and acceleration and costs of running on the bridge.	-87		-87	-151	-18	-169	-210	-24	-234
		-6.5		-6.5	-11.3	-1.4	-12.7	-15.8	-1.8	-17.6
B. Time Economy	1. Time economy for passengers	559		559	965	124	1,089	1,343	172	1,515
		41.9		41.9	72.4	9.3	81.7	100.7	12.9	113.6
	2. Time economy for cargoes	13		13	23	1	24	32	2	34
		1.0		1.0	1.7	0.1	1.8	2.4	0.2	2.6
	3. Time economy for drivers	33		33	56	11	67	79	16	95
		2.5		2.5	4.2	0.8	5.0	5.9	1.2	7.1
	4. Time economy for vehicles	183		183	315	45	360	440	65	505
		13.7		13.7	23.6	3.5	27.0	33.0	4.9	37.9
C. Tollage revenue	1. If the bridge is available for charges									
Total		3,537		3,537	4,112	163	4,275	4,661	231	4,892
		265.3		265.3	308.4	12.2	320.6	349.6	17.3	366.9

Note: Values with an asterisk refer to the five years after 1981, and for the years ahead of 1986, the same value as in 1995 is applied.

Table 8-9 A COMPREHENSIVE LIST OF YEARLY BENEFITS (Case 4)

Unit: Upper bracket: 100 LM
Lower bracket: ¥ million
Bridge toll : Free
Costs for port and harbour - Higher Estimate

Benefits / Quality of Traffic / FY		1981 Accrual traffic volume	1981 Developable traffic volume	1981 Total	1995 Accrual traffic volume	1995 Developable traffic volume	1995 Total	2010 Accrual traffic volume	2010 Developable traffic volume	2010 Total
A. Saved Costs	1. Costs of construction and maintenance for the port and harbour facilities necessary to meet the expected demand increase in traffic volume in future	*2,072 *155.4		*2,072 *155.4	1,666 125.0		1,666 125.0	1,666 125.0		1,666 125.0
	2. Costs for maintenance and operation of ferries (if these are hard to assess, ferry fares are to be considered instead)	2,835 212.6		2,835 212.6	2,905 217.9		2,905 217.9	2,980 223.5		2,980 223.5
	3. Costs of maintenance and operation for small vessels	1 0.1		1 0.1	-1 -0.1		-1 -0.1	-3 -0.2		-3 -0.2
	4. Difference between costs of ferry-using traffic accompanying frequent start, stop and acceleration and costs of running on the bridge.	-87 -6.5		-87 -6.5	-151 -11.3	-18 -1.4	-169 -12.7	-210 -15.8	-24 -1.8	-234 -17.6
B. Time Economy	1. Time economy for passengers	559 41.9		559 41.9	965 72.4	124 9.3	1,089 81.7	1,343 100.7	172 12.9	1,515 113.6
	2. Time economy for cargoes	13 1.0		13 1.0	23 1.7	1 0.1	24 1.8	32 2.4	2 0.2	34 2.6
	3. Time economy for drivers	33 2.5		33 2.5	56 4.2	11 0.8	67 5.0	79 5.9	16 1.2	95 7.1
	4. Time economy for vehicles	183 13.7		183 13.7	315 23.6	45 3.5	360 27.0	440 33.0	65 4.9	505 37.9
C. Tollage revenue	1. If the bridge is available for charges	993 74.5		993 74.5	1,709 128.2	191 14.3	1,900 142.5	2,390 179.3	267 20.0	2,657 199.3
Total		6,602 495.2		6,602 495.2	7,487 561.5	354 26.6	7,841 588.1	8,717 695.9	498 37.4	9,215 691.1

Note: Values with an asterisk refer to the five years after 1981, and for the years ahead of 1986, the same value as in 1995 is applied.

Table 8-10 A COMPREHENSIVE LIST OF YEARLY BENEFITS (Case 5)

Unit: Upper Bracket : 100 £M
Lower bracket : ¥ million
Bridge toll : Free
Costs for port and harbour - Lower Estimate

	Benefits / Quality of Traffic / FY	1981 Accrual traffic volume	1981 Developable traffic volume	1981 Total	1995 Accrual traffic volume	1995 Developable traffic volume	1995 Total	2010 Accrual traffic volume	2010 Developable traffic volume	2010 Total
A. Saved Costs	1. Costs of construction and maintenance for the port and harbour facilities necessary to meet the expected demand increase in traffic volume in future	*1,014 * 76.1		*1,014 * 76.1	810 60.8		810 60.8	810 60.8		810 60.8
	2. Costs for maintenance and operation of ferries (if these are hard to assess, ferry fares are to be considered instead)	2,835 212.6		2,835 212.6	2,905 217.9		2,905 217.9	2,980 223.5		2,980 223.5
	3. Costs of maintenance and operation for small vessels	1 0.1		1 0.1	-1 -0.1		-1 -0.1	-3 -0.2		-3 -0.2
	4. Difference between costs of ferry-using traffic accompanying frequent start, stop and acceleration and costs of running on the bridge	-87 -6.5		-87 -6.5	-151 -11.3	-18 -1.4	-169 -12.7	-210 -15.8	-24 -1.8	-234 -17.6
B. Time Economy	1. Time economy for passengers	559 41.9		559 41.9	965 72.4	124 9.3	1,089 81.7	1,343 100.7	172 12.9	1,515 113.6
	2. Time economy for cargoes	13 1.0		13 1.0	23 1.7	1 0.1	24 1.8	32 2.4	2 0.2	34 2.6
	3. Time economy for drivers	33 2.5		33 2.5	56 4.2	11 0.8	67 5.0	79 5.9	16 1.2	95 7.1
	4. Time economy for vehicles	183 13.7		183 13.7	315 23.6	45 3.5	360 27.0	440 33.0	65 4.9	505 37.9
C. Tollage revenue	1. If the bridge is available for charges	993 74.5		993 74.5	1,709 128.2	191 14.3	1,900 142.5	2,390 179.3	267 20.0	2,657 199.3
Total		5,544 415.8		5,544 415.8	6,631 497.3	354 26.6	6,985 523.9	7,861 589.6	498 37.4	8,359 626.9

Note: Values with an asterisk refer to the five years after 1981, and for the years ahead of 1986, the same value as in 1995 is applied.

Table 8-11 A COMPREHENSIVE LIST OF YEARLY BENEFITS (Case 6)

Unit: Upper bracket: 100 LM
Lower bracket: ¥ million
Bridge toll : Free
Costs for port and harbour: Nil

Benefits \ Quality of Traffic \ FY		1981 Accrual traffic volume	1981 Developable traffic volume	1981 Total	1995 Accrual traffic volume	1995 Developable traffic volume	1995 Total	2010 Accrual traffic volume	2010 Developable traffic volume	2010 Total
A. Saved Costs	1. Costs of construction and maintenance for the port and harbour facilities necessary to meet the expected demand increase in traffic volume in future									
	2. Costs for maintenance and operation of ferries (if these are hard to assess, ferry fares are to be considered instead)	2,835		2,835	2,905		2,905	2,980		2,980
		212.6		212.6	217.9		217.9	223.5		223.5
	3. Costs of maintenance and operation for small vessels	1		1	-1		-1	-3		-3
		0.1		0.1	-0.1		-0.1	-0.2		-0.2
	4. Difference between costs of ferry-using traffic accompanying frequent start, stop and acceleration and costs of running on the bridge.	-87		-87	-151	-18	-169	-210	-24	-234
		-6.5		-6.5	-11.3	-1.4	-12.7	-15.8	-1.8	-17.6
B. Time Economy	1. Time economy for passengers	559		559	965	124	1,089	1,343	172	1,515
		41.9		41.9	72.4	9.3	81.7	100.7	12.9	113.6
	2. Time economy for cargoes	13		13	23	1	24	32	2	34
		1.0		1.0	1.7	0.1	1.8	2.4	0.2	2.6
	3. Time economy for drivers	33		33	56	11	67	79	16	95
		2.5		2.5	4.2	0.8	5.0	5.9	1.2	7.1
	4. Time economy for vehicles	183		183	315	45	360	440	65	505
		13.7		13.7	23.6	3.5	27.0	33.0	4.9	37.9
C. Tollage revenue	1. If the bridge is available for charges	993		993	1,709	191	1,900	2,390	267	2,657
		74.5		74.5	128.2	14.3	142.5	179.3	20.0	199.3
Total		4,530		4,530	5,821	354	6,175	7,051	498	7,549
		339.8		339.8	436.6	26.6	463.1	528.8	37.4	566.2

Note: Values with an asterisk refer to the five years after 1981, and for the years ahead of 1986, the same value as in 1995 is applied.

8.2 Construction Costs

8.2.1 Construction Costs

As already discussed in para. 6.4, "Estimate of construction costs," the breakdown of the costs necessary for the construction of a bridge is as follows.

Table 8-12 CONSTRUCTION COSTS FOR BRIDGE (ŁM)

Item	Construction Cost
A. Bridge construction	7,482,700
B. Road construction	354,700
C. Subtotal (A + B)	7,837,400
D. Detailed design, surveying, and other investigations	235,100
E. Tax	548,600
F. Reserves	1,567,400
G. Total (A+B+D+E+F)	10,188,500
H. Maintenance and operation costs	54,700 (ŁM/year)

8.2.2 Construction Period

According to Table 6-7, "Construction schedule," the bridge construction will take some 7 years.

Although the time for the start of construction should be determined after due consideration of technology, economics and administration, technological aspects alone are considered here to assess the economic impact. The effects of investment in bridge will take more and more concrete form as the years go by. Should the studies, detailed engineering and surveying be started immediately in 1974, the commissioning operation of the bridge will be scheduled for 1981 or seven years from now.

During the 7-year construction period, the investments will be required most in one and a half year before commissioning, and the costs during that one and a half year period are taken into account for the appraisal of economic impact.

8.3 Economic Appraisal

Assuming that the year of commissioning is 1981, and that the redemption takes 30 years, the final year of redemption will be the year 2010.

As pointed out under para. 8.1.3, the values of benefits vary with which items of benefits are taken up and in what way they are combined. For this reason, the following two sets of cases are considered for the appraisal of economic impact.

One set including three cases refers to the bridges available free of charge, and the other set also comprising three cases refers to the bridges available at charges.

Table 8-13 CASES CONCEIVABLE FOR THE EXAMINATION OF ECONOMIC IMPACT

Tollage	Port and harbours	Costs for ports and harbours	Case
Free	esse	Higher estimate	1
Free	esse	Lower estimate	2
Free	nil	-	3
Charged	esse	Higher estimate	4
Charged	esse	Lower estimate	5
Charged	nil	-	5

As already described, the costs for the expansion of ports and harbour facilities required to accommodate the future traffic expansion turn out to be a benefit. According to a paper, titled "Gozo-Ngarr Harbour Proposed Remodelling," the said expansion costs can be divided into two cases; one for higher estimate and the other for lower estimate (Cases 1 and 2 as referred to in Table 8-13). By way of reference, also, Cases 5 and 6 (see Table 8-13) are examined, together with Cases 1 and 2.

Cases 3 and 6 refer to the case where the existing port and harbour facilities are to be used without additional installation in Malta even when the volume of ferry traffic is increased in the future.

With reference to the six cases listed in Table 8-13, the cost benefit ratios and internal rates of return are calculated as shown in Table 8-14, 8-15 and Fig. 8-1.

It is understood from these results that even in the case of free tollage system where the benefits are considered most highest the internal rate of return, r, is 2.93 per cent, far below the loan terms proposed by likely international monetary institutions. The following is another internal rate of return assessed by applying by way of example the following tollage system for which the current ferry rates and the rates of toll roads operating in Japan are referenced.

Preferred tollage (one-way rate) for bridge

Car, van	0.5 LM/vehicle
Truck	1.0 LM/vehicle
Bus	1.5 LM/vehicle
Motor cycle	0.15 LM/vehicle

According to the preferred tollage above, the internal rate of return for Case 4 is r = 4.86%.

The application of tollage to bridge operation invites various problems, and it is to be understood that its economic assessment here has been made only by way of example.

Now three ferries are operating 5 to 7 shuttles a day between Malta and Gozo. If the operation is increased up to 10 to 11 turnrounds per day per ferry (see Table 7-2), the number of vehicles to be carried a year will be 433,000 (see Table 7-3), which is far above the originating traffic volume of 298,000 vehicles a year expected in 2010.

This means that the future traffic volume increase could be disposed of by amplifying the existing ferry system. It is therefore suggested that efforts be concentrated on the more effective use of the existing ferry system for the time being, and that the construction of the bridge be held off until the traffic volume will have been fully developed by the promotion of economic and social development in Malta. This is because the effects of investment in the construction of bridges will be augmented by protraction. When it comes to maturity, detailed surveys should be made again for final decision.

Although the ferries are sometimes forced to suspend their services in winter, they will be operable if adequate port and harbour facilities are installed in Malta. It is likely that the development and amplification of the port and harbour facilities will provide an increased flexibility for the ferry operation.

Our final conclusions, as supported by the above considerations, may be summarized as follows.

1) From the viewpoint of economics, much cannot be expected of the investment in the present project.
   (Max. internal rate of return, r: 2.93%)
2) For the time being, the more increased use of the existing ferries should be planned.

Table 8-14 INTEREST RATES, FINAL YEAR OF REDEMPTION AND B/C OVER 30 YEARS

Interest rate	Case 1		Case 2		Case 3	
	Final year of redemption	Cost benefit ratio over 30 years (1981-2010)	Final year of redemption	Cost benefit ratio over 30 years (1981-2010)	Final year of redemption	Cost benefit ratio over 30 years (1981-2010)
0.5	2001	1.41	2005	1.20	2010	1.00
1.0	2002	1.31	2007	1.12	2013	0.93
1.5	2004	1.22	2009	1.04	2016	0.86
2.0	2006	1.14	2012	0.97	2021	0.80
2.5	2008	1.06	2016	0.90	2027	0.75
3.0	2011	0.99	2020	0.84		0.70
3.5	2015	0.93	2028	0.79		0.65
4.0	2020	0.87		0.74		0.61
4.5	2030	0.82		0.69		0.57
5.0		0.77		0.65		0.53
5.5		0.72		0.61		0.50
6.0		0.68		0.57		0.47
6.5		0.64		0.54		0.45
7.0		0.61		0.51		0.42
7.5		0.57		0.48		0.40
8.0		0.55		0.46		0.38
8.5		0.52		0.43		0.36
9.0		0.49		0.41		0.34
9.5		0.47		0.39		0.32
10.0		0.45		0.37		0.31
10.5		0.43		0.36		0.29
11.0		0.41		0.34		0.28
11.5		0.39		0.33		0.27
12.0		0.37		0.31		0.25
12.5		0.36		0.30		0.24
13.0		0.34		0.29		0.23
13.5		0.33		0.27		0.22
14.0		0.32		0.26		0.21
14.5		0.30		0.25		0.21
15.0		0.29		0.24		0.20

Internal Rate of Return		
	Case 1	r = 2.93 %
	Case 2	r = 1.79 %
	Case 3	r = 0.50 %

	Bridge tollage	Costs for ports and harbours
Case 1	Free	Higher Estimate
Case 2	Free	Lower Estimate
Case 3	Free	Nil

Table 8-15 INTEREST RATES, FINAL YEAR OF REDEMPTION AND B/C OVER 30 YEARS

Interest rate	Case 4		Case 5		Case 6	
	Final year of redemption	Cost benefit ratio over 30 years (1981-2010)	Final year of redemption	Cost benefit ratio over 30 years (1981-2010)	Final year of redemption	Cost benefit ratio over 30 years (1981-2010)
0.5	1997	1.83	1999	1.63	2002	1.43
1.0	1997	1.70	2000	1.51	2003	1.32
1.5	1998	1.58	2001	1.40	2005	1.22
2.0	1999	1.47	2002	1.30	2006	1.14
2.5	2001	1.37	2004	1.21	2008	1.06
3.0	2002	1.28	2006	1.13	2011	0.99
3.5	2004	1.19	2008	1.05	2015	0.92
4.0	2006	1.12	2011	0.98	2019	0.86
4.5	2008	1.05	2015	0.92	2027	0.86
5.0	2012	0.98	2022	0.86		0.75
5.5	2017	0.92		0.81		0.70
6.0	2026	0.87		0.76		0.66
6.5		0.82		0.72		0.62
7.0		0.77		0.68		0.59
7.5		0.73		0.64		0.55
8.0		0.69		0.60		0.52
8.5		0.65		0.57		0.49
9.0		0.62		0.54		0.47
9.5		0.59		0.52		0.44
10.0		0.56		0.49		0.42
10.5		0.54		0.47		0.40
11.0		0.51		0.44		0.38
11.5		0.49		0.42		0.36
12.0		0.47		0.41		0.35
12.5		0.45		0.39		0.33
13.0		0.43		0.37		0.32
13.5		0.41		0.36		0.30
14.0		0.39		0.34		0.29
14.5		0.38		0.33		0.28
15.0		0.36		0.32		0.27

Internal Rate of Return		
	Case 4	r = 4.86
	Case 5	r = 3.86
	Case 6	r = 2.93

	Bridge tollage	Costs for ports and harbours
Case 4	Charged	Higher Estimate
Case 5	Charged	Lower Estimate
Case 6	Charged	Nil

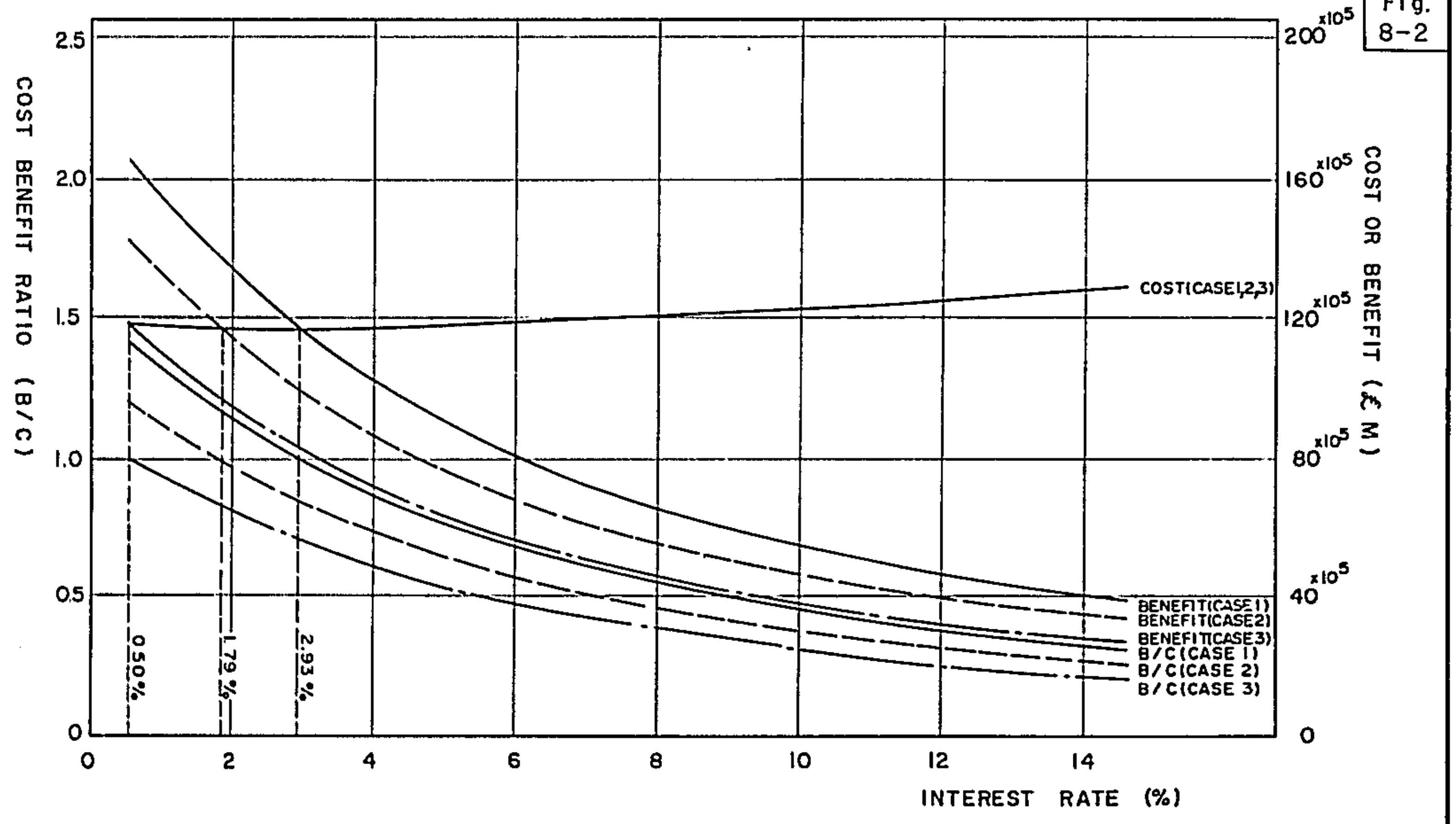


Fig. 8-2	LINK ROAD BETWEEN MALTA AND GOZO ISLANDS
	COST, BENEFIT AND COST BENEFIT RATIO