## 別紙(4)　ＪＳＬにおける暴露試験施設の見学

Jurong Shipyard Limited（ＪＳＬ）

(1) 日　時

１９８５年８月１２日　１０時から１１時まで

(2) 場　所

Pulau Samulun, Jurong Town Singapore, 2262

Tel.　2651766

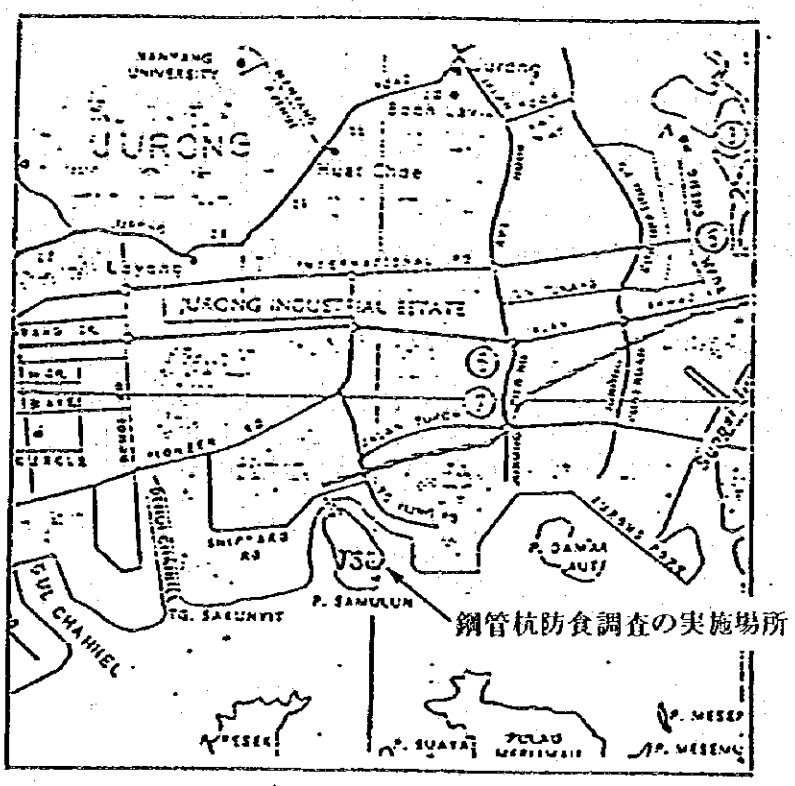
Telex.　RS24318

見学場所を図－C.1に示す。

(3) 参加者

日本側　蒔田（建設省），樫野（建設省），中山（運輸省），清宮（運輸省）

相手側　YU CHLNG-ONG（Production Manager）




図－C.1　見学場所

(4) 見学目的と背景

日本鋼管杭協会（主要メンバー，川鉄，久保田，新日鉄，日本鋼管，住友金属）は，東南アジア（フィリピンとシンガポール）での鋼管杭の海洋環境下での腐食を調査するため，暴露試験を１９８３年より実施している。シンガポールでは，ＪＳＬの協力を得て，ドルフィンの側に十四本の鋼管杭を用いて暴露試験を行っている。十四本の内訳については，表－C.1に示す。鋼管杭の設置状況を写真－C.2に示す。本施設は熱帯域における鋼材の腐食現象の把握について有益な手法と考える。

表C－1　試験杭の概要

TABLE: TYPES OF COATING FOR CORROSION-PROTECTS TEST PILES (Singapore)

| Remark | Type of Coating | Qty |
|---|---|---|
| S1--S4 | No treatment | 4 |
| S5--S6 | No treatment (Cathodic protection) | 2 |
| S7--S8 | Inorganic zinc-rich primer (75μ) + Coal tar epoxy (300μx3) | 2 |
| S9--S10 | Inorganic zinc-rich primer (75μ) + epoxy (200μx3) | 2 |
| S11 | Coal tar epoxy (300μx2) | 1 |
| S12 | Polyester coating with glass cloth (1.4mm) | 1 |
| S13 | Epoxy coating with glass-cloth (2.0mm) | 1 |
| S14 | Extrusion type polyethylene lining | 1 |
| | Total | 14 |

MINISTRY OF FOREIGN AFFAIRS,
SINGAPORE.

MFA/ASEAN/548/85

10 October 1985

Mr F Hibi
First Secretary (Construction)
Embassy of Japan
16 Nassim Road
Singapore 1025

Dear Sir

ASEAN-JAPAN COOPERATION ON SCIENCE AND TECHNOLOGY

In August 1985, a Japanese technical mission visited Singapore to discuss with officials of the HDB and PSA ways in which the Japanese can assist in the implementation of the programme on corrosion. The Japanese mission requested that a proposal be transmitted to them in order that a detailed agreement for the joint programme could be formulated.

2 In this connection, we would appreciate if you could transmit the proposals of the HDB and PSA to the Director of the Technical Cooperation Division, Economic Cooperation Bureau, Ministry of Foreign Affairs, Japan.

Yours faithfully

RICHARD GROSSE
for PS (FOREIGN AFFAIRS)

Housing & Development Board

Proposal for Expert Assistance in Corrosion

The Housing & Development Board (HDB) is the national housing authority in Singapore. It provides public and middle income housing, estate management services, promotes the advancement of construction technology and plays a supportive role in community development in public housing estates.

The Building & Development Division of the HDB has requested for Japanese technical assistance to study the problems of corrosion associated with its stainless steel water tanks (SST) (Grade AISI 304).

Stainless Steel Tank (SST) (AISI 304) have been in use in HDB apartment buildings since 1982, for storing portable water. To date, there are approximately 2500 SST in service.

SST is assembled by bolting the sectional panels (1220 x 1220 mm) together by bolt, nuts and internal stays of AISI 304. These panels were made of imported SS sheet from Japan but fabricated and welded at 4 corners locally.

Owing to the inherent feature of this design, there are many joints in contact with the stored water.

In the presence of high chloride ion contents and other contaminants, there was evidence of extensive corrosion at the horizontal joints on the bottom panels and corner joints where vertical and bottom panels met.

The bolt heads, the washers and the connector plates also shown corrosion.

However, the vertical joints on side panel did not show any significant corrosion.

There was no visible evidence of corrosion on joints and panels outside of SST.

The corrosion is suspected to be of crevice corrosion and in some instances of pitting corrosion.

There is therefore a need to protect SST from further corrosion.

Japanese expert assistance to study this problem is sought.

Port of Singapore Authority

The Port of Singapore Authority (PSA), is responsible for the provision and maintenance of port facilities and services and for the control of navigation within the port limits and its approaches.

It has been the concern of port engineers that some of the marine structures, especially those constructed in reinforced concrete, are not providing good service. They tend to crack and spall off after some time. It is believed that this could have been started off by the corrosion of steel reinforcements. The option would be to use stainless steel and thick concrete cover, which is expensive. The PSA therefore proposes that joint research be conducted with the Japanese, to study the problem of corrosion of steel in the marine environment.

February 13, 1986

Re. Japan-ASEAN Cooperation on Science and Technology

These papers are prepared for discussions between Singapore Authorities concerned and the Japanese team visiting Singapore on February 17, 1986.

Besides the contents in attached papers, both parties are expected to discuss in details of the Project as well as observations on sites.

Re. SD3

1. Background Information and justification for the Project

Corrosion of drinking water storage tanks is a serious problem in Singapore as well as in some other countries.

It may harm the human life and may cause a very large economic loss as it shortens the service life of the facilities. Development of the prevention technique against corrosion is therefore, one of the most important and urgent themes in Singapore.

Presently, no institutes have conducted research and development on corrosion resistance of stainless and how its reliability is affected by water and atmosphere in Singapore.

2. Objective

The Objectives of the Project are :

(1) To study the effect of atmospheric factors on corrosion of metals in the tropical zone;

(2) To evaluate metal durability by the most adequate experimental methods in relation to the results obtained in the practice in the field.

3. Research Work

A. Estimation of Corrosion Factors

Water Quality - PH, $Cl^-$ density, $SO_4^{2-}$ density, Hardness, Water flow velocity, etc.

B. Corrosion Monitoring Technique

Corrosion Rate

Analysis for corrosion products

C. Corrosion Preventive Technique

a) Electrolytic Prevention Method

Preventive Current Density

Dissolved Solid, Dissolved Oxygen, Water Temperature, Water Supply Quantity

Shape of Tank

Current Distribution, Electrode Disposition

Water Specific Resistance

Circuit Resistance

Electrode

Material

b) Painting Method

Resin Paint Coating (Epoxy Resin, Poly-acryl Resin, Prime Coat, Pot Life etc.)

c) Combination of Electrolytic Prevention and Painting Method

Relation on Prevention Current Density and Coating Materials

D. Confirmation of Corrosion Prevention Effect

Applying Test for Real Size Tank

Re. PSA

1. Background information and justification for the Project

Corrosion of concrete structures at marine environment is a serious problem in Singapore as well as in other countries. Concrete structures like wharves and piers are fundamental facilities in ports and they play an important role in berthing of ships and cargo handling. Therefore, in case wharves and / or piers are not in service because of their corrosion, activities in port are affected seriously and it would cause a very large economical loss as well as it takes a large amount of expense for repairing them. In fact corroded concrete structures of Port of Singapore Authority are being repaired at high cost. However, prevention and repair methods against corrosion have not yet been established and expertise and experience in corrosion studies is limited in Sigapore. It is important and useful for Singapore to develop prevention and repair methods against corrosion of concrete structures at marine environment.

2. Objectives

The objectives of the Project are ;

(1) To develop prevention and repair methods against corrosion of embedded steel bars in concrete structures of wharves and piers at marine environment.

(2) To prepare a manual and / or recommendations on the above.

3. Research Work

(1) Field investigations of existing concrete structures in Port of Singapore Authority.

(2) Exposure test.

(3) Examination of prevention and repair methods against corrosion.

(4) Work shops on corrosion problems

(5) Trainings

〔別　添　1〕

シンガポールにおける高置水槽の腐食

1. 腐食の概要

ＨＤＢの供与による共同住宅（約3,000棟）の屋上に設置された飲料水貯蔵用の高置水槽（SUS－304製）の水槽内部の底板が、全面に渡り腐食し対策に苦慮している。

このステンレス製水槽は、日立製鋼及び日本冶金などより購入したパネル組み立て式のもので、組み立ては現地の施工業者が行ったものである。

これらの水槽は、1981年に設置されたもので現在約7,500基残っており、少なくとも今後数年間は防食対策を行い使用したいとの意向である。

原因としては、水と一緒に水槽内に入った砂の堆積による通気差電池腐食によるものと考えられる。

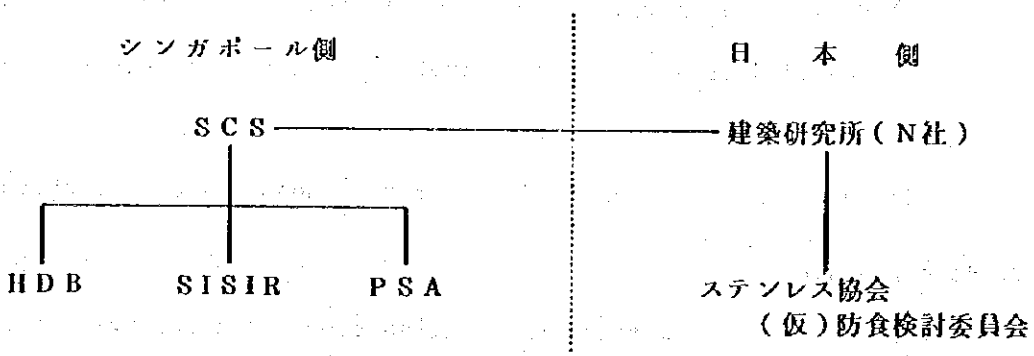
2. 防食対策

従来から鋼板製の水槽のほとんどが、塗装のみによる防食対策が行われて来たが、この種の水槽は長期にわたり連続的に使用することを余儀なくされるため、より長期的に、しかも保守管理が容易で経済性に優れた防食対策が必要とされている。

ＳＵＳ－304製の水槽では過去には塗装施工した経験もなく、従来から使用しているエポキシ樹脂にしても、付着力や塗料の溶出などの問題があり、腐食防止の可能性は少ないものと考えざるを得ない。むしろ、電気防食法による対策の方が可能性が高いものと思われる。

従って、今回の技術協力プロジェクトでは、外部電源方式の電気防食をまず第一に考え、併せて塗装のみによる防食、さらには電気防食と塗装の併用による防食を考えることとした。

3. 技術協力体制




(注) 1. 実験計画の立案、検討、収集したデータの解析、防食対策の立案は、ステンレス協会に設けた委員会で行う。
2. 実験は、シンガポール（主としてSISIR）で行う。

4. ＳＩＳＩＲについて

イ．概　要

SISIRは、各省庁の技術的問題についての指導的役割を果しており、ＨＤＢ、ＰＷＤ、ＰＳＡに対しても技術指導をしており、ＳＣＳにも技術課題を提案している。

今回の日本・アセアン科学技術協力に関するＨＤＢ、ＰＷＤ、ＰＳＡなどの研究に関しても当然その活動に参加する立場にある。

ロ．研究組織及び研究設備

組織は別図のようになっており、腐食関係の業務はMTACのＭＳが担当している。

ＭＴＡＣでは主としてプラスチック材料及び金属材料に関する各種の実験設備が整備されており、約２０名の職員がおり、人員及び設備の点では相当に充実した試験研究体制を持っている。しかし、金属材料の腐食促進試験設備としては小型の塩水噴霧装置があるので、かなり手薄のようである。なお、腐食電位、分極抵抗などの測定装置はなく、腐食促進試験も行えない。

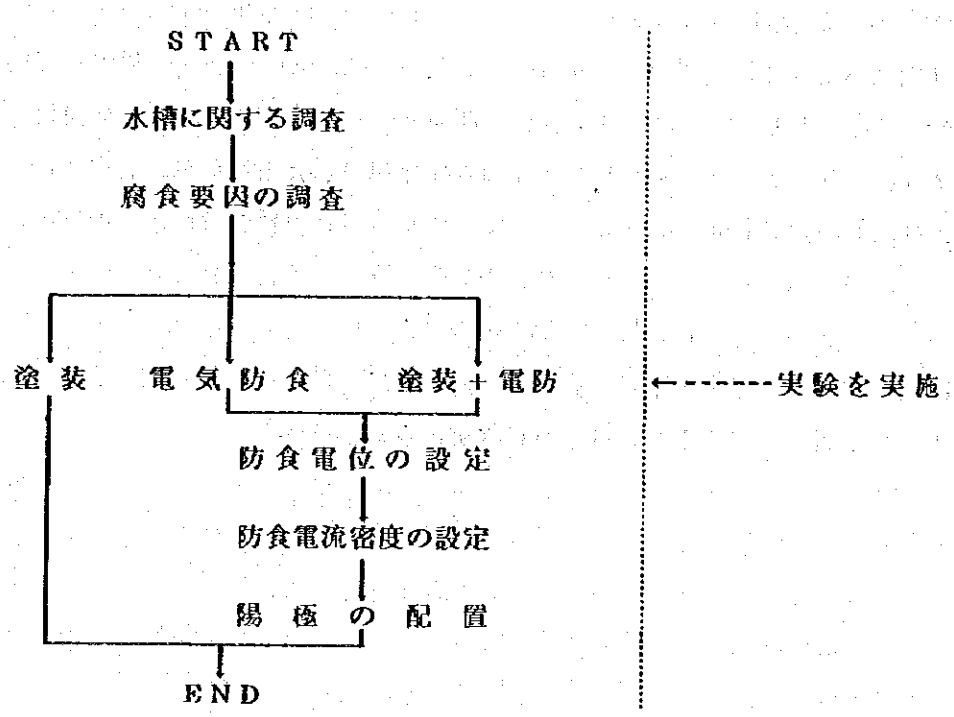
（所有機器）

金属試験片加工機、電子顕微鏡、疲労試験機、恒温恒室、強度試験機、組成分析機、インストロン、ＩＣＰ分析機、ガスクロ、ばくろ試験場、Water Heater など。

〔別　添　2〕

防食対策について

1. 防食対策案のための基本的な手順は次による。




図－1　防食対策フロー

2. 水槽に関する調査

シンガポールに据え付けられている受水槽及び高置水槽について、腐食状況、設置状況、使用状況、維持管理状況その他法的規制、基準などの調査を行う。

3. 腐食要因の調査

防食に必要な防食電位や防食電流密度は、その設置される環境の腐食性により異なるため事前に調査を行う必要がある。

イ．水質に関する調査

夏期と冬期に、水温、ＰＨ、ＣＬ－濃度、溶存酸素濃度、電気伝導度、流速（最大値）、金属イオンを測定する。

ロ．水槽底部の堆積物の調査

夏期と冬期に、堆積物の外観、臭気の程度、硫化物量、ＰＨ、酸化還元電位を測定する。

4. 防食法立案のための実験計画

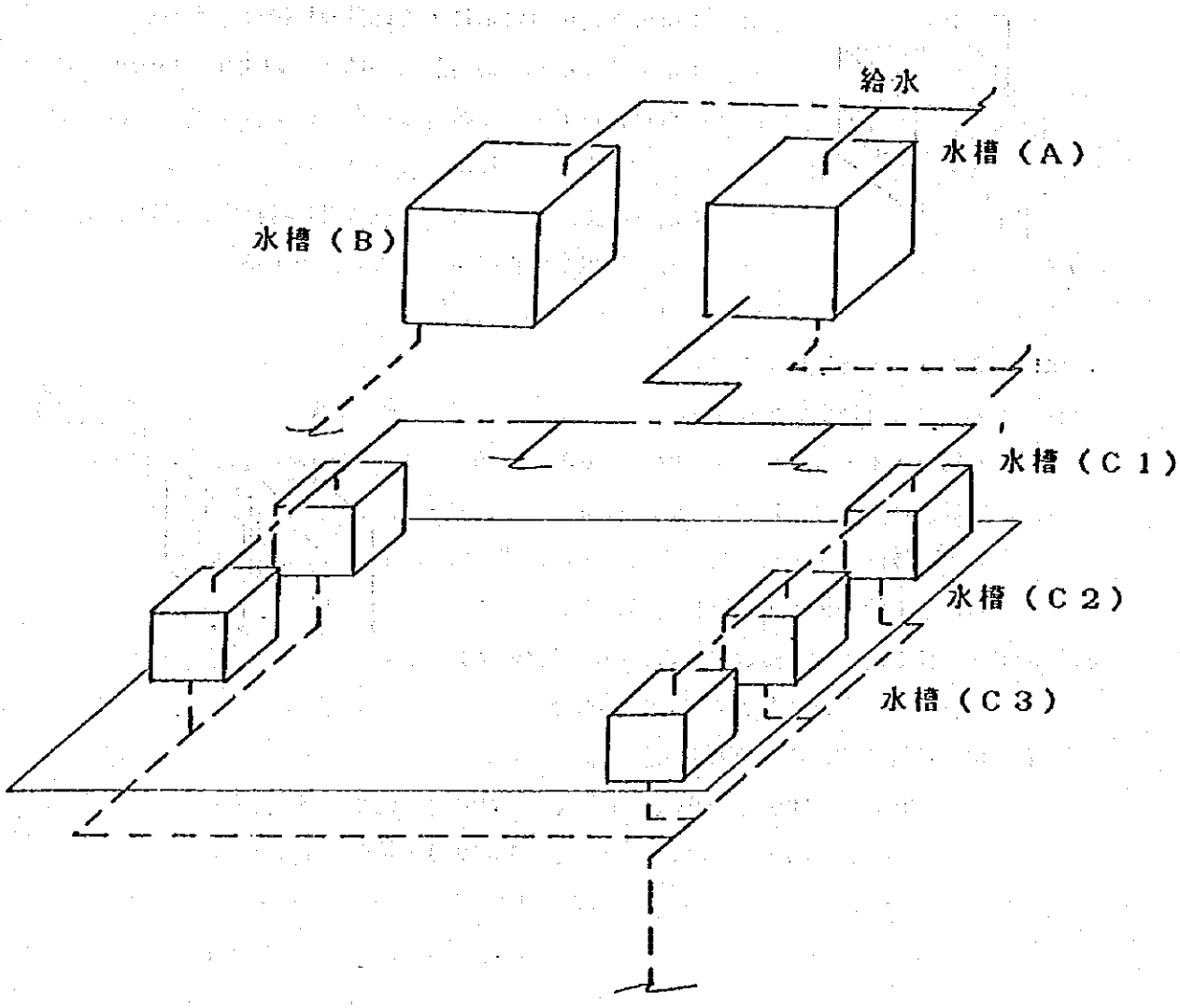
1）実験室レベル

イ．実験対象

ステンレス製水槽の腐食を防止するための実験対象は、次の表によるものとする。

| | 電気防食 | 防食塗装 | 電防＋塗装 |
|---|---|---|---|
| 実験室レベル | ○ | ○ | ○ |
| 実際の水槽での実験 | ○ | 1988年以降 | 1988年以降 |

ロ．実験装置概要




図－２　実験装置の全体概要

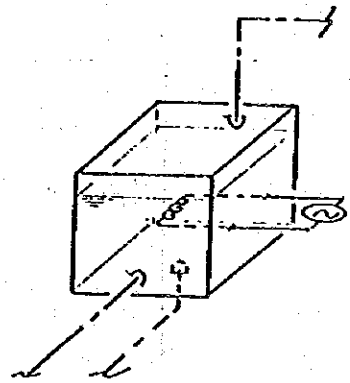
ハ、実験装置の詳細

a．水槽（Ａ）による実験

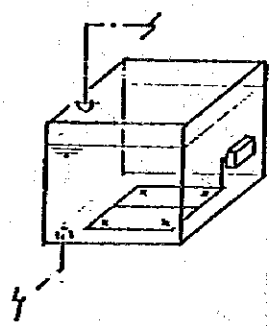
目的；水槽（Ａ）は実験装置への給水タンクであるが、併せて内部底板の腐食を再現させる。

仕様；水槽は、ＳＵＳ－304製パネル式（1000＊1000＊1000）とし、ヒーター（１０kW）組込みとする。

計測；月１回、腐食状況を観察する。



b．水槽（Ｂ）による実験



目的；塗装と電防の併用による効果の比較確認する。

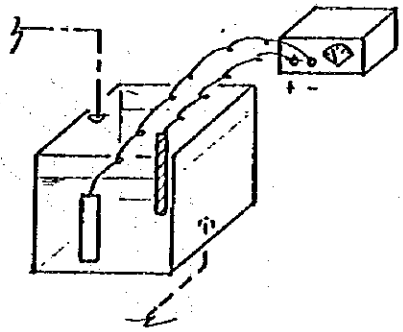
仕様；水槽はＳＵＳ－304製（1000＊1000＊1000）で、底板は、エポキシ塗装とし、白金－チタン電極により電防を施す。（電流密度は　　mA／㎡とする。）

計測；電位の変化をデータレコーダで自動計測、記録する。また、月１回程度底板の劣化状況を調査する。

c．水槽（Ｃ１）による実験（１２基）

目的；最も適した防食電位を求める。

仕様；水槽はアクリル樹脂製（500＊500＊500）試験片はＳＵＳ－304製（40＊250＊0.8t）で、塗装はエポキシ塗料とする。また、基準電極として飽和カロメル電極を用いる。

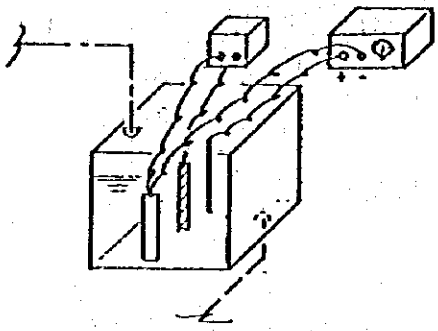


計測；２ヶ月１回程度、腐食状況の観察、塗膜の劣化状況の観察、試験片の重量測定を行う。

防食電位；次ぎに掲げる１０種類とする。

-300、-400、-500、-600、-700 mV（塗装　無）

-600、-700、-800、-900、-1000 mV（塗装　有）



d．水槽（Ｃ２）による実験（１０基）

目的；最も適した防食電流密度を求める。

仕様；水槽はＳＵＳ－304製（５００＊５００＊５００）で、電極は白金－チタン電極を用いる。

計測；防食電位の自動計測、記録を行うとともに塗膜の劣化状況を観察する。

電流密度；次ぎに掲げる１０種類とする。

40、60、80、100、120 mA／$m^2$（塗装 無）

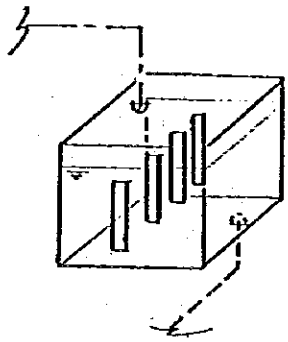
80、100、120、150、180 mA／$m^2$（塗装 有）

e．水槽（Ｃ３）による実験

目的；塗装による防食効果を確認する。

仕様；水槽はＳＵＳ－304製（５００＊５００＊５００）とし、試験片はＳＵＳ－304（４０＊２５０＊0.8ｔ）で、塗装無、エポキシ塗装、ポリウレタン塗装　各５枚とする。

計測；２ヶ月に１回程度、重量の測定、塗膜の劣化状況を観察する。



2）実水槽による実験

現在使用している水槽による実験で、塗料を使用する場合にはＳＵＳ－304との付着性、水中への溶出など衛生上の問題もあるため、当面は電気防食のみの試験を行う事とした。

イ．実験対象

腐食の進行が激しいと想定される水槽を５基選び、下記の仕様による電気防食を行い、水槽の形状、内部補強の構造などの影響について検討を行う。

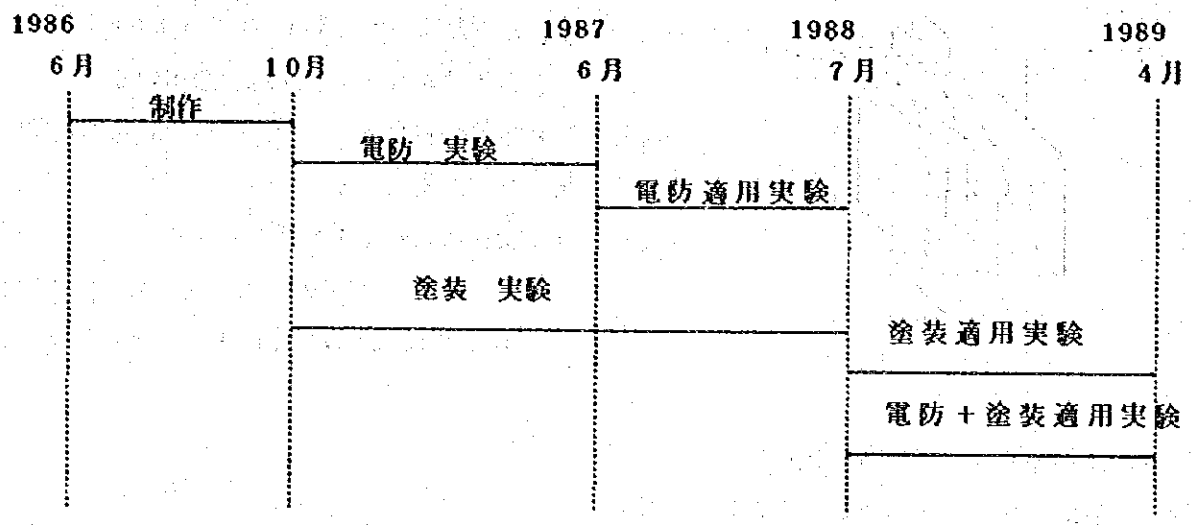
仕様；電極は、白金－チタン電極とし、槽底板に行う。

防食電位　－　　mV

電流密度　　mA／$m^2$

計測；１基５点について、２日に１回電位の測定を行う。なお、１基１点については設置後１５日間は連続測定、記録を行う。

5. スケジュール（案）


1986
6月
10月
1987
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1988
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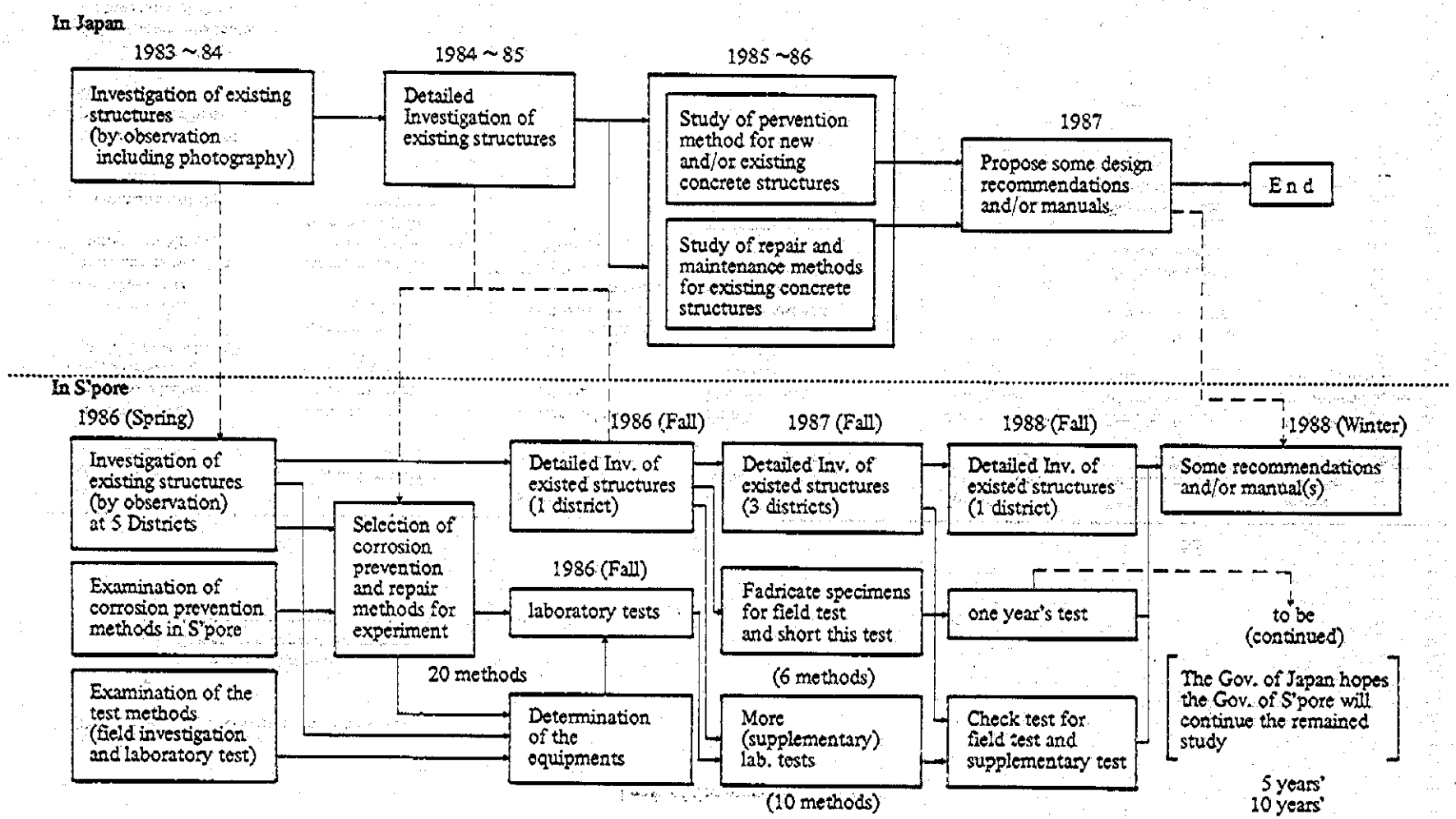
1989
4月
制作
電防 実験
電防適用実験
塗装 実験
塗装適用実験
電防＋塗装適用実験

A flowchart of the co-operation program for research of port & harbour concrete structures (S'pore and Japan)



## Draft of the schedule of experts

Three experts are necessary to be dispatched.

A: Corrosion engineering (for reinforced concrete)
B: Cement and concrete engineering
C: A specialist of investigation of existing structures

| 61 | | 62 | | 63 | | |
|---|---|---|---|---|---|---|
| Spring (about 3 weeks in S'pore) | Fall (about 2 months in S'pore) | Spring (about 2 weeks in S'pore) | Fall (about 2 months in S'pore) | Spring (about 2 weeks in S'pore) | Fall (about 2 months in S'pore) | Winter (1 week in S'pore) |
| Investigation of damaged wharves (by observation) (A, B, C especially (C) | Detailed Inv. of existing structure(s) (C) | Assure the plan in this year | Detailed Inv. of existing structures (C) | Assure the plan in this year | Detailed Inv. of existing structures | Propose recommendations and/or a manual(s) |
| Collection and examination of corrosion prevention methods in S'pore | Laboratory tests (A, B) | A, B, C It is better that the three experts are going to S'pore. If it's impossible, A should go | Fabricate specimens for field test and start this test. Laboratory tests | | One year's tests of exposed specimens | |
| Examination of the test methods | A: especially for existing structures B: especially for new structures | | A: for existing structures B: for new structures | | Check tests for one year's test | |
| Selection of corrosion prevention methods for experiment (A, B) | | | | | Supplementary laboratory tests | |
| Collect some information on the states of the art of ASEAN at an authorized organization (ex, ADB). | | | | | | |

## ASEAN JAPAN COOPERATION PROGRAMME ON MATERIALS AND TECHNOLOGY

## PROPOSED NATIONAL PROJECTS FROM SINGAPORE

PROJECTS

1. Study of corrosion in drinking water storage tanks and corrosion prevention methods:

– Housing and Development Board and Singapore Institute of Standards and Industrail Research

2. Concrete structures at ports and harbours:

– Port of Singapore Authority and the National University of Singapore

3. Training, workshops

## PROJECT 1

## ASEAN-JAPAN COOPERATION ON MATERIALS SCIENCE AND TECHNOLOGY

## PROPOSED NATIONAL PROJECT FROM THE REPUBLIC OF SINGAPORE

1. TITLE

Study of corrosion in drinking water storage tanks and corrosion prevention methods.

2. PROGRAM OF WORK

The following schedule of activities are proposed:

1987

(a) Investigation of corrosion in existing stainless steel water tanks.

(b) Planning and confirmation of research method for corrosion study.

(c) Review and selection of corrosion prevention methods for study.

(d) Acquisition of equipment.

1988

(a) Setting up of test rigs and equipment for laboratory and site monitoring of corrosion.

(b) Setting up of test equipment for study on corrosion prevention methods.

(c) Monitoring of corrosion and corrosion prevention methods to determine:

(i) rate of corrosion of existing stainless steel water tanks;
(ii) nature and cause of corrosion;
(iii) effective corrosion prevention method and
(iv) other matters of interest encountered during the investigation process.

1989

(a) Review of study and results.

(b) Conducting additional tests.

(c) Training course.

1990 PROGRAM OF WORKS ( CONT'D )

(a) Compilation and analysis of results.

(b) Drafting of recommendation and publication.

(c) Workshop/seminar.

3. CO-ORDINATION OF WORK

Facilities and other ancillary supports for the research work shall be provided by HDB and SISIR as follows:

(a) HDB shall provide facilities for site test.

(b) SISIR shall provide facilities to house laboratory equipment and laboratory test rigs, used for the project.

(c) Monitoring work shall be jointly carried out by HDB and SISIR.

(d) Research and development works shall jointly carried out by HDB and SISIR.

(e) SISIR shall provide office for the Japanese experts.

4. MANPOWER

One long term Japanese expert for 3 years and 2 short term corrosion specialists will be in Singapore to participate with the local counterparts in the various aspects of field inspection, investigation and laboratory study.

The number of local professionals participating in the research works are as follows:

(a) HDB – 2 Engineers and 1 Contract Technical Officer

(b) SISIR – 2 Scientists and 1 Contract Technical Officer

It is proposed that the Technical Officers only, shall be financed by the project for a period of 3 years at an estimated cost of US$80,000/–.

5. EQUIPMENT

(a) Steel test tank
(b) Plastic test tank
(c) Potentiostat
(d) Electrometer
(e) Amper meter
(f) Point micrometer
(g) Oxygen meter
(h) Electrolytic conductivity meter
(i) Immersion test apparatus
(j) Accelerated corrosion test apparatus
(k) Ion meter
(l) Chemical balance
(m) Temperature controller
(n) Liquid flow controller

(o) Cathodic protection test apparatus
(p) Coating thickness measurement apparatus
(q) Ultra sonic coating measurement apparatus

The estimated cost of equipment is US$250,000/–.

6. OTHER ITEMS

A sum of US$50,000/– is to be provided for consumables such as chemicals, micrographic prints, monitoring charts, probes and accessories.

A sum of US$35,000 is to be provided for transportation of experts and field monitoring works.

A sum of US$20,000 is to be provided for chemical analysis and testing.

7. SUMMARY OF COST

| | | US$ |
|---|---|---|
| (a) | Contract Technical Officers | 80,000 |
| (b) | Equipment | 250,000 |
| (c) | Consumables | 50,000 |
| (d) | Transportation for experts and field monitoring | 35,000 |
| (e) | Chemical analysis and testing | 20,000 |
| | TOTAL | US$435,000 |

The above estimates do not include the cost for experts, training attachment and visits to Japan. Attached is a detail breakdown of the total cost for the project (i.e. inclusive of those cost that would be incurred by HDB and SISIR).

8. HDB & SISIR PARTICIPATION

HDB

| | | |
|---|---|---|
| First Engineer | – | Co-investigator |
| Second Engineer | – | Support Engineer (field investigation) |
| Contract Technical Officer | – | Field monitoring |

SISIR

| | | |
|---|---|---|
| First Scientist | – | Co-investigator |
| Second Scientist | – | Support Researcher (laboratory study) |
| Contract Technical Officer | – | Field & laboratory monitoring work |

The laboratory facilities fo the Department of Metal Technology, SISIR will be available for laboratory studies of the project.

## DETAIL BREAKDOWN OF TOTAL ESTIMATED EXPENDITURE

| | | CONTRIBUTION FROM JAPAN | COUNTERPART HDB | COUNTERPART SISIR |
|---|---|---|---|---|
| | | US$ | US$ | US$ |
| (a) | Technical Officer | 80,000 | | |
| (b) | Equipment | 250,000 | | |
| (c) | Consumables | 50,000 | | |
| (d) | Transportation | 35,000 | | |
| (e) | Testing, Analysis | 20,000 | | |
| (f) | Engineers & Scientists | | 100,000 | 100,000 |
| (g) | Laboratory/Office space allocation | | | 30,000 |
| (h) | Repair for equipment | | 5,000 | 5,000 |
| (i) | Existing site facilities | | 5,000 | |
| (j) | Other Admin Support | | 1,500 | 1,500 |
| | SUB-TOTALS | 435,000 | 111,500 | 136,500 |

## PROJECT 2

## ASEAN-JAPAN COOPERATION ON MATERIALS SCIENCE AND TECHNOLOGY

## PROPOSED NATIONAL PROJECT FROM REPUBLIC OF SINGAPORE

### 1. TITLE

Concrete structures at ports and harbours.

### 2. PROGRAM OF WORK

The following schedule of activities are proposed:

1987

(a) survey of existing structures at PSA,
(b) review existing methods of corrosion prevention and repair,
(c) planning of laboratory and field exposure investigations,
(d) selection of repair methods for investigation,
(e) literature survey on corrosion prevention and repair methods for structures at ports and harbours,
(d) purchase of equipment.

1988

(a) detailed investigation of representative structures at PSA,
(b) initiating laboratory and field exposure tests,
(c) training course.

1989

(a) detailed investigation of representative structures at PSA,
(b) one-year results of laboratory and field exposure tests,
(c) training course.

1990

(a) two-year results of laboratory and field exposure tests,
(b) drafting of recommendations and/or manuals,
(c) workshop and/or seminar.
(d) visit to ports and harbours in Japan

### 3. FIELD INVESTIGATIONS

PSA will provide facilities for inspection of existing structures by experts and local engineers (from PSA and NUS) and for setting up of exposure sites. Laboratory tests will be carried out at NUS (and at PSA, if a laboratory is set up).

## 4. MANPOWER

Three experts from Japan will be visiting Singapore for short stays to participate with local engineers in the various aspects of field inspection and investigation. The number of local engineers is as follows:

(a) from PSA – 3 engineers
(b) from NUS – 5 staff members and 2 research assistants

It is proposed that the two Research Assistants only be financed by the Project for a period of 3 years (estimated cost US$80,000/–).

## 5. EQUIPMENT

(a) Concrete cover – digital covermeter,
(b) Strength evaluation (NDT) – PUNDIT, Windsor Probe, and Schmidt Hammer,
(c) Strength evaluation – portable coring machine,
(d) Corrosion – automatic potential measurement system, electrochemical apparatus (polarisation resistance),
(e) Seawater – chemical analysers for salts in water,
(f) Carbon dioxide – carbon dioxide environment tester,
(g) Water content meter,
(h) Water-cement ratio analyser,
(i) Length change comparator,
(j) Camera – with telephoto and wide-angle lens,
(k) Diffusion cells (to be fabricated in laboratory),
(l) Corrosion testing tank (to be fabricated in laboratory),
(m) Other measuring equipment e.g. pH meter etc.
(n) Environment chamber
(o) Fume cupboard for chemical analysis

The estimated cost of equipment is US$260,000/–.

## 6. OTHER ITEMS

(a) A sum of US$30,000 is to be provided for consumables such as photographic and photocopying, chemicals and materials for laboratory and field exposure tests.

(b) A sum of US$10,000 is to be provided for transportation cost in relation to the field exposure tests.

(c) A sum of US$30,000 is to be provided for chemical analyses of hardened concrete for salt penetration and carbonation.

(d) A sum of US$60,000 is to be provided for repair materials and for preparation of structural elements for repair.

The total under other items is US$130,000/–.

## 7. SUMMARY

| | | Contribution from | | |
|---|---|---|---|---|
| | | Japan | PSA | NUS |
| | | US$ | US$ | US$ |
| (a) | Research manpower | 80,000 | 30,000 | 70,000 |
| (b) | Equipment | 260,000 | 50,000 | 100,000 |
| (c) | Consumables and repair materials, etc. | 130,000 | – | |
| | Total | US$470,000 | 80,000 | 170,000 |

## 8. NUS PARTICIPATION

The following staff members will participate in the Project:

| | | |
|---|---|---|
| (a) | Assoc. Prof. C T Tam | – coordinator |
| (b) | Dr Y H Loo | – exposure tests |
| (c) | Dr K C G Ong | – field investigations |
| (d) | Dr R Sri Ravindrarajah | – exposure tests |
| (e) | Dr K H Tan | – field investigations |
| (f) | 2 Research Assistants (to be recruited) | – all activities |

The Research Assistants will be expected to register for a higher degree based on the work performed during the Project period.

The laboratory facilities of the Department of Civil Engineering will be available for laboratory studies to be carried out as part of the Project. These facilities include Universal Testing Machines, e.g. 500 kN Instron servo-controlled machine, Compression Testing Machines, Concrete Laboratory equipment and Data Loggers. The estimated value of the facilities used for the project is US$100,000.

## 9. PSA PARTICIPATION

1987.08.03

## PROJECT 3

## TRAINING COURSES, WORKSHOPS AND ATTACHMENTS

### TRAINING COURSES

Two training courses on corrosion prevention are planned to be conducted in Singapore during the project period. These are intended for participation by all ASEAN countries. A three day program for 25 participants (10 from Singapore and 3 each from the other 5 ASEAN countries) on each occasion is estimated at a cost of US$20,000.

### WORKSHOP: Seminar

A two day workshop to be held at the end of the project period is planned for 50 participants (30 from Singapore and 4 each from the other 5 ASEAN countries). This is estimated to cost US$30,000.

### ATTACHMENTS

It is proposed that a visit be arranged for 16 ASEAN engineers (6 from Singapore and 2 each from the other 5 ASEAN countries) to observe the corresponding program of activities that have already begun at ports and harbours in Japan. This may be for a period of 14 days (inclusive of travelling) and is estimated at a cost of US$60,000.

Total cost:

| | |
|---|---|
| Training courses | US$40,000 |
| Workshop | US$30,000 |
| Attachments | US$60,000 |
| | US$130,000 |