

No. 1

Basic Design Study Report
on
The Project for Rehabilitation
of
Ahmed Hamdi Tunnel
in
Arab Republic of Egypt

February 1992

JAPAN INTERNATIONAL COOPERATION AGENCY

Basic Design Study Report on The Project for Rehabilitation of Ahmed Hamdi Tunnel in Arab Republic of Egypt

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PREFACE

In response to a request from the Government of Arab Republic of Egypt, the Government of Japan decided to conduct a basic design study on the Project for Rehabilitation of Ahmed Hamdi Tunnel and entrusted the study to the Japan International Cooperation Agency (JICA).

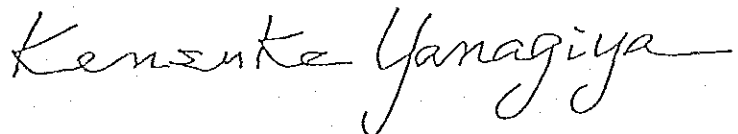
JICA sent to Egypt the phase 1 study team headed by Mr. Shigeru NAKAMURA, Director, Grant Aid Div., Economic Cooperation Bureau, Ministry of Foreign Affairs, from 23th June to 4th July, 1991, and the phase 2 study team headed by Dr. Akira INOKUMA, Head, Tunnel Division, Public Works Research Institute, Ministry of Construction from 1st August to 20th September, 1991.

The teams held discussions with the officials concerned of the Government of Egypt, and conducted field studies at the study area. After the phase 2 study team returned to Japan, further studies were made. Then, a mission headed by Dr. Katsuhiko IWAI, Chief Tunnel Engineer, Department of Engineering, Nihon Doro Kodan, was sent to Egypt in order to discuss a draft report and the present report was prepared.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

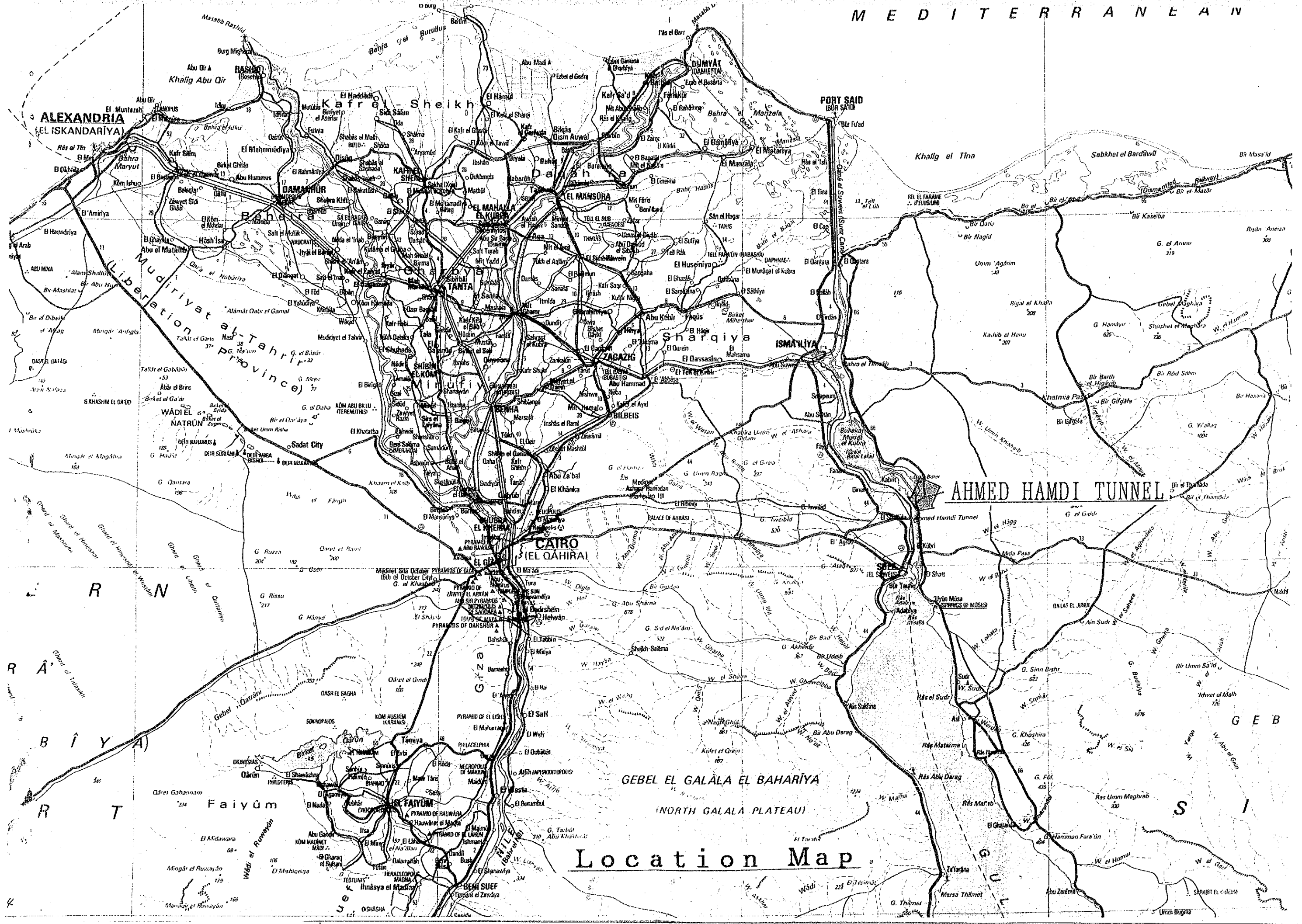
I wish to express my sincere appreciation to the officials concerned of the Government of the Arab Republic of Egypt for their close cooperation extended to the teams.

February, 1992



Kensuke Yanagiya
President

Japan International Cooperation Agency



Location Map

AHMED HAMDİ TUNNEL

GEBEL EL GALALA EL BAHARIYA
(NORTH GALALA PLATEAU)

ALEXANDRIA
(EL ISKANDARIYA)

CAIRO
(EL QAHIRA)

Faiyūm

(Liberation Province)
Mudiriyyat al-Tahrir

PORT SAID
(SOUR SAID)

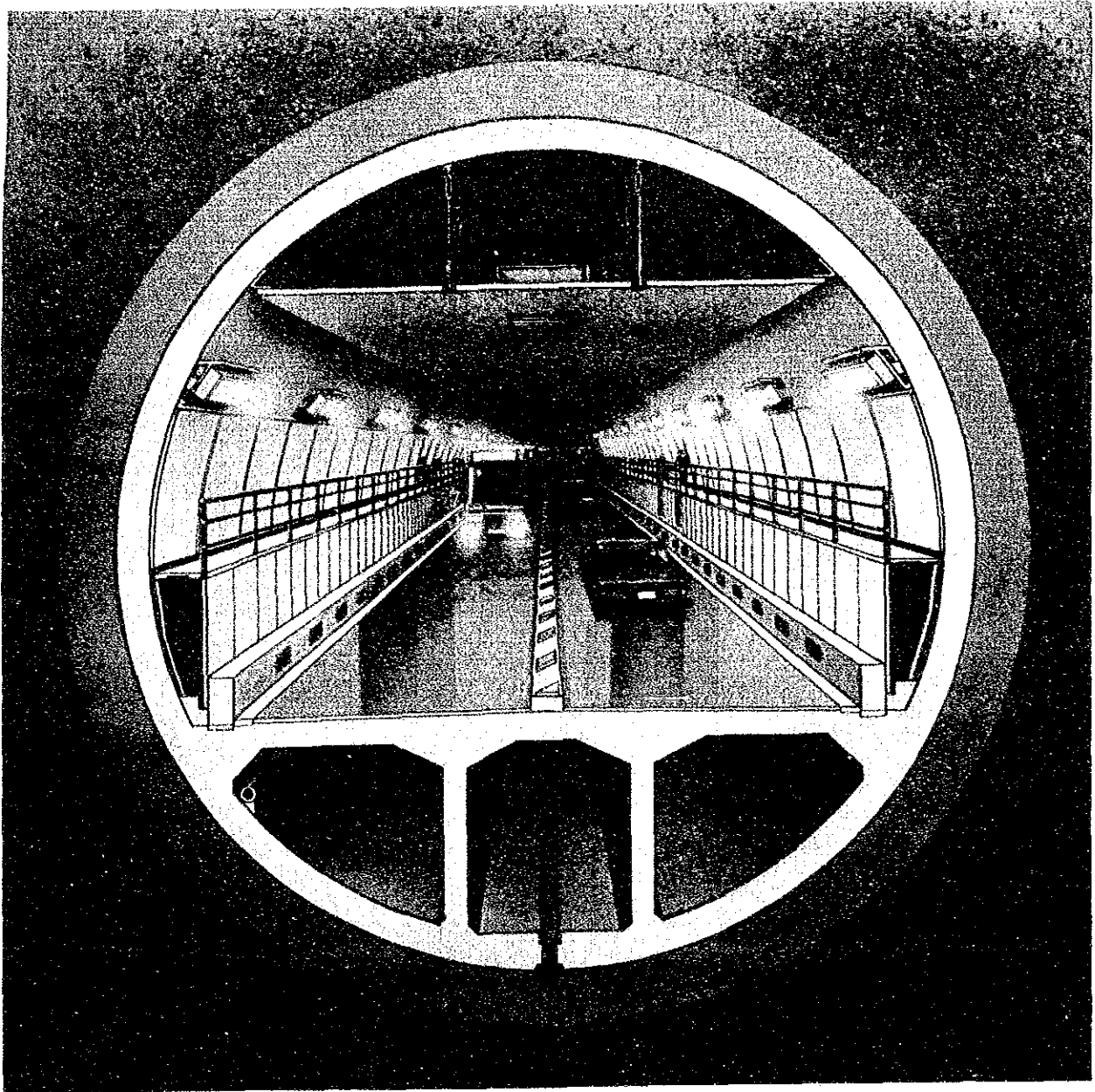
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R A' N

R B I Y A

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Proposed Tunnel Section
after
Rehabilitation Works

SUMMARY

Summary

This Final Report of the Basic Design Study on the project for REHABILITATION of AHMED HAMDI TUNNEL, Arab Republic of Egypt, is the result of a request for Grant Aid by the Government of Arab Republic of Egypt to the Government of Japan on August 13, 1990.

1. Background of the Rehabilitation Works

(1) Current Situation of Egypt

Egypt is located at the north-east of African Continent, and is facing Mediterranean in north and Red Sea in east both with long shore-lines. The boundaries are with Libya in west, Sudan in south and Israel in east on Sinai Peninsula.

The population in 1988 is approximately 51.4 million with 12.0 million in Cairo, the capital. The residential and agricultural area is limited to the basin of the River Nile, the river mouth delta and part of the shoreline along Mediterranean. The remaining area is desert mostly.

Historically, Egypt has been enjoying much benefit from the River Nile, and has been developed as an agricultural country.

In Egypt, such agricultural products as cotton, fruits and vegetables have been produced mainly for exporting purpose to get hard currencies, which has caused a reduction of grain products, together with a decrease in self-supply of main foods for the people of Egypt. On the other hand, however mining industry, manufacturing industry and service industry are developing in good shape.

The Government of Egypt is now implementing the Five-Years (from 1988 to 1992) Social and Economic Development Programme in order to achieve the National Objectives which are categorized into three types of objectives as below:

- 1) The social objective of an Improved Quality of Life for all Egyptians, Lower Population Growth, and Reversal of the Brain Drain;
- 2) The Economic Objective of Industrial Development to Create Opportunities for Jobs and Export Earnings, with Foreign Aid Reduced and Private Sector Expanded;
- 3) The Strategic Objective of Food Self-Sufficiency, National Integration of Remote Districts.

In order to achieve the above National Objectives, the Government of Egypt intends to put a high priority on the domestic economy. The concrete measures being taken for this are stated below:

- 1) decentralize public sectors and publicly-owned enterprises and improve technology and productivity;
- 2) promote investment in private sectors such as agriculture, stock-raising, tourism, construction, housing, manufacturing, transportation and communication;
- 3) open the door for investment in Egypt by foreign countries, and promote labour-intensive and export-intended types of industry;
- 4) obtain financial aid and cooperation from western European countries, Japan and the neighboring Arab countries.

Based on the above, the national economy of Egypt could be expected to be revitalized both in public and private sectors, thus bringing a steady economic growth and gradual increase in Gross National Product by an annual rate of 5.5 % on the average.

(2) Current Situation of Social and Economic Sector in the Peninsula of Sinai

The Government of Egypt is striving to achieve the economic and social prosperity in both West and East bank zone of Suez Canal (hereinafter called the Canal) and the Peninsula of Sinai. Especially, in the Peninsula of Sinai, the Government is intending to develop such leading economic sectors as agriculture, manufacturing, mining and tourism.

The Government is to reorganize the current situation of a mono-crop agricultural (livestock) economy into a diversified, self-reliant and multi-sector economy in the Peninsula of Sinai and to create job opportunities for its people.

In addition to the above, the Government of Egypt is trying to achieve the strategic objective of establishing sound environment for permanent settlements in all parts of the Peninsula of Sinai under a desert climate and integrating the Peninsula of Sinai successfully into the Mainland of Egypt in economy, culture and politics.

(3) Importance of Ahmed Hamdi Tunnel

Suez Canal, located at the northwest end of the Peninsula of Sinai, which serves as the sole water route connecting Mediterranean and Red Sea, is approximately 162 km in length. The Canal has an important role both for international marine transportation and for domestic economy in Egypt. However, the Canal separates the mainland of Egypt and the Peninsula of Sinai.

At present, the means of transportation connecting the Mainland of Egypt and the Peninsula of Sinai can be categorized into two types: ferry-boat system crossing the Canal and the tunnel system crossing under the Canal.

The ferry-boat system crossing the Canal is operated in six lines in the northern, central and southern parts of the Canal. But its capacity is comparatively small.

Ahmed Hamdi Tunnel crossing under the Canal was completed in 1983 and has been put in use for 9 years as an indispensable route for the social and economic development in the Peninsula of Sinai and both West and East sides of the Canal.

The Tunnel is not only the sole route of surface transportation connecting the Mainland of Egypt with the Peninsula of Sinai, but also carries such fundamental life-lines as fresh water supply pipelines, all of which are vital infrastructure for people in the Peninsula of Sinai.

According to the latest survey of the traffic situation in the Tunnel in May and August, 1990, an average number of traffic of surface transportation of 1,500 ~ 1,800 vehicles per day with a maximum traffic volume of 5,000 vehicles per day has been recorded. And the number of vehicles will increase year by year in future.

In view of the above social and economic situation in the whole Peninsula of Sinai, it may not be an overstatement to say that the Tunnel, together with other networks of surface transportation all over the Peninsula of Sinai, is expected to become more and more important due to regional development of the Peninsula of Sinai from now on.

(4) Current Situation of the Tunnel and the Necessity of an Early Start for the Rehabilitation Works

Since its opening in 1983, the Tunnel has been put in use only for 9 years, during which, unfortunately, complicated troubles of functional and structural deterioration of the Tunnel appeared, possibly due to the leakage of salty water. The primary tunnel structure of reinforced concrete segment and road-deck of the Tunnel has been damaged to a serious extent.

The Suez Canal Authority (hereinafter called S.C.A.) has taken necessary steps for temporary repairs of the Tunnel from time to time, all of which, however, could not necessarily be said to have effectively prevented further deterioration of the Tunnel.

It is supposed that the structural strength as well as safety margin of the primary tunnel structure have been sharply going down nearly to a dangerous level.

On the other hand, S.C.A. is now planning to expand the Canal. The expansion works of the Canal, however, could possibly give such mechanical impacts to the structural strength of the existing tunnel structure as change in water and earth pressure, unless necessary and proper steps are taken in time to reinforce the structural strength of the Tunnel. So the Expansion Project cannot be completed or may be delayed without reinforcement of the structural strength of the Tunnel.

In consideration of the above mentioned situation and in order to keep the soundness of the tunnel structure, an early start of the Rehabilitation Works is urgently required.

(5) Effect of the Rehabilitation Works

The effects of the Rehabilitation Works for Ahmed Hamdi Tunnel have been summarized as follows:

The project is directly expected to:

- 1) save the labours and costs for maintenance of the Tunnel for S.C.A. which have been recorded to amount to 1,400,000 Egyptian Pounds annually on the average,
- 2) allow a full use being made of the traffic capacity of the Tunnel of 1500 vehicles per hour so that it can serve as a main route of surface transportation connecting the Mainland of Egypt with the Peninsula of Sinai. This is expected to make a great contribution to the development and expansion of agriculture, manufacturing, mining and tourism in the Peninsula of Sinai as well as foreign trade with the neighboring countries, all of which are oriented as the main objectives of regional development in the Peninsula of Sinai,

- 3) be very helpful for achieving the strategic objective of Egypt, because it provides a traffic capacity big enough for future demand,
- 4) make a great contribution to meeting the international needs for the Canal's marine transit of huge-sized vessels which are expected to pass through the Canal in future after the Expansion Project of the Canal (deepening and widening the existing Canal) is completed. Also, it may bring about an increase in the transit revenue for the national economy of Egypt.

2. Outline of the Official Request for Grant Aid for Rehabilitation Works of the Tunnel.

The object for the Rehabilitation Works is Ahmed Hamdi Tunnel, located 17km north of the city of Suez, connecting the Mainland of Egypt with the Peninsula of Sinai.

The content of the Request is the structural and functional rehabilitation of the whole Tunnel of 1,650m in length.

The Rehabilitation Works is based on the recommendations in the Final Report by the Task Team of the Government of Japan issued in May 1990. The method to be adopted for the project shall be reinforced concrete lining after applying waterproofing sheet all over the inside of the Tunnel under the condition that 1 (one) lane of traffic is basically kept open throughout the project period. This is to completely prevent the leakage of salty water from the outside of the existing tunnel structure through segment-joints into the Tunnel.

The Works includes the road deck and the related facilities at the same time. The purpose of the Works is to recover completely the structural and functional capacity of the Tunnel.

3. Execution Organization in Egypt

The responsible organization for this Rehabilitation Works in Egypt is S.C.A.

The planning and execution of the Works go to Works Department of S.C.A.

Works Department has already assumed the responsibility of the Tunnel's operation and maintenance control, through which they have obtained plenty of technical know-how and experience.

Considering their capability and experience, it could be assumed that they are fully competent to execute the proposed Maintenance/Control Method for the Rehabilitated Tunnel.

4. Field Survey

The followings are the contents of the field survey.

Study Items	Contents
(1) General Tunnel Site Survey	• General tunnel site survey on structure and facilities
(2) Study on - Background of the Plan - Requirement - Project - Confirmation	• General survey on the present/future status of the national/regional development plan
(3) Study on the Present Condition of Tunnel Deterioration	• Revision of the updated deterioration report by S.C.A., measurement of stress reinforcing steel bar, and evaluation of safety
(4) Traffic Conditions of the Tunnel Structure	• Survey on Traffic Conditions and the characteristics
(5) Study on the Related Facilities	• Survey on the present conditions of the size, location and supporting for such facilities as Water Supply Pipelines
(6) Study on the Ventilation System	• Survey on the present conditions of the size and operation for such facilities as Ventilation and Lighting, etc.

Study Items	Contents
(7) Survey/Study of Construction Materials	• Study on local availability and selection of materials
(8) Survey on Construction Work	• Examination of the constructional and financial capability of local contractors, construction equipment, skilled and unskilled workers, construction materials locally available and related laws and regulations, etc.
(9) Tunnel Section Survey	• Instrumental measurement of center line, level, and section inside the tunnel
(10) Geotechnical Investiga- tion	• Survey of the soil characteristics

Based on the survey results of the above items 1 ~ 3 and the recommendation in the Final Report by the Task Team of the Government of Japan issued in May 1990, it has been concluded that:

- 1) The Rehabilitation Works of the Tunnel is intensively important and
- 2) The Works shall be executed as soon as possible.

Furthermore, several technical discussions have been held with S.C.A. and the local government authorities on the Rehabilitation Works, from whom we received the relevant data and information. Finally, the Design Policy and Criteria, and the Construction Conditions necessary for the execution of the Basic Design Study have been decided.

5. Basic Design Policy and Criteria

5.1. Basic Design Policy and Criteria

The First priority is "To keep the soundness of the Tunnel" and the followings have been confirmed with S.C.A. through the discussions during the field survey.

- (1) The tunnel structure shall undergo no further deterioration and similar Rehabilitation Works shall not be required again. To achieve this, the followings are to be considered.

The Rehabilitation Works for the whole length (1650m) of the Tunnel shall be implemented by the method of reinforced concrete lining after applying waterproofing sheet on the existing concrete segments including the road deck.

After the Rehabilitation Works, the Tunnel shall be maintained through regular inspection and slight partial repair works only.

- (2) The above mentioned rehabilitation design for the Tunnel shall allow future widening, deepening and doubling projects of the Suez Canal.
- (3) The existing road capacity and limit shall be secured.

- The road limit shall be equal to the existing one, which is 5.0m in height and 7.5m in width.

- (4) Concerning the drainage system, the ground water shall be directed to the drain at the invert and be collected into Nadir sump tank.

(5) The Ventilation System Plan shall be studied based on the present situation of the existing system so that the system can be reused as much as possible and adjustment can be applied as necessary. The system shall be designed based on practical, technical and economical considerations. The recommendation includes study on the safety at the time of emergency such as "Fire" and on easy maintenance.

(6) The Road System such as Ceiling, Lighting, Wall Panel and Fire Hydrant, and the Related Facilities such as Electrical Power Cable and Communication Telephone Cables after being rehabilitated shall be reused as much as possible. The decision of the Reuse can be by the following considerations:

- The existing performance
- Damage and/or decrease in efficiency after dismantlement and reinstallation

- Decrease in efficiency for the sake of safe keeping
- Adjustability for the Rehabilitation Works
- Workability
- Cost

(7) The Permanent Fresh Water Supply Pipelines (two lines) shall be installed outside of the Tunnel crossing the bottom of Suez Canal in order to secure the water supply to the Peninsula of Sinai and to facilitate the Rehabilitation Works.

5.2. Construction Condition

In addition to the above Basic Design Policy and Criteria the Construction Conditions for the Rehabilitation Works have been confirmed as follows:

- (1) The immediate execution of proper Rehabilitation Works shall be carried out as quickly as possible.

For this purpose, the Construction plan shall take the following policies into consideration:

- Early Start
- Shortening of Work Schedule - Schedule Optimum
- Cost Optimum
- Safety First

Based on the above policies, the construction plan is to adopt the most practical and advanced construction method to meet the target of the Schedule.

- (2) The traffic restrictions during the Rehabilitation Works are to be as follows:

- 1) One lane traffic.
- 2) The speed limit will be 20km/h. Further restriction is to be applied to large vehicles.
- 3) The traffic is to be stopped between 8:00 pm through 6:00 am. During the period of special work such as the assembling/dismantling/moving work for Centles and Sliding Forms, the traffic is to be stopped the whole day(s) according to schedule of construction. The period of traffic stoppage should not exceed one month during the Rehabilitation Works. Each stoppage period should last 4 days to the maximum.

- (3) The Works is to be carried out by 3 shifts (24 hours per day).
- (4) The fresh water supply pipeline shall be kept in operation at least one line at a time.
- (5) Electrical power cable and communication telephone cable shall be temporarily removed from the Tunnel for the execution of the Rehabilitation Works except for those necessary for the Works.

6. Basic Design and Construction Plan

The typical tunnel section after the Rehabilitation Works is shown in Fig. 1. This has been prepared by the result of the Basic Design.

- (1) By full adoption of the updated new tunnel technology, it is possible that the tunnel structure does not undergo such deterioration again.
- (2) The loads to be considered at the Basic Design for this tunnel lining are to be counted as earth pressure, water pressure, self weight, impacts by the Canal expansion works and earthquake.

-The design has been carried out against all loads and safety has been confirmed.

-The lining design shall be strong enough to stand earth and water pressure which is always present.

During the Canal expansion, it can be assumed that soil medium deformation may occur.

-It has been designed that this deformation is to be transferred to the new lining, through the existing segment ring, fleece and waterproofing sheet, and safety has been confirmed.

Considering of the tunnel endurance, the concrete cover for the new lining has been decided as 70 mm.

- (3) It has been designed that the tunnel structure after the Rehabilitation Works shall be safe and sound enough for the final stage of the Canal deepening to a depth of -27.0m.

To clarify the safety of the widening and deepening of the Canal, the Safety Measurement Method has been studied and proposed to estimate the soil medium deformation by the detail dredging steps in the Canal expansion.

Through the analysis of this measurement results, a practical approach can be expected to be found out for work in the similar situation.

It is, of course, no doubt that the method will be very effective for the evaluation of the tunnel safety during the Canal expansion from the existing depth of 20.5m to the depth of 24.0m and further to 27.0m.

- (4) To prevent salty water leakage which is the cause of the tunnel deterioration, the waterproofing sheet of 2mm in thickness shall be installed before lining.
- (5) It is possible that the selection/procurement of the material in Egypt such as water, cement and aggregate for lining and road deck concreting shall be strictly safe against salt deterioration.
- (6) Concerning the drainage system, ground water shall be directed through a fleece of 7.0mm in thickness installed outside of the waterproofing sheet to the gutter at the invert and collected into Nadir sump tank.
- (7) The road deck, as shown in Fig.1, is structurally directly connected to the new lining and designed strong enough to stand earth and water pressure and the impact of the Canal expansion in addition to the traffic load.
- (8) As for the ventilation system, the following 3 systems have been examined. For these systems: (1) The transverse system, (2) the semi-transverse system and (3) the

semi-transverse system with the pilot shaft, evaluations have been done on ventilation performance, measures to prevent disaster, economy and maintenance.

Concerning the ventilation performance, all of the three types are available for use. However, from viewpoint of measures to prevent disaster, the Transverse system has been proved better than the others.

So, the Transverse system has finally been selected as the Ventilation System of this Tunnel.

The Transverse system contains fans both for air supply and exhaust, and is rather high in operation cost. However, in normal situation, the air supply fans only are to be operated. That is almost the same as the semi-transverse system in function. Meanwhile, it may be operated to deal with emergency situation like "Fire".

For the design of the ventilation system, PIARC*1) (1987) standard which is approved as an international standard is to be applied.

Concerning the traffic volume design, since it is not practical to anticipate correctly the future traffic volume based on the development plan for the Peninsula of Sinai, the maximum possible traffic capacity has been applied.

- (9) Concerning the related facilities, the evaluation results for Reuse or Replacement and the contents of Replacement are as shown in Table 1.

*1) PERMANENT INTERNATIONAL ASSOCIATION OF ROAD CONGRESSES

(10) It has been decided that the fresh water supply pipelines located in the Tunnel at present shall be moved out from the Tunnel in view of safety, economy, working efficiency of the Rehabilitation Works and the future maintenance. The route is to be on land but also includes one part crossing the bottom of Suez Canal. One line is to be installed first and filled with water. After commencement of the water supply operation of the 1st line, the existing pipes in the Tunnel shall be dismantled and installed as the 2nd line after being selected for reuse.

(11) The schedule of construction within 35 months.

Early Start : For the installation of the fresh water supply pipelines, the dredging for the portion crossing under the Canal and the excavation/earthing for the onland portion are to be directly carried out by S.C.A. as her scope of work in advance.

In order to shorten the Work Schedule, the followings are considered.

1) The Rehabilitation Works area especially for Road Deck is to be divided into 4 sections in the whole Tunnel length.

Because the most critical pass in the work schedule is the concreting for the Road Deck. And by this 4 parallel work application, the critical pass can be improved drastically.

2) Concreting steps are to be minimized especially for the portion of the lower lining and road deck.

- 3) By moving the fresh water supply pipelines from the Tunnel to outside, the working efficiency in the Tunnel especially for the portion of the lower lining and road deck which is the most congested and critical area is to be remarkably improved.
 - 4) By keeping one traffic lane open, the construction plan for the execution of the complicated and continuous work in the narrow Tunnel is to be proceeded with:
 - Centle working efficiency
 - Parallel concreting and concrete curing
 - Material flow in and out
 - Traffic restriction
 - 5) All centles and concrete forms are to be operated by the automatic motor driven wheel/rail system.
- (12) After the completion of the Rehabilitation Works, the maintenance for the Tunnel's safety and function keeping will be very important tasks. So, the Maintenance Method to prevent similar deterioration has been studied.
- Also, the Maintenance/Control Method for traffic restriction, leaked water collection/drainage etc. during the Rehabilitation Works has been developed.

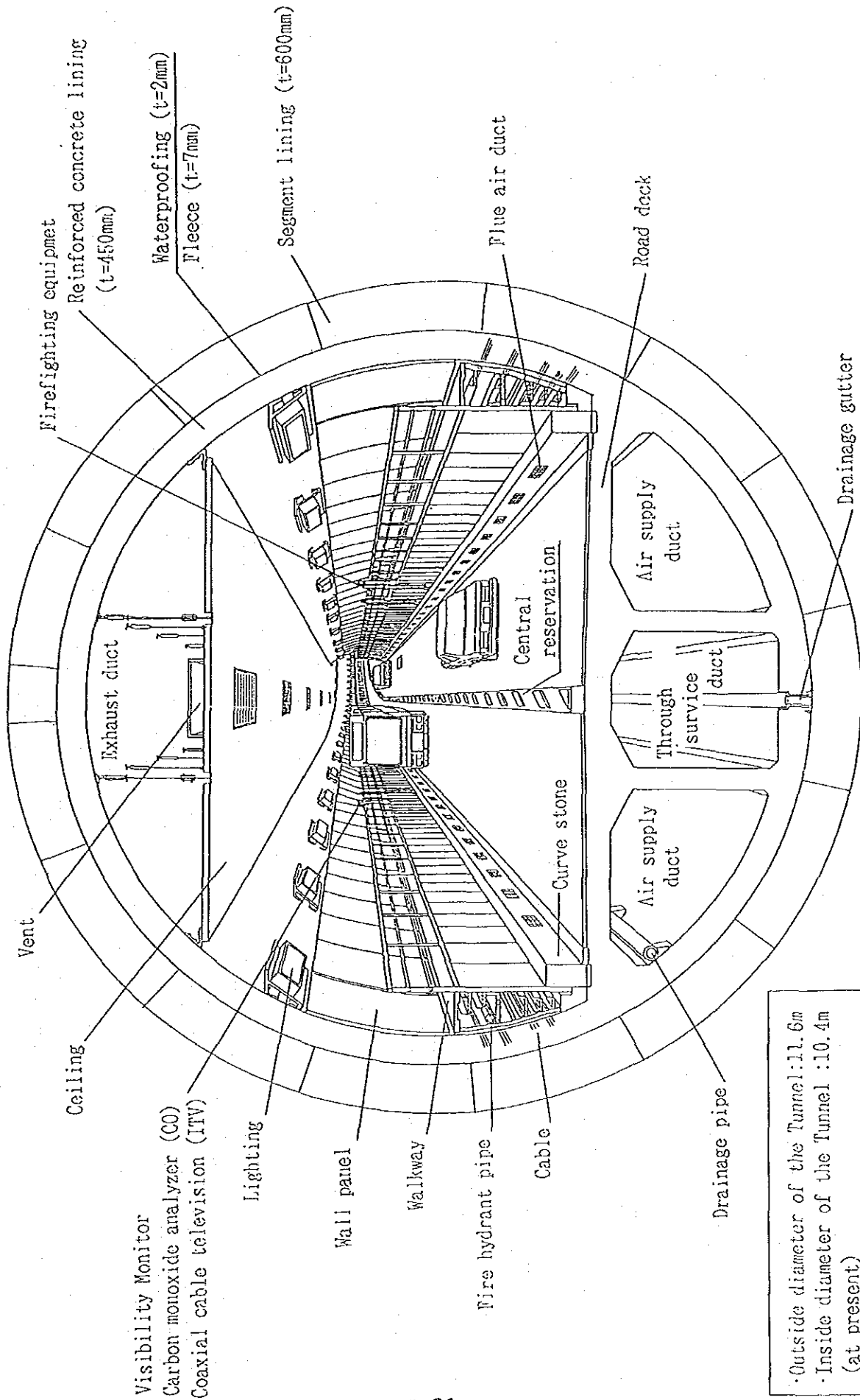


Fig.1 Typical Tunnel Section after Rehabilitation Works with Part Names

- Outside diameter of the Tunnel:11.6m
- Inside diameter of the Tunnel :10.4m (at present)
- Inside diameter of the Tunnel : 9.5m (after Rehabilitation Works)

Table-1 Evaluation as to Replacement or Reuse for Materials and Equipment for Related Facilities

Facilities	Evaluation
<p>1. Ventilation Exhaust Duct</p> <p>1) Ceiling panel</p> <p>2) Duct cowling</p> <p>3) Hanger</p> <p>4) Beam (Support frame)</p> <p>5) Coverings from wind leaking</p> <p>6) Diaphragm</p>	<p>REPLACE</p> <p>REUSE</p> <p>REUSE</p> <p>REPLACE</p> <p>REPLACE</p> <p>REPLACE</p> <p>1) Ceiling panels shall be replaced with new precast concrete panel due to difference in size.</p> <p>2) Duct cowling can be totally transferred onto the new ceiling.</p> <p>3) Hanger might be partially reused except components with damage and size change.</p> <p>4) The T-Shaped steel beam shall be abolished because of adherence of sealing mortar on the surface.</p> <p>5) and 6) Materials shall be replaced with fireproof ones.</p> <p>* Maintenance wheel for inspection is to be installed.</p>
<p>2. Wall panels</p>	<p>REPLACE</p> <p>The existing panel material is not fireproof and is to be replaced with an incambastable Silica acid Calcium panel.</p>
<p>3. Walkways</p> <p>1) Steel frame</p> <p>2) Deck plate</p> <p>3) Side panel</p>	<p>REPLACE</p> <p>REUSE</p> <p>REPLACE/ REUSE</p> <p>1) Steel frame composing the principal structure of walkway must be newly prefabricated because of difference in size of external shape due to the Rehabilitation lining.</p> <p>2) The existing deck plate can be reused by cutting off one and to meet the new size.</p> <p>3) The existing precast concrete panel can be reused by replacing the seriously damaged one, but the upper side covered with plastic panel shall be replaced with the galvanized steel plate to make it fireproof.</p>
<p>4. Pipe</p> <p>1) Drainage pipe</p> <p>2) Drain pipe</p> <p>3) Exhaust pipe</p> <p>4) Fire hydrant pipe</p>	<p>REPLACE</p> <p>REPLACE</p> <p>REPLACE</p> <p>REUSE</p> <p>Pipes except 4) shall be replaced with new ones because of salt deterioration and damage.</p> <p>* Drain pipe of 200φ presently arranged in the walkway space shall be moved to the upper corner of the fresh air duct.</p>
<p>5. Monitoring</p> <p>CO monitoring system</p> <p>VI monitoring system</p>	<p>REUSE</p> <p>REUSE</p> <p>This might be available for reuse after certifying the necessary properties by test and adjustment.</p> <p>Cable shall be replaced because of deterioration and shortage of cable length.</p>
<p>6. Safety Facilities</p> <p>1) Tunnel lighting (Except transformer and panel board)</p> <p>2) TV Camera</p> <p>3) Fire points</p> <p>4) Telephone System</p> <p>5) Radio Telephone System</p>	<p>REPLACE</p> <p>REUSE</p> <p>REUSE</p> <p>REUSE</p> <p>REUSE</p> <p>1) Tunnel Lighting system shall be changed into a new system as it is nearly useless and possible of the serious damage during the construction.</p> <p>2) to 5) These equipment might be available for reuse after overhaul, but cables shall be replaced with new ones.</p>
<p>7. Electrical Cables</p> <p>1) Cable Below Walkway</p> <p>2) 11kv Power Cable</p>	<p>REPLACE</p> <p>REUSE</p> <p>1) Cables put in the space under walkway are to be replaced due to deterioration and length change.</p> <p>2) 11kv Power Cable is to be reused.</p>

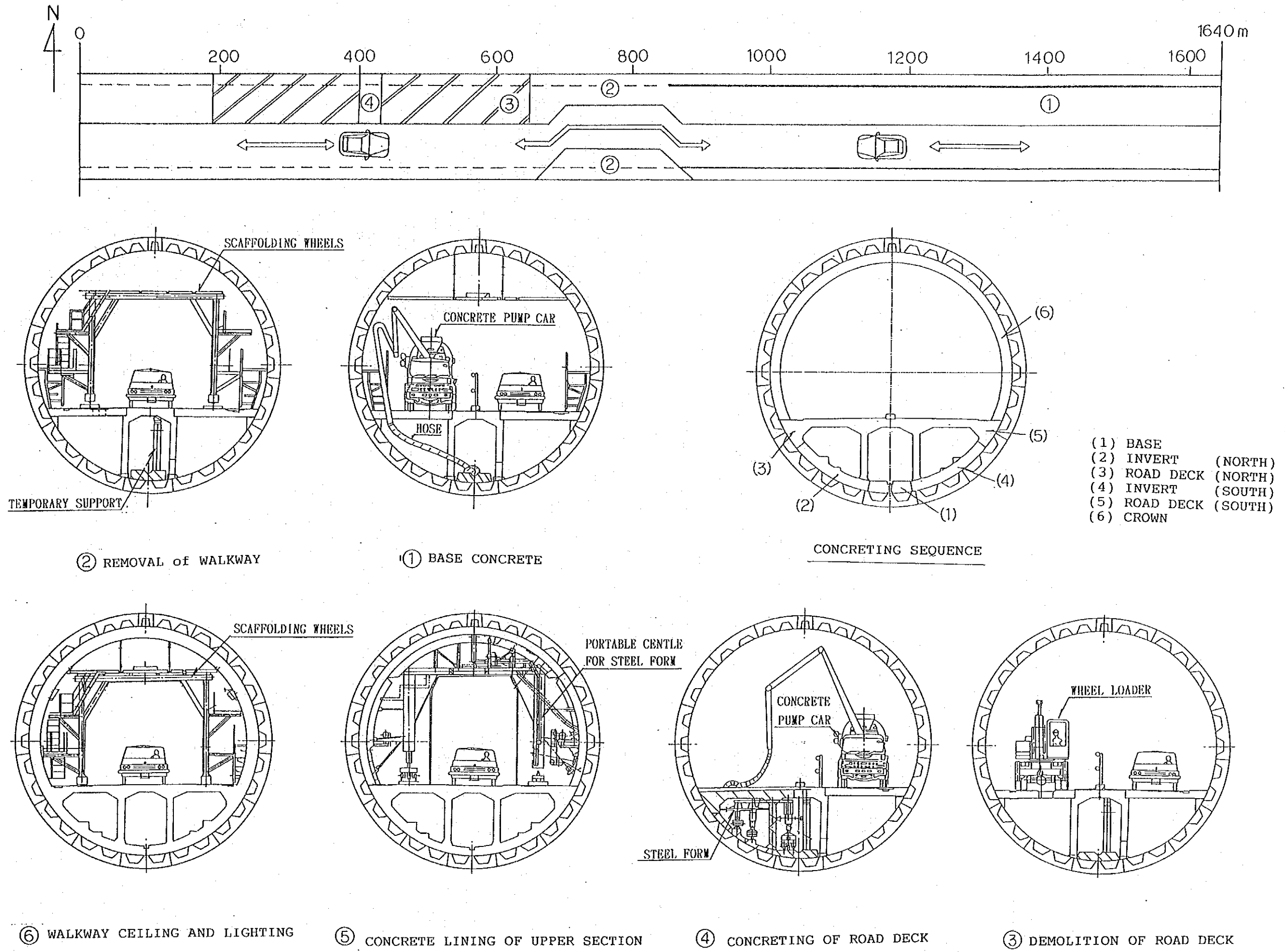


Fig. 2 Prospective View

7. Conclusion

The summary of the conclusion of the Basic Design Study for the Rehabilitation Works for Ahmed Hamdi Tunnel is as follows:

- (1) The Structural Strength of the Tunnel has been rapidly approaching the limit of ultimate strength and it is already in a difficult situation of keeping the soundness of the Tunnel in view of structural mechanics without reinforcement. Immediate execution of the Rehabilitation Works shall be carried out as quickly as possible.
- (2) By full adoption of the updated new tunnel technology, it is possible that the tunnel structure does not undergo such deterioration again.

With the high technology and management level of S.C.A., the Authority is surely able to execute the maintenance control method which has been proposed in this Basic Design Study after the completion of the Rehabilitation Works.

- (3) Concerning the road facilities, though walkways become narrow, it is possible to install cables and pipings there. As for the Ventilation system, the existing one can be adopted and the present size and level can possibly be kept after the Rehabilitation Works.

- (4) In the process of implementing the Five Year Social and Economic Development Program in Egypt and in order to achieve the National Objectives which aim at economic development in both West and East bank zone of Suez Canal and the Peninsula of Sinai, the role of the Tunnel is vitally important because it is the sole route of surface transportation connecting the Mainland of Egypt with the Peninsula of Sinai.

At present, the traffic speed is restricted within 20 km/h for the sake of traffic safety and only one lane operation can be kept open for maintenance work when required. As a result of this, the traffic capacity shall be severely reduced temporarily. However, it is possible to recover the Tunnel's soundness completely without any reduction of its road function as it was designed originally. Therefore, the Rehabilitation Works shall be carried out as soon as possible.

- (5) After the completion of the Rehabilitation Works, immediate execution of the Canal Expansion Project will be possible.

It can not only meet the international need for the Canal's marine transit of huge-sized vessels, but also enable S.C.A. to increase the transit revenue for the national economy of Egypt.

- (6) S.C.A. is spending 1,400,000 Egyptian Pounds annually on average for maintenance/survey of the Tunnel. After the Rehabilitation Works, this huge cost can be drastically reduced.

(7) In consideration of the expected economic and social effect as the result of this Rehabilitation Works, this project can be appraised as highly appropriate for Grant Aid, and it may serve as a very good example of Japan's contribution to development of friendly relationship between Egypt and Japan.

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Abbreviation

•the Authority	=	Suez Canal Authority (=S.C.A.)
•the Canal	=	Suez Canal
•Consultant	=	the Consultant who is to execute the Detail Design and Supervision for the Rehabilitation Works
•Contractor	=	the Contractor who is to execute the Rehabilitation Works
•E.C.	=	European Community
•Egypt	=	the nation of Egypt, Arab Republic of Egypt
•the Government of Egypt	=	the Government of Arab Republic of Egypt
•Japan	=	the nation of Japan
•JICA	=	Japan International Cooperation Agency
•S.C.A.	=	Suez Canal Authority
•Sinai Peninsula	=	the Peninsula of Sinai
•the Tunnel	=	Ahmed Hamdi Tunnel
•the Works	=	the Rehabilitation Works for Ahmed Hamdi Tunnel
•the Rehabilitation Works	=	the Rehabilitation Works for Ahmed Hamdi Tunnel
•CO	=	Carbon monoxide
•VI	=	Visibility
•IMF	=	International Monetary Fund
•PIARC	=	Permanent International Association Of Road Congress

CHAPTER 1

INTRODUCTION

Chapter 1 Introduction

Ahmed Hamdi Tunnel (hereinafter called the Tunnel) which is 1,650m in length, with an outer diameter of 11.6 m and inner diameter of 10,4 m, was completed in 1983. The Tunnel was constructed in the primary tunnel structure of shield tunnel of reinforced concrete segment, with the traffic capacity of 2 lanes for vehicles.

Since its opening in 1983, the Tunnel has up to now been put in use only for 9 years. However, an overall functional and structural deterioration is currently going on in the whole length of the Tunnel and above all, in the primary tunnel structure of concrete segments, reinforcement steel and road decks to a serious extent possibly due to the complicated factors such as leakage of salty water and others.

Being afraid of the above situation of the Tunnel, in 1989 and 1990, the Government of Egypt requested the Government of Japan to send two teams of experts in order to provide S.C.A., which has been responsible for the operation and maintenance of the Tunnel, with technical suggestion for repair of the Tunnel.

In reply to the request by the Government of Egypt, the Government of Japan decided to despatch some experts to Egypt, and JICA sent the technical cooperation team of experts to Egypt more than twice, and offered S.C.A. the technical suggestion on the Rehabilitation of the Tunnel after the field survey of the Tunnel.

In the above historical background, the Government of Egypt made an official request for Grant Aid for the Rehabilitation of the Tunnel to the Government of Japan on 13th August, 1990.

In reply to the official request for Grant Aid on the Rehabilitation Project of the Tunnel made to the Government of Japan by the Government of Egypt, Ministry of Foreign Affairs of Japan deemed the Project's objective roughly appropriate for Grant Aid by the Government of Japan and decided to hold a basic design study to examine the viability of the Project in Grant Aid System. Thus, JICA despatched the missions for study and field survey three times during the period from 23th June to 9th September, 1991. The missions were composed of:

- 1) Advance Team headed by Mr. Shigeru Nakamura, Director, Grant Aid Division, Economic Cooperation Bureau of Ministry of Foreign Affairs of Japan from 23th June to 4th July, 1991,
- 2) Consultant Team headed by Mr. Takayoshi Ohtsuka, Leader and chief consulting engineer of the team from 1st August to 9th September, 1991,
- 3) Follow up team headed by Dr. Akira Inokuma, Head of Tunnel Division, Public Works Reserch Institute, Ministry of Construction from 28th August to 4th September, 1991.

The Field Survey is intended to :-

- (1) survey, and collect data and information on the traffic situation of the Tunnel,
- (2) collect data and information on deteriorated situation of the Tunnel through site investigation on the tunnel structure and other related equipment,
- (3) collect samples of the existing concrete segment, materials for concrete structure such as coarse and fine aggregate, cement, and water for quality checking purpose,

- (4) survey on the geological conditions of the Tunnel,
- (5) make the instrumental survey of the Tunnel,
- (6) collect data and information necessary to prepare the method of construction, estimated schedule and costs of construction for the Rehabilitation Project of the Tunnel.

For the above purposes it is necessary, from the engineering points of view, to prepare the Basic Design Study for the Rehabilitation Project of the Tunnel.

During the period of the field survey, the mission had very significant technical discussions on the Project with the engineers concerned in the Authority and other related authorities in Egypt. The mission carried out detailed survey on the deteriorated tunnel structure and other related equipment of the Tunnel, including the geological and instrumental survey of the Tunnel and study of construction materials locally available in Egypt, and obtained necessary and sufficient data and information for the Basic Design Study for the Rehabilitation of the Tunnel.

After returning to Japan, the mission had a careful study of the data and information which were obtained during the periods of the field survey and prepared herewith the Report of Basic Design Study on the Rehabilitation of the Tunnel for S.C.A..

CHAPTER 2

BACKGROUND OF THE PROJECT

Chapter 2 Background of the Project

2.1 Background of the Project

2.1.1 Current Situation of Social and Economic Sector in Egypt

(1) Outline of Social and Economic Situation in Egypt

Historically, Egypt has been enjoying much benefit from the River Nile, and has been developed as an agricultural country.

However, Egypt has recently been confronted with the difficulty in obtaining enough cultivatable land to meet a rise in population by an annual rate of more than 1 million people.

Therefore, the population of cities, above all, the Metropolitan Districts of Cairo have been getting bigger and bigger, mainly due to the inflow of displaced farmers from all parts of the rural regions in Egypt. The majority of these displaced farmers have, unfortunately, very few opportunities of getting jobs, because the labour intensive industries in Egypt have not necessarily been growing so big in size as expected to absorb the above displaced farmers, and are in a position to be obliged to support themselves by subsidies from the Government of Egypt.

In Egypt, such agricultural products as cotton, fruits and vegetables have been produced mainly for exporting purpose to get hard currencies, which has caused a reduction of grain products, together with a decrease in self-supply of main foods for the people of Egypt, and ironically, Egypt is in a situation of having to depend on import of main foods.

In the above situation, it could not necessarily be denied that both of public and private sectors in Egypt are now confronted with difficulties of increasing in the chronic fiscal deficits and balance-of-payment deficits, together with an increase in the accumulated external debts which has amounted to 54 billion US Dollars (referred to census in 1988) and an inflation by an annual rate of 17 % possibly due to the depreciation of monetary value of Egyptian Pound.

Moreover, a total of National Income of 33.2 billion US Dollars was recorded in 1988, which was equivalent to the level of 650 US Dollars in terms of Individual Income.

(2) The Five-Years Social and Economic Development programme in Egypt

The Government of Egypt is now implementing the Five-Years Social and Economic Development Programme in Egypt in order to achieve the National Objectives which are categorized in three types of objective stated in the below :

- 1) The Social Objective of an Improved Quality of Life for all Egyptians, Lower Population Growth, and Reversal of the Brain Drain,
- 2) The Economic Objective of Industrial Development to Create Opportunities for Jobs and Export Earnings, with Foreign Aid Reduced and Private Sector Expanded,
- 3) The Strategic Objective of Food Self-Sufficiency, National Integration of Remote Districts.

In order to achieve the above National Objectives, the Government of Egypt intends to put a high priority on the domestic economy, and is in a course of reconstructing the public finance in compliance with the IMF's recommendation to raise the fares for public utilities, and cut down the subsidies by the Government of Egypt for people, and revitalizing

and expanding the domestic economy, which is encouraged by the governmental policies to promote the investments in private-sectors such as agriculture, stock-raising, tourism, construction, housing, manufacturing, and transportation and communication industries, and to open the door for the investments in Egypt by foreign countries. The concrete measures being taken to achieve the Economic Objective are as stated below :-

- 1) decentralize public sectors and publicly owned enterprises and improve the technology and productivity:
- 2) promote investment in private sectors: such as agriculture, stock-rising, tourism, construction, housing, manufacturing, transportation and communication;
- 3) open the door for investment in Egypt by foreign countries, and promote labour-intensive and export-intended types of industry:
- 4) obtain financial aid and cooperation from West European countries, Japan and neighbouring Arab countries.

In near future, the national economy of Egypt could be expected to be revitalized both in public and private sectors, and achieve steady economic growth and gradual increase in Gross National Product by an annual rate of 5.5 % on the average, which should contribute to modernization and national integration of Egypt.

2.1.2 Current Situation of Social and Economic Sector in the Peninsula of Sinai

AS far as the Peninsula of Sinai is concerned, the Government of Egypt is intending to develop above all such leading economic sectors as agriculture, manufacturing, mining and tourism in the Peninsula, in order to reorganize the current situation of a mono-crop agricultural (livestock) economy into a diversified, self-reliant and multi-sector economy in the Peninsula of Sinai and to create the opportunities for jobs for its people.

In addition to the above, the Government of Egypt is trying to achieve the strategic objective of establishing sound environment for permanent settlements in all parts of the Peninsula of Sinai under a desert climate and integrating the Peninsula of Sinai successfully into the Mainland of Egypt in economy, culture and politics.

- 1) In the field of agriculture and stock-raising, investments in irrigation and water-supply projects have been encouraged in order to expand the cultivatable land for permanent settlements from the Mainland of Egypt, to improve the land capability for farming and grazing and to increase in the productivity of barley, dates, olives, vegetable and perishables which are expected to be for both domestic consumption and export to the potential markets of neighbouring Arab countries. Investment in stock raising is encouraged as well.

By the way, the 1st stage of irrigation and water-supply projects of 27km in length has been under way in the northern part of the Peninsula of Sinai to extend and connect the Damietta branch of the River Nile and the 2nd stage is expected to commence in the coming future.

In the southern part of the Peninsula of Sinai, the irrigation and water-supply projects of 93km in length are under construction.

After the above irrigation and water-supply projects are completed, the cultivatable land is expected to increase by 400,000 feddans in the northern part, and 75,000 feddans in the central part from 1993 to 1997.

The literature source : The data who given by His excellency, the Governor of Ismailia, Professor Dr. Ahmed El-Gowely on the occasion of interviewing with His Excellency on 11th August, 1991.

- 2) In the field of manufacturing and mining industries, in order to decentralize manufacturing industries and create opportunities for jobs in the Peninsula of Sinai, the development projects in the fields of coal, petroleum and minerals such as gypsum, kaolin and glass sand have been under way, together with projects in the field of chemical manufacturing such as salt processing works, some of which are expected to have, from the locational points of view, a comparative advantage in trade with the Middle East and Mediterranean countries.

- 3) In the field of tourism, there has been a considerable increase in the number of domestic and overseas tourists who enjoy their holidays on the coastlines of Mediterranean Sea in summer, and Aqabah, Red Sea in all seasons even in the coldest and hottest months of the year.

In order to attract the above tourists, the development projects in accomodation facilities such as hotels and housings for tourists have been under way, together with the projects on special attractions provided by history and nature.

2.2 Traffic Situation Connecting the Mainland of Egypt with the Peninsula of Sinai and Importance of Ahmed Hamdi Tunnel

2.2.1 Means of Transportation Crossing Suez Canal

At present, the means of transportation connecting the Mainland of Egypt and the Peninsula of Sinai can be categorized in two types of ferry-boat system crossing over the Canal and the tunnel system crossing under the Canal.

- (1) The current situation of ferry-boat system and its advantages and disadvantages

The ferry-boat system crossing over the Canal is operated in six lines of the northern, central and southern parts of the Canal.

The advantages and disadvantages of the ferry-boat system may generally be stated as follows.

Advantages :

- 1) It is comparatively easy to increase loading capacity and the number of ferry-boats.
- 2) The operation cost is comparatively low.
- 3) There is no hindrance to the operation of ferry-boats by maintenance.
- 4) There is no restriction to the Expansion Projects of the Canal.

Disadvantages :

- 1) The hourly transit capacity is comparatively small.
- 2) In case of convoys passing the Canal, ferry boats have to stop their operation.

In the above situation, total capability of the ferry-

boat system could be said, from the functional points of view, to have reached its upper-limit.

- (2) The current situation of tunnel transportation and its advantages and disadvantages

The Tunnel is being operated as the sole route of surface transportation crossing the Canal connecting the Mainland of Egypt with the Peninsula of Sinai.

The advantages and disadvantages of the tunnel system may be stated as follows :

Advantages :

- 1) The hourly transit capacity is comparatively big.
- 2) There is no restriction to time available for operation.
- 3) There is no restriction to the Expansion Projects of the Canal.

Disadvantages :

- 1) There is restriction to passing through of the Tunnel by big-sized and heavy-weighted vehicles.
- 2) In case of maintenance of the Tunnel being necessary, stoppage of traffic is unavoidable in the Tunnel.

2.2.2 Importance of Ahmed Hamdi Tunnel

As stated above, there has been a gradual increase in the traffic of surface transportation connecting the Mainland of Egypt with the Peninsula of Sinai and the neighbouring countries in the Middle East due to economic development in the Peninsula of Sinai.

S.C.A has fulfilled an important role in operation and maintenance of the Tunnel, which has for 9 years ever since its completion, served as an indispensable route for the social and economic development in the Peninsula of Sinai and both West and East sides of the Canal.

The reason for the above is that the Tunnel is not only the sole route of surface transportation connecting the Mainland of Egypt with the Peninsula of Sinai, but also it has several sorts of fundamental life-lines such as fresh water supply pipelines through it, all of which are vital infrastructure for people in the Peninsula of Sinai.

According to the latest survey of the traffic situation in the Tunnel an averaged number of traffic of surface transportation of 1,100 to 1,500 vehicles per day in weekdays, and 1,800 vehicles per day in weekends, with a maximum traffic of 5,000 vehicles per day as a rare case, has been recorded. On average, 90 % of the vehicles passing through the Tunnel are categorized as passenger cars and 10 % are trucks and lorries.

In view of the above social and economic situation in all parts of the Peninsula of Sinai, it could not be an overstatement to say that the importance of the Tunnel, together with other networks of surface transportation all over the Peninsula of Sinai, is expected to be bigger and bigger due to regional development of the Peninsula of Sinai from now on.

2.3 Current Situation of the Tunnel

2.3.1 Deteriorated Situation of the Tunnel

Since its opening in 1983, the Tunnel has been put in use only for 9 years, during which, unfortunately, complicated troubles of functional and structural deterioration of the Tunnel appeared throughout the whole length of the Tunnel, possibly due to the complicated factors such as leakage of salty water and others. Above all, the primary tunnel structure of reinforced concrete segment and road-deck of the Tunnel has been damaged to a serious extent.

S.C.A. has taken necessary steps for temporary repairs of the Tunnel from time to time, all of which, however, could not necessarily be said to have effectively prevented further deterioration of the Tunnel.

Being afraid of the above deteriorated situation of the Tunnel, the Government of Egypt requested the Government of Japan to send technical experts to Egypt in order to offer an appropriate suggestion for repair of the Tunnel in 1989 and 1990.

In reply to the request by the Government of Egypt, the Government of Japan decided to despatch some technical experts, and Japan International Cooperation Agency (JICA) sent the technical cooperation team of experts to Egypt two times, and offered an appropriate technical suggestion on the Rehabilitation of the Tunnel to the Government of Egypt after the field survey of the Tunnel.

2.3.2 Technical Judgement on the Deteriorated Situation of the Tunnel and the Proposal on the Rehabilitation of the Tunnel by the Technical Cooperation Team from the Government of Japan

The outlines of the technical suggestion on the Rehabilitation of the Tunnel offered by the technical cooperation team of experts are stated below :-

- (1) Judging from the deteriorated situation of the primary tunnel structure of reinforced concrete segments and road deck in the whole length of the Tunnel, it is supposed that the structural strength as well as safety margin of the primary tunnel structure have been sharply going down nearly to a dangerous level.
- (2) The deterioration of the Tunnel is supposed to have been possibly due to the complicated factors such as leakage of salty water caused by the improper installation of reinforced concrete segments and thus resulting in a bad waterproofing quality of segment-joints.
- (3) The back-side of the primary tunnel structure of the Tunnel is found to be filled with gravel. The gravel layer, however, is supposed to have formed a permeable layer and allowed ground water to leak to the back-side of the primary tunnel structure in the whole length of the Tunnel.
- (4) According to the boring tests and observation of leakage of salty water from the primary tunnel structure, the water pressure is found to have no effects on the Tunnel.
- (5) According to the field survey and design calculation

of the primary tunnel structure, the actual earth pressure to the primary tunnel structure is found to be no less than 50 % of the design load.

However, the structural strength of the primary tunnel structure has been reduced partially to 50 % of the design load, mainly due to the deterioration of reinforced steel of concrete segments and the safety margin of primary tunnel structure is supposed to be sharply going down and will approach the dangerous level in the near future.

(6) Judging from the above deteriorated situation of the Tunnel, the most important suggestion for the Rehabilitation of the Tunnel could be to build up a waterproof tunnel structure inside of the existing tunnel structure, that is to say, reinforced concrete lining for the tunnel structure should be executed all over the inside of the existing tunnel structure, in combination with waterproof sheet to be covered between the reinforced concrete lining and the existing tunnel structure so as to prevent completely the leakage of salty water from the outside of the existing tunnel structure through its segment-joints.

(7) Three types of construction methods for the Rehabilitation of the Tunnel could be considered and prepared, in which the alternative method of D-3 is preferred by S.C.A., for the reason that a waterproof tunnel structure could be built up all over the inside of the existing tunnel structure, under the condition that 1 lane of traffic in the Tunnel is kept open day and night during the full period of construction for the Rehabilitation of the Tunnel.

(8) On the other hand, S.C.A. is now planning to expand the Canal. Dredging works for the Expansion Project

of the Canal, however, possibly could give such mechanical impacts to the structural strength of the existing tunnel structure as change in water and earth pressure, and accelerate the deterioration of the Tunnel to a serious degree, unless necessary and proper steps are taken in time to reinforce the structural strength of the Tunnel.

By the way, S.C.A. has announced the 2nd Expansion Project of the Canal (deepening and widening the existing Canal), the outline of which is stated below :

(1) The 1st stage

The 1st stage of the Expansion Project of the Canal (deepening the Canal from -19.5 m to -20.5m in depth and widening from 160m to 200 m in width at level of -11.0m) in the whole length of 162 km of the Canal has been underway, so that the Canal might have the capacity to enable a big-sized ship of 180,000 DWT with a draft of 56 feet to pass through the Canal.

The 1st stage has been completed except the southern part of the Canal, which is scheduled to be completed by the end 1993.

(2) The 2nd stage

The 2nd stage of the Expansion Project of the Canal (deepening the Canal from -20.5m to -24.0m in depth and widening from 200m to 226m in width) is now under the feasibility study to see if it has the capacity to enable a big-sized ship of 260,000 DWT with a draft of 68 feet to pass through the Canal, which is scheduled to be completed by the end of 1995.

(3) The future stage

S.C.A. is planning the future stage of Expansion

Project of the Canal to have to capacity to enable a big-sized ship of 500,000 DWT with a draft of 72 feet to pass through the Canal.

Besides, S.C.A. is planning the future stage of Double-lines of traffic in the Canal.

The western branch is planned to be assigned for south-bound convoys mainly in ballast, and the eastern branch relatively in big draft for north-bound convoys.

2.4 Outline of Request

2.4.1 Official Request for Grant Aid for the Rehabilitation of the Tunnel

In reference to the situation stated above, the Government of Egypt made an official request for Grant Aid for the Rehabilitation of the Tunnel to the Government of Japan on 13th August, 1990.

2.4.2 Content of Request

The Content of Request is the Rehabilitation of the whole length of 1,650m of the Tunnel by the method of reinforced concrete lining for tunnel structure all over the inside of the existing tunnel structure, in combination with waterproofing sheet to be covered between the reinforced concrete lining and the existing tunnel structure so as to prevent completely the leakage of salty water from the outside of the existing tunnel structure into segment-joints, under the condition that 1 lane of traffic is basically kept open day and night during the full period of construction.

2.5 Outline of the Project Area

2.5.1. Location of the Project Site

The project site is Ahmed Hamdi Tunnel, which is located at 17km north of the city of Suez, connecting the Mainland of Egypt with the Peninsula of Sinai.

2.5.2. Social and Economic Situation of the Project Site

As stated above, the project site is located on both West and East sides of the Canal, and the Peninsula of Sinai.

The Government of Egypt is intending to develop such economic sectors as agriculture, manufacturing, mining and tourism in the Peninsula of Sinai, in order to reorganize the current situation of a mono-crop agricultural (livestock) economy into a diversified, self-reliant and multi-sector economy in the Peninsula of Sinai and to create the opportunities for jobs for its people.

In addition to the above, the Government of Egypt is trying to achieve the strategic objective of establishing sound environment for permanent settlement in all parts of the Peninsula of Sinai under a desert climate and integrating the Peninsula of Sinai successfully into the Mainland of Egypt in economy, culture and politics.

CHAPTER 3

OUTLINE OF THE PROJECT

Chapter 3 Outline of the Project

3.1 Objective

The Government of Egypt and Suez Canal Authority are intending to rehabilitate the whole length of 1,650m of the Tunnel which is in a structurally and functionally deteriorated situation in order to improve the safety of traffics in the Tunnel and to recover the full traffic capacity initially designed for the Tunnel.

The objective of the Project is to build up the reinforced concrete lining and road deck for tunnel structure all over the inside of the existing tunnel structure, in combination with waterproofing sheet to be covered all over between the reinforced concrete lining and the existing tunnel structure to prevent completely the leakage of salty water from the outside of the existing tunnel structure into segment joints, and recover the full capacity of related equipment in a economical and effective way, in order to materialize the Authority's intention of the Rehabilitating the Tunnel.

3.2 Study and Examination on the Request

The social and economic effects of the Project for the national and regional development in Egypt are expected to be both direct and indirect, as stated below.

3.2.1 Direct Effects of the Project

The Project is directly expected to :

- (1) improve the safety of traffics in the Tunnel remarkably and recover the full traffic capacity initially designed for the Tunnel, 1 lane of which is now in a

situation of having to be periodically closed for maintenance for a considerable period,

- (2) save the labours and costs for maintenance of the Tunnel for S.C.A., which have been recorded to amount to 70 workers daily and 1,400,000 Egyptian Pounds annually on the average, but the effort of trying to improve the deteriorated situation of the Tunnel has substantially been in vain,
- (3) be very helpful for maintaining the structural safety of the Tunnel at a sufficient level to stand the change of earth pressure which might occur in the execution of dredging work for the Expansion Project of the Canal (deepening and widening the existing Canal).

3.2.2 Indirect Effects of the Project

In addition to the above direct effects, the Project is indirectly expected to :

- (1) enable the utilization of the full traffic capacity of the Tunnel as a main route of surface transportation connecting the Mainland of Egypt with the Peninsula of Sinai, which is expected to make a great contribution to the development and expansion of agriculture, manufacturing, mining and tourism in the Peninsula of Sinai as well as foreign trade with the neighbouring countries, all of which are oriented as the main objectives of regional development in the Peninsula of Sinai,
- (2) be very helpful for achieving the strategic objective of Egypt, which is intended to create permanent set-

tlements on the Peninsula and integrate the Peninsula of Sinai successfully into the Mainland of Egypt in economy, culture and politics,

- (3) make a great contribution to meet the international needs for the Canal's marine transit of huge-sized vessels which are expected to pass through the Canal in future after the Expansion Project of the Canal (deepening and widening the existing Canal) is completed. Also, it enables S.C.A. to increase transit revenue for the national economy of Egypt.

Judging from the urgent necessity of the Project from the of vitalizing the national and regional development in Egypt, together with the social and economical effects of the Project stated above, it could be reasonably emphasized that the Project is viable and recommendable for Grant Aid by the Government of Japan and there is no other alternative than rehabilitating the structure and function of the whole Tunnel in order to improve the safety of traffics in the Tunnel and to recover the full traffic capacity initially designed for the Tunnel as soon as possible.

3.3 Project Description

3.3.1 Executing Agency and Operational Structure

The local agency in Egypt which is now in charge of operating and maintaining the Tunnel is Suez Canal Authority (S.C.A.). As stated in the attached sheet, the responsible organization for operating and maintaining the Tunnel in S.C.A. is Works Department, which is composed of Director, Deputy Director and Manager of Ahmed Hamdi Tunnel with several engineering and supervisory staffs, and more than 150 workers, all of whom have accumulated many technical experiences for operating and maintaining the Tunnel. S.C.A. spends an annual expenditure of 1,400,000 Egyptian Pounds in average for its maintenance purpose.

3.3.2 Location and Condition of the Project Site

The project site is Ahmed Hamdi Tunnel, which is located at 17km north of the city of Suez and connects the Mainland of Egypt with the Peninsula of Sinai.

In addition, the project site is surrounded under a desert climate, but within relatively easy access to the city of Cairo by surface transportation. Power, fresh water and labour are locally available.

3.3.3 Outline of Facilities and Equipment of the Tunnel

The facilities and equipment of the Tunnel should basically be used for rehabilitating the whole length of the Tunnel which is in a structurally and functionally deteriorated situation, and the existing materials and equipment which could be regarded as possible to be re-used for the Tunnel, from the engineering points of view, should be re-used partially and/or totally, for rehabilitation purpose.

3.3.4 Operation and Maintenance Plan of the Tunnel

As stated above, the responsible organization for operating and maintaining the Tunnel in S.C.A. is Works Department.

Judging from their accumulated technical experiences for operating and maintaining the Tunnel, it could be said that the Tunnel could be operated and maintained solely by well-experienced staffs in Works Department of S.C.A. in compliance with the method of maintenance prepared by JICA.

3.4 Technical Cooperation

Judging from the level of technical experiences for operating and maintaining the Tunnel accumulated by S.C.A., it could be reasonably said that the Tunnel could be operated and maintained solely by Works Department of S.C.A., and there is no necessity of offering a technical cooperation in the operation and maintenance of the Tunnel by JICA.

CHAPTER 4

BASIC DESIGN

Chapter 4. Basic Design

4.1 Field Survey

The Basic Design Study is now situated in the stage of project formulation and preparation. It is divided into three phases, field survey, analysis in Japan and explanation of the Draft Report.

The Basic Design Study Flow Chart is shown in Fig.4.1.1.

The actual Execution Plan for the Basic Design Study is based on the process in this "Flow Chart".

First, the study started from the phase of field survey. The Execution plan for Field Survey is as in Table 4.1.1 and the itinerary is as Table 4.1.2.

The survey reports are shown in the following "4.1.1 Traffic Conditions of the Tunnel" through "4.1.7 Survey/Study of Construction Materials".

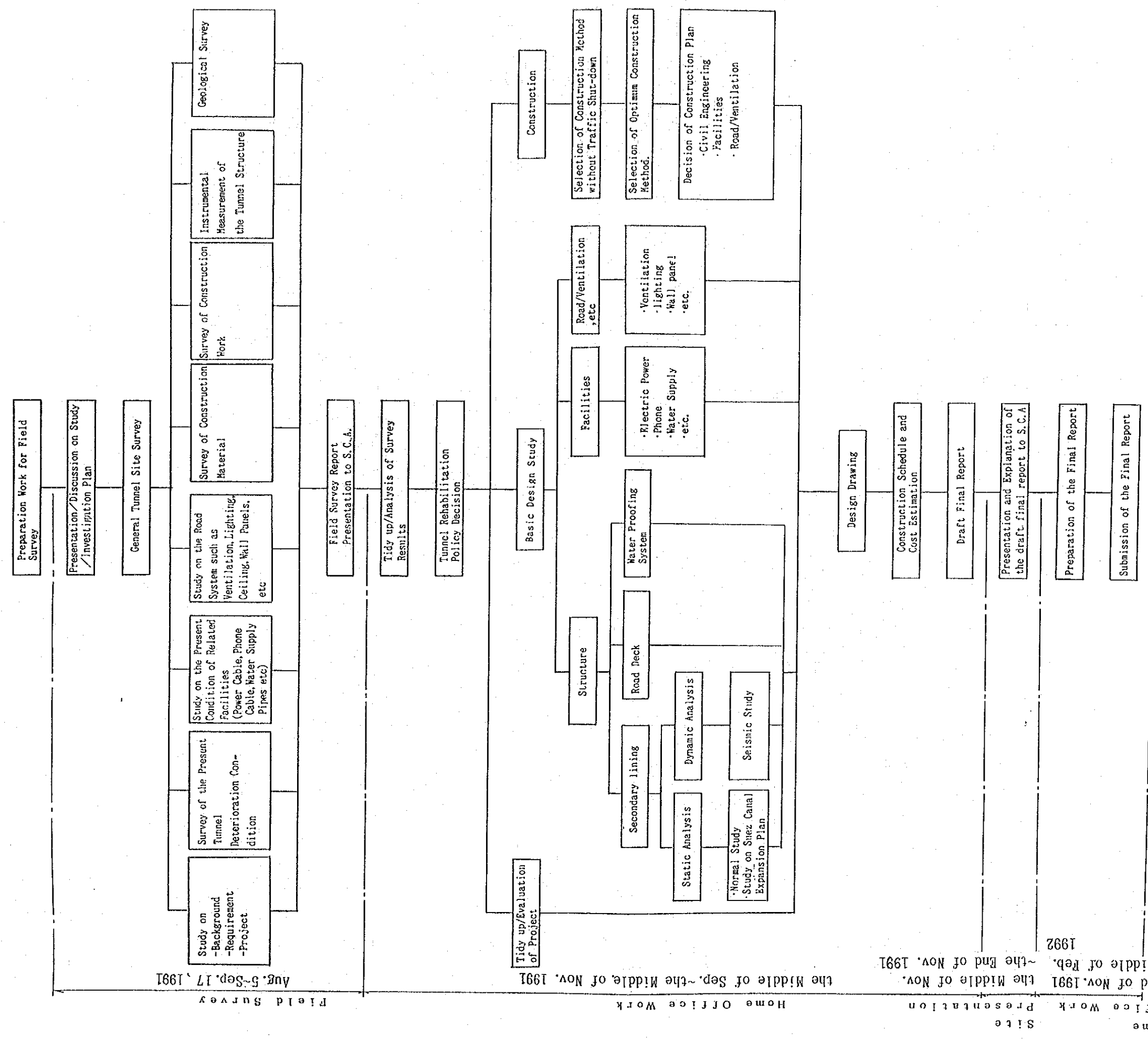


Fig. 1.1.1 Basic Design Study Flow Chart

Field Survey
Aug. 5-Sep. 17, 1991

Home Office Work
Tidy up/Evaluation of Project
the Middle of Sep. - the Middle of Nov. 1991

Home Office Work
Site Presentation
the End of Nov. 1991
the Middle of Nov. 1991
the Middle of Sep. - the End of Nov. 1991
1992

Table 4.1.1 Investigation Item List of Field Survey by JICA for Basic Design Study of AHMED HANDI TUNNEL (1/3)

No.	Study Item	Objectives	Contents
1	Presentation/Discussion on Study/ Investigation Plan	<ul style="list-style-type: none"> • To ensure effective and fruitful investigation and obtain full understanding of the Study contents by SCA 	<ul style="list-style-type: none"> • Presentation of INCEPTION REPORT and Discussion on Study/Investigation Plan • Confirmation of the Minutes of Discussion by Advance Team of June 27, 1991 - Negotiation of SCA support for Equipment, Labor, etc.
2	General Tunnel Site Survey	<ul style="list-style-type: none"> • To ensure understanding by Team Members of the updated situation 	<ul style="list-style-type: none"> - By the following route in the Tunnel Road Deck - On Ceiling - Fresh Air Supply Ducts - Trough Service Duct - Drain Water Pump - Ventilation System - Control Center
3	Study on - Background of the Plan - Requirement - Project	<ul style="list-style-type: none"> • To appraise whether or not the Project is suitable for Grant Aid by the Government of Japan 	<ul style="list-style-type: none"> - Collect the available data through hearing and discussion with the officials concerned (1) The status of the Project in the National and/or Regional Development Plan (2) The status of the Project in development project of the Peninsula of Sinai <ul style="list-style-type: none"> • The background of the Project and the contents of the request by the Government of Egypt • Survey of the activities of executive agency and related organization (3) The Transportation/Traffic policies in the Peninsula of Sinai and adjacent area, and the direct/indirect effect to the local people in the area (4) The relation between the Project and the expansion plan of Suez Canal (5) The result of the updated Traffic Condition and the Future Estimation (6) The Suez Canal Traffic Condition (7) The Suez Ferry Traffic Condition (8) The present/updated condition with the drawings and the other data for the size, location, and supporting of the existing equipment such as Electric Power Cable, Phone Cable, Water Supply Pipes, etc. (9) The Vendors list and the source of the construction material for the existing segments such as: <ul style="list-style-type: none"> Cement Water Coarse and fine aggregate Reinforcing steel bar and their actual recorded specification names and numbers. (ref. item 7 below)

Table 4.1.1 Investigation Item List of Field Survey by JICA for Basic Design Study of AHMED HANDI TUNNEL (2/3)

No.	Study Item	Objectives	Contents
4	Survey of the Present Tunnel Deterioration Condition	<ul style="list-style-type: none"> To confirm the tunnel's condition and the safety of the tunnel structure in present 	<ul style="list-style-type: none"> Review up-to-date reports on deterioration of the tunnel by SCA Observe the condition of concrete, reinforcing steel bar, joints, and bolts of the existing tunnel by visual inspection, records and photographs Measurement of stress reinforcing steel bar Measurement of the size of cracks appearing on segment and roac deck
5	Study on Present Condition of Related Facilities such as Power Cable, Phone Cable, Water Supply Pipes, etc.	<ul style="list-style-type: none"> To prepare an appropriate construction plan, together with a maintenance manual of the equipment 	<ul style="list-style-type: none"> Survey present conditions such as size, location, and supporting of the facilities Survey the method and place to remove the equipment for temporary purpose Survey the possibility for use of equipment after (re-)installation Holdings and Discussions with the officials concerned about the below items: <ul style="list-style-type: none"> working condition of each equipment shut off time for construction handling manuals and applicable standards temporary relocation of equipment during construction final layout of equipment after the completion of rehabilitation work re-usability of equipment, etc.
6	Study on the Road System such as Ventilation, Lighting, Ceiling, Wall Panels, etc.	<ul style="list-style-type: none"> To check the possibility of reinstallation of the existing equipment *1) for use 	<ul style="list-style-type: none"> Survey of the operation and maintenance situation <p>*1) Especially ventilation system is subject to detailed survey in such items as follows:</p> <ul style="list-style-type: none"> design requirement condition of the existing system, together with control system operating condition and efficiency of the existing system alternative ideas for ventilation
7	Survey of Construction Material	<ul style="list-style-type: none"> To present deterioration of the tunnel sturcture <p>(1) To check the quality of construction materials locally available (coarse and fine aggregate, cement, and water) (Concrete test will be performed in the detail design stage)</p> <p>(2) To check the existing segment of tunnel structure and the countermeasures to prevent the Tunnel from deterioration in rehabilitation as well as maintenance</p>	<p>(1) Survey the materials locally available</p> <ul style="list-style-type: none"> Coarse and fine aggregate: sieve analysis test, specific gravity and absorption test, salt content test, alkali-aggregate reaction test, and polarizing microscope observation, etc. Cement: test for specific gravity, particle size and stability, etc. Water: Analyze chemical contents <p>(2) Collect core samples from unused segment, and test and analyze carbonation depth, salt content, and observe distribution and mixing proportion of chemical contents in the unused segment by polarizing microscope</p>

Table 4.1.1 Investigation Item List of Field Survey by JICA for Basic Design Study of AHMED HANDI TUNNEL (3/3)

No.	Study Item	Objectives	Contents
8	Survey of Construction Work	<ul style="list-style-type: none"> To get market information required for cost-estimation and construction schedule 	<ul style="list-style-type: none"> Survey the constructional and financial capability of local contractors, construction equipment, skilled and unskilled workers, construction materials locally available and related laws and regulations, etc.
9	Instrumental Measurement of the Tunnel Structure	<ul style="list-style-type: none"> To obtain necessary data for construction plan To ensure the construction gauge inside the Tunnel To consider the structure of such concrete form, and the method of adjustment To check the safety of the tunnel structure 	<ul style="list-style-type: none"> Instrumental measurement of center line, level, and section inside the tunnel at an interval of approximately 40 meters
10	Geological Survey	<ul style="list-style-type: none"> To obtain soil parameters required for design of tunnel lining 	<ul style="list-style-type: none"> Obtain soil samples by boring and core soil sample from the tunnel by drilling, and perform standard penetration test, pore water pressure test, PS logging, water content test, unit weight test, unconfined compression test, and triaxial compression test, etc.
11	Overall Survey Coordination and Report Presentation to SCA	<ul style="list-style-type: none"> To organize Coordinate thoughts survey report for Survey report presentation and negotiation for the future Plan/Step. 	<ul style="list-style-type: none"> Hold Coordination Meeting with SCA Preset the Survey Report with available information/data and negotiation for the future Plan/Step

Special Note: Purchase shall be announced in advance 3 ~ 4 months ahead.

Table 4.1.2

Itinerary of Basic Design Study
on the Project for Rehabilitation of
AHMED HAMDY TUNNEL in Arab Republic of Egypt

No.	Item	Remarks												1991. 8												1991. 9											
		1		5		10		15		20		25		30		1		5		10		15															
①	Flight:Tokyo → Cairo via Paris	1	2																																		
②	Preparation for Study		3																																		
③	Courtesy Call to SCA in Cairo, Japanese Embassy and JICA			4																																	
④	Movement:Cairo → Ismailia (am) Courtesy Call to SCA (pm)			5																																	
⑤	Presentation / Discussion on Study / Investigation Plan				6																																
⑥	General Tunnel Site Survey					7	8																														
⑦	Study on Background, Requirement and Project							10		15																											
⑧	Survey of the Present Tunnel Deterioration Condition							10													29																
⑨	Study on the Present Condition of Related Facilities (Power Cable, Phone Cable, Water Supply Pipes, etc)							10													29																
⑩	Study on the Road System such as Ventilation, Lighting, Ceiling, Wall Panels, etc							10													29																
⑪	Survey of Construction Material				5																29																
⑫	Survey of Construction Work							10						25																							
⑬	Instrumental Measurement of the Tunnel Structure							10													29																
⑭	Geological Survey					7																17															
⑮	Report Presentation to SCA															30	1																				
⑯	Report to JICA and JpnEmb																2																				
⑰	Preparation for Demobilization																	4	5																		
⑱	Movement:Suez → Cairo																	5																			
⑲	Flight:Cairo → Tokyo via London																		7	9																	

Concrete Core Sampling

4.1.1 Traffic Conditions of the Tunnel

The latest survey of the traffic conditions of the Tunnel by S.C.A. in 1988 and 1991 and the 24 hours traffic survey of the Tunnel by the engineers on August 9th and 11th, 1991 during the period of field survey are shown in Tables 4.1.3 and 4.1.4.

According to the latest survey of traffic volume of surface transportation through the Tunnel in the recent 3 years in Tables 4.1.3. and 4.1.4., an averaged number of 1,100 to 1,500 vehicles per day in weekdays, and 1,800 vehicles per day in weekend, with a maximum traffic of 5,000 vehicles per day as a rare case recorded.

On average, 90 % of the vehicles passing through the Tunnel are categorized as passenger cars and 10 % are trucks and lorries.

However, it could be expected that there is much possibility of an increase in the traffic of surface transportation in the Tunnel from now on in view of a considerable increase in the number of permanent settlements and both domestic and overseas tourists in all parts of the Peninsula of Sinai.

Table 4.1.3 The Total Vehicles through Ahmed Hamdi Tunnel

Month	Year 1988/1989						Year 1989/1990						Year 1990/1991					
	Cars Private/Taxi	Pick up Buses Lorries	Trucks equipment	Cars accepted	Total		Cars Private/Taxi	Pick up Buses Lorries	Trucks equipment	Cars accepted	Total		Cars Private/Taxi	Pick up Buses Lorries	Trucks equipment	Cars accepted	Total	
JULY	26668	16432	2882	3474	49456		28359	16249	2516	3035	50159		30883	18626	2695	1487	53691	
AUGUST	25163	16894	3529	2973	48559		27769	16055	2895	2428	49147		27198	19425	3306	2143	52072	
SEPTEMBER	18198	15756	3349	3310	40613		18112	15467	2971	2542	39092		17039	13826	2982	2339	36186	
OCTOBER	14497	13847	3389	2571	34304		16153	12642	2818	2508	34121		13817	12719	2277	2054	30867	
NOVEMBER	11677	12937	4165	3053	31832		12772	12563	3010	2227	30572		13131	12728	2416	1134	29409	
DECEMBER	11672	12394	4968	2900	31934		12529	12576	3643	2193	30941		12382	12737	2205	1228	28552	
JANUARY	12533	12215	4482	2408	31638		14806	12738	3170	2624	33338		13698	12979	2358	2651	31686	
FEBRUARY	10422	11618	3916	2476	28432		11249	11772	3467	2081	28569		10612	10259	2166	1904	24941	
MARCH	14566	14225	4029	2994	35814		14002	14061	4067	2185	34315		14490	12445	1964	865	29764	
APRIL	13499	12923	4519	2159	33100		17200	13744	3166	1754	35864		18948	13409	1725	425	34507	
MAY	18935	13707	3162	2302	38106		14129	14797	3189	2335	34450		12959	14122	2543	1825	31449	
JUNE	23190	15258	3081	4023	45552 (1518)		23113	15866	2950	2936	44865 (1495)		20322	16133	2451	1379	40285 (1342)	
Annual Total (Per day)	201020	168206	45471	34643	449340 (1231)		210193	168530	37862	28848	445433 (1220)		205479	169408	29088	19434	423409 (1160)	
Proportion	%44.74	%37.43	%10.12	%7.71	%100		%47.19	%37.84	%8.49	%6.48	%100		%48.53	%40.01	%6.87	%4.59	%100	

Table 4.1.4 24 hours Traffic Survey in the Tunnel

date Vehicles	1991. 8. 9 (holiday)	1991. 8. 11 (Typical one day)
Small Cars	1 0 1 4	8 2 4
Bus & Pick-up	7 3 0	5 3 4
Lorry	7 6	6 1
Hevy Trucks	5 2	9 8
Total	1 8 7 2	1 5 1 2