Ministry of Agriculture and Irrigation
The Republic of the Union of Myanmar

THE PREPARATORY SURVEY REPORT ON THE PROJECT FOR IMPROVEMENT OF MACHINERY FOR REHABILITATION OF POLDER EMBANKMENT IN AYEYAWADY DELTA IN THE REPUBLIC OF THE UNION OF MYANMAR

AUGUST 2012

JAPAN INTERNATIONAL COOPERATION AGENCY

SANYU CONSULTANTS INC

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PREFACE

Japan International Cooperation Agency (JICA) decided to conduct "The Preparatory Survey Report on the Project for Improvement of Machinery for Rehabilitation of Polder Embankment in Ayeyawady Delta" and entrust the survey to Sanyu Consultants Inc.

The survey team held a series of discussions with the officials concerned of the government of The Republic of the Union of Myanmar, and conducted a field investigation. As a result of further studies in Japan, the present report was finalized.

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

Finally, I wish to express my sincere appreciation to the officials concerned of the Government of The Republic of the Union of Myanmar for their close cooperation extended to the survey team.

August 2012

Teruyoshi KUMASHIRO
Director General,
Rural Development Department
Japan International Cooperation Agency

Summary

1. National Land, Natural Conditions and Socio-Economic Conditions

Republic of the Union of Myanmar (hereinafter referred to as "Myanmar") is located in the western edge of South-East Asian Continent, neighbored by Thailand and Laos in the eastern side, by China in the northeast as well by India and Bangladesh in the western side. It has the territorial area of about 680 thousand square kilometer with its population of 58.84 million (as of 2009, estimated by Asian Development bank), consisting of 7 divisions and 7 districts. Ayeyawady River flows from the northern territory to the south through the central area between two mountain ranges running southward in eastern as well as western part of the country, forming a plain in its watershed area.. It is a large river with a total length of 2,400 km, with its catchment area of 410 thousand square kilometer, while the lowland, marshy area in its extreme downstream is called Ayeyawadi Delta extending over 31,000 km^2, serving as the largest rice bowl in Myanmar.

The central and southern parts of the territory belongs to tropical zone while the northern part thereof does to temperate zone, thus the territory is characterized as a whole by humid climate with annually prevailing high atmospheric temperature. Its annual climate is divided into rainy and dry seasons owing to two monsoon winds, south-westerly and north-westerly, where the rainy season falls during the period from May to October, and the dry one covers during the period from November to April. Annual precipitation ranges 600～800 mm in the central dry zone, while that in Ayeyawady Delta it reaches 2,500 mm. Precipitation during dry season reaches almost null because of dry north-westerly monsoon wind. As to atmospheric temperature, the annual average of maximum temperature in the largest city of Yangon ranges 33～40℃ and that of minimum does 15～24℃.

As regards current socio-economic state, as the result of socialistic policy promoted by the Government of Myanmar since 1962 inefficient macro-economic regime has been settled, and in 1987 the United Nation judged Myanmar as a least developed developing country (LLDC). Since 1988, the Government announced a political transition from planned economy into liberal one, and owing to its promotion of economic liberalization and alleviation of economic control, though they were confined to quite limited degree, comparatively favorable economic growth was resulted since 1962. However, this favorable growth has leveled off, turning into a recession since 1997 influenced by an Asian currency crisis that prevailed in the same year. Also, economic and monetary sanctions were reinforced by the US, EU and Australia against the government authority's appeal to arms to control against large-scaled demonstrative movements arisen from the home-confinement of Ms. Su Chi in 2003 and fuel price-hike in 2007.

In May 2008, the Government of Myanmar conducted a national poll for adopting new national constitution as planned in its democratization road-map, as a result new constitution has come into effect in November 2010. Then, general election was executed in November 2010, and it's 20 years since it had been held last time. Political handover to civil administration was performed in March 2011, since then newly established government has started administration. The new regime has set 50 political criminals free in May 2011, and it stated to grant political amnesty to 651 criminals in January 2011, followed by actual granting of amnesty to one after another. At the same time, the new government regime energetically promotes reconciling approaches to ethnic minorities.

Nominal GDP in 2009 reached around 34,200 million US$ (as of 2009 estimated by IMF), equivalent to per capita GDP of 462 US$ (as of 2009 estimated by IMF). Economic growth rate and price escalation rate both showed 7.9% (as of 2009 estimated by IMF), while the rate of unemployment reached around 4.0% (according to data by ADB in 2003). Myanmar's major industry stays at agriculture, and Myanmar's annual amount of exports reached 7,200 million US$ in 2009, while its annual imports amounted to 4,000 million US$, with its major exporting items ranging natural gas, pulses and jewelry etc, also with its principal import commodities including crude petroleum, parts of machinery, palm-oil, textures etc.

2. Background, Proceedings and Outlines of the Project

Cyclone "Nargis" that landed on the territory of Myanmar in May 2008 caused a heavy casualty including death-toll or missing of over 138 thousand people as well as catastrophic damages on life and production activities of the inhabitants who live in the disaster areas. Inhabitants in Ayeyawady Delta have ever lived and been engaged in farming within the areas surrounded by polder-embankment that have prevented sea-water invasion. However, these polder embankments have been destroyed by the cyclone "Nargis", simultaneously paddy field area of totally 770 thousand hectare was damaged by the same cyclone after the invasion or inundation of salt water during high-tide period that severely affected paddy yields, thus depriving damage-prone farmers of such production means as seed, livestock, farm machinery etc.

The affected areas have been vulnerable not only to cyclones but also to general floods and high-tides during rainy season. In order to protect / ensure inhabitants' means of living and agricultural production, rehabilitation of polder embankment damaged by the cyclone "Nargis" is the most urgent and important issue to be approached. The government of Myanmar has already started to take measures for a part of restoration, however, still fails to realize thorough, satisfying rehabilitation in terms of both quality and quantity due to technical insufficiency or fund shortage. Under such circumstances, the government of Myanmar has requested the government of Japan to implement a project for formulating a Development Plan to conserve farmland through the rehabilitation of polder embankment.

Based on this request, "Farmland Conservation Project for Urgently Rehabilitating Agricultural Production and Rural Community in the damaged Areas of Cyclone Nargis in the Republic of Myanmar" (by a type of development plan study) was implemented during the period from December 2009 to October 2011, in which a Master Plan for restoring all 34 polders damaged by the cyclone by 2016 has been formulated under the cooperation of Japanese assistance., while at the same time capacity of staff of Irrigation Department (hereinafter referred to as "ID") of Ministry of Agriculture and Irrigation(hereinafter referred to as "MoAI") for formulating plans and for implementing projects has been strengthened through the verification project. Nevertheless, most of the construction machinery and equipment currently managed by ID has already been dilapidated and their life has already been expired. Such an aged situation has led to frequent machine troubles with susceptibility of getting out of order. Thus, need of construction machinery's renewal has been identified so as to steadily facilitate the rehabilitation works as they are planned.

Similarly, designs and implementation plans with high levels of safety (quality) in compliance with the engineering technology level in Myanmar have been formulated in the verification project, but it is essential to test and verify construction materials by means of equipment and testing

apparatus to secure and guarantee the fruit of these designs and plans. The Irrigation Technology Center (hereinafter referred to as "ITC"), only one public testing organization in Myanmar, was established in 1986 by the application of Japanese Grant Aid Project, then two times of technical transfer therein have been performed through Technical Cooperation project by Japan International Cooperation Agency (hereinafter referred to as "JICA"), thus playing core role in developing techniques for irrigated agriculture. However, testing equipment/ apparatus has been aged and dilapidated in this center, thus acutely requiring their renewal. As a result, such a dilapidated situation causes inconveniences or result in bottlenecks in providing technical services for testing construction materials and measuring soil characteristics in implementing rehabilitation works for restoring facilities in the areas damaged by the cyclone. Under such a situation, the government of Myanmar has made a request to the government of Japan a Grant Aid on the provision of equipment for the construction works to rehabilitate polder embankment in Ayeyawady Delta. Responding to this request, JICA decided to execute a preparatory study and dispatched a study team to Myanmar.

3. Outlines of the Survey Results and the Project Components

JICA decided to carry out a preparatory study to examine the feasibility of applying Japanese Grant Aid Project to this request, thus dispatched a study team to the site for the 1st site study (during the period from January 14th to February 3rd 2012) as well for the 2nd site study (during the period from March 21st to April 10th). The study team made consultations with ID that is responsible for the implementation of the related projects at Myanmar's side, and at the same time it conducted site study in Ayeyawady Delta. After repatriating to Japan and completing its home study, JICA sent a study mission for explaining outline of overall design during the period from July 8th to July 14th to the project site, to explain to and consult with those who are responsible for this Aid project at Myanmar's side, thereby reaching a consensus with them.

(1) Basic principles in terms of overall design

The Grant Aid Project aims at providing construction and testing equipment for serving rehabilitation works on polder embankment that has been damaged by the cyclone. In the light of the result of the consultation with the government of Myanmar, the following provision of equipment has been planned based on the following principles:

① To identify roles and responsibility on the rehabilitation works for the damaged sites in Ayeyawady Delta clearly, also to make role sharing among the ministry in charge and related public agencies, to identify actual executing organizations of rehabilitation works as well as the operation and management of the works, thereby reflecting these findings to the implementation plan.

② To collect information through the site study on the current situation and actual progress of rehabilitation works on damaged polder embankment, as well to re-identify the amount of remaining works to be implemented hereafter, thus elaborating the identification of required construction machinery/ equipment to be provided for the rehabilitation within 5 years in conformity with the Development Plan.

③ To collect information on the current state of existing machinery/ equipment held by ITC

and also on the method of testing related to the rehabilitation works of the polder embankment, thereby elaborating the provision of required testing equipment.

④ To consider the organizational structures, staff composition, budgetary state, available fund for maintenance and management and other factors of ID and ITC that are implementing organizations of rehabilitation works thereby to elaborate adequate kinds, specifications and quantities of machinery and equipment to be provided.

⑤ To estimate and decide overall contents and amount of machinery and equipment to be provided through consultations with the government of Myanmar, thus determining the final draft plan of aid cooperation jointly considering the result of site reconnaissance study to be followed hereafter.

(2) Contents of the project

Based on the results obtained in the 1st and 2nd phase site study, contents and amount of machinery and equipment that have been agreed with Myanmar's side are tabulated below. What is different between those contained in the initial contents of the request and final draft of cooperation aid is that the borehole drilling machine that was initially listed in the original request has been altered into pile-driver (hydraulic vibration hammer to be attached to back-hoe). The initial idea imaged to drill cast-in-place concrete piles with a borehole drilling machine for working foundation for gates, however, after taking geologic structure found in the site of Ayeyawady Delta and method of implementing works into re-consideration, use of pile driver was finally judged more relevant than the initial idea.

Comparison between the requested contents and agreed draft of aid project

Type of Machinery	Requested items (identified at 1st site study)	Final Draft of aid Project	Reason of alteration
Back-hoe (Hydraulic Excavator)	28	24	The volume of works was re-evaluated through the data obtained from ID during the 1st site study.
Bulldozer	14	12	Ditto
Vibration Roller	2	2	Assessed as 2 by the examination of estimated work volume as well in the consultations with ID.
Mobile Workshop	2	2	—
Hydraulic Vibration Hammer	1	1	Initial request had included borehole drilling machine, but late, the request was altered into Hydraulic vibration hammer during 2nd site study.
Soil Material Testing Equipment	1set	1set	—
Concrete Material Testing Equipment	1set	1set	—
Water Quality Testing Equipment	1set	1set	—
Spare Parts	1set	1set	—

4. Project Implementation Schedule and Estimated Project Cost

In the case that this project is implemented as a project under Japanese Grant Aid Project, it will take 4 months for providing detailed design and another 7 months for the manufacture and transportation of machinery and equipment as well of the instruction on their usage. Likewise, overall project cost for procuring machinery and equipment is estimated at **** million yen (to be borne by Japanese side), while the project cost to be borne by Myanmar side amounts to 640 million yen which is mainly the cost of fuel for heavy machinery.

5. Project Evaluation

(1) Feasibility

The implementation of this project as a target of cooperation by Japanese Grant Aid Project is judged feasible taking account of the following reasons:

① Cyclone "Nargis" that had been ashore on Myanmar's coast in May 2008 caused a heavy casualty including death-toll or missing of over 138 thousand people as well as catastrophic damages on life and production activities of the inhabitants who live in the disaster areas. Inhabitants in Ayeyawady Delta have ever lived and been engaged in farming within the areas surrounded by polder-embankment that have protected them from sea-water invasion. However, these polder embankment have been destructed by the cyclone "Nargis", leading to damages on paddy field area of totally 770 thousand hectare by the cyclone after the invasion or inundation of salt water during high-tide period that severely affected paddy yields, thus damage-prone farmers have lost such production means as seed, livestock, farm machinery etc. By implementing this aid project it is considered possible to implement rehabilitation works for the damaged polder embankment, thereby hereafter minimizing future damages by high-tiding and cyclones.

② Most of the construction machinery / equipment that ID currently holds have already been aged and dilapidated, thus disorder or breakages of these machinery / equipment quite often takes place, thus the need of their renewal has been identified. Even after the completion of the rehabilitation works on damaged polder embankment targeted in this project these machinery and equipment will still be available for other public works, thus it is considered contributing also to hereafter farmland consolidation in Myanmar.

③ In order to ensure and to maintain quality of the rehabilitation works for damaged polder embankment, it is considered indispensable to perform tests, to measure soil mechanical characteristics and to identify properties of various construction materials including earth for embankment. Various equipment for testing held by ITC that is the sole and only one public testing agency in Myanmar has not yet renewed even after elapsing over 20 years since its establishment in 1988 in spite of their state of dilapidation and partial disorder, though staff of ITC by themselves keep their maintenance services and repairing, thus still managing to make use of them nowadays. It would be possible to happen to arise problems on the precision of the result of testing in some kinds and cases of using such dilapidated equipment. The implementation of this aid project not only can guarantee the quality of the planned

rehabilitation works but also can offer availability of making use for other public projects and works, thereby it can be considered further and hereafter contributing to farmland consolidation in Myanmar.

(2) Effectiveness

The following effects are expected in the rehabilitation of the damaged polders through the implementation of this aid Project.

(1) Quantitative effects

Indexes	Base year (2012)	Target year (2017) (The completion time of rehabilitation work in 34 polders)
The length of rehabilitation embankment (Total 34 polders)	383.47 km (Rehabilitation work completed in 15 polders as of 31 Dec. 2011)	Total 941.83 km (for remaining 19 polders : 477.11 km)
Conservation of paddy fields	0.0 acres (0.0 ha)	145,053.6 acres (58,703.2 ha) (remaining 19 polders)
The number of test ・Compaction test ・Density test ・Concrete test	 32 times / year 311 times / year 1 time/1 sluice rehabilitation work	 160 times (for 5 year) 1,555 times (for 5 year) 32 times (32 spots for 5 year)

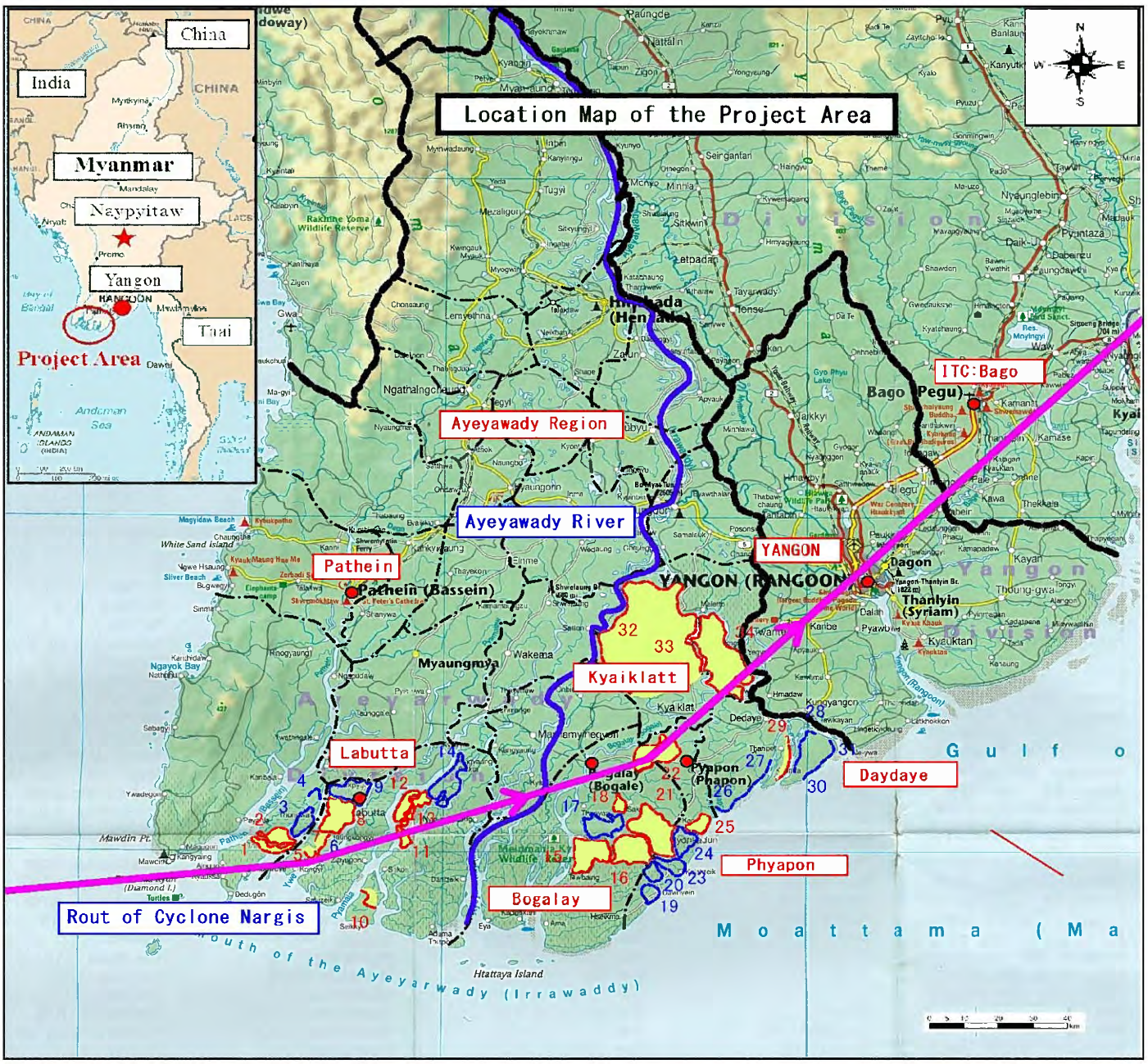
(2) Qualitative effects

・The desirable quality of the works can be guaranteed by performing the tests with the procured testing equipment in implementing rehabilitation works for damaged embankment.

・After the completion of the rehabilitation works for damaged polder embankment, awareness of the inhabitants toward the preventive effect against the damages by high-tiding / floods will be enlightened.

CONTENTS

Location Map



Polders in Project Area

【Labutta】
1.Alegyun(1)polder
2.Alegyun(2)polder
3.Alegyun(3)polder
4.Magyibinmadaukan

【Labutta】
5.Thingangyi
6.Zinywe
7.Leikkwin
8.Labutta(South)
9.Labutta(North)
10.U Gaungpu
11.Bitud Island(1)
12.Bitud Island(2)
13.Bitud Island(3)
14.Bitud Island(4)

【Bogalay】
15.Daunggyi pocet
16.Daunggyi(East)
17.Daunggyi (West)
18.Daunggyi(Upper)

【Phyapon】
19.Dawnyein polder
20.Myokone polder
21.Kyetphanwezaung
22.Banbweza
23.Daydalu
24.Lerpanbin
25.Zinbaung

【Daydaye】
26.Myaseinkan
27.Thandi
28.Suchubbaluma
29.Ilseikchaunggyi
30.Tamalakaw
31.Kyonsoat

【Kyaiklatt】
32.Maubin Island(North)
33.Maubin Island(South)
34.Thonegwakyun

LEGEND:
: Region boundary
: Township boundary
: Project area (19 Polders)
: Major city/town
: Township

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Abbreviations

ACL	Authorized Crest Level
ADB	Asian Development Bank
ADPC	Asian Disaster Preparedness Centre
A/P	Authorization to Pay
B/A	Banking Arrangement
CDN	Consortium of Dutch NGO's
Con (9)	Construction Circle (9)
DMH	Department of Meteorology and Hydrology
DS	Dry season
ECL	Existing crest level
E/N	Exchange of Notes
G/A	Grant Agreement
GDP	Gross Domestic Product
HWL	High water level
ID	Irrigation Department
IMF	International Monetary Fund
ITC	Irrigation Technology Center
JICA	Japan International Cooperation Agency
JIS	Japanese Industrial Standards
LLDC	least less-developed country
M/D	Minutes of Discussion
Mech:Div (1)	Mechanical Division (1)
MoAI	Ministry of Agriculture and Irrigation
O&M	Operation and maintenance
pH	Potential of hydrogen
WMO	World Meteorological Organization
Wopt	Optimum moisture content ratio
WS	Wet season
Z.A.V.C	Zero air void curve

Units

1 basket (Paddy)	=	20.88 kg	=	46 pounds		
1 basket (Groundnuts)	=	11.4 kg				
1 basket (Soybeans)	=	32.7 kg				
1 inch (in.)	=	2.54 cm	=	1/12 feet		
1 foot (ft.)	=	30.48 cm	=	1/3 yard	=	12 inches

1 yard (yd.)	=	0.9144 m	=	3 feet	=	36 inches
1 meter (m)	=	3.28 feet	=	1.09 yard		
1 mile	=	1.61 km				
1 kilometer (km)	=	0.62 miles				
1 square-foot (sq-f)	=	929 sq-cm	=	0.093 sq-m		
1 acre (ac)	=	0.405 ha	=	4048 sq-m		
1 hectare (ha)	=	2.47 acres				
1 acre-foot	=	1233.4 cum				
1 gallon (gal. UK)	=	8 pints	=	4.546 litter (UK)		
1 sud	=	2.83 cum	=	100 cu-feet		

1 mS/cm (milli-Siemens per centimeter)= 1 dS/m (deci-Siemens per meter)

= 1000 µS/cm (micro-Siemens per centimeter)

(e.g. EC = 0.1 – 0.3 mS/cm = 100 – 300µS/cm for normal tap water)

Chapter 1 Background of the Project

Chapter 1 Background of the Project

1-1 Background and Outline of the Project

1-1-1 Background and Outline of the Request

The above-mentioned cyclone "Nargis" gave catastrophic damages to the life and production activities of the local inhabitants. Besides, Ayeyawady Delta is not only vulnerable to cyclones but also to floods and high tides occurring during rainy season. Therefore, rehabilitation of the seriously damaged polder embankment has been urgent and important task for protecting inhabitant's life and agricultural production.

Most of construction machinery / equipment currently held by ID are too old, life of which has already been expired, thus they are apt to get out of order and mechanical troubles frequently take place. Moreover, renewal of dilapidated equipment for testing various soil samples and embankment materials installed in ITC is acutely needed in order to keep and guarantee quality of the rehabilitation works for the polder embankment. Under such circumstances, Myanmar requested Japan to cooperate with the rehabilitation under Japanese Grant Aid Project. The implementation of this project enables to facilitate earlier implementation of the rehabilitation works for the damaged polder embankment and to warrant the quality of these works.

1-1-2 Outline of the Contents and Scale of the Request

The contents and the quantities of the project identified in the 1st site study (conducted during the period from 14th January to 3rd February 2012) are summarized in the following:

Table 1-1-1 Contents and amounts of the Requested Machinery / Equipment

Name & Type	Specifications	Quantity	Usage
Back-hoe (Hydraulic excavator)	Power output of engine > 120kw (150HP) Volume of bucket > 1.0m^3	28	Excavation and embankment of polder embankment works, protective finish-up work on slope surface
Bulldozer	Power output of engine > 145kw (190HP) 20 ton class	14	Stripping, leveling and compacting of polder embankment works
Vibration Roller	Power output of engine > 80kw (110HP) Size of vibration Roller 12 ton class	2	Finish-up vibration compaction over the crest part in polder embankment works
Mobile Workshop	Power output of engine > 140kw (190HP) 4-wheel drive, hydraulic crane suspending 3 ton	2	For repairing work of heavy machinery
Borehole drilling machine	Force of engine larger than 50HP Hydraulic Auger ϕ 300mm×10m	1	Foundation works for water gates
Soil Mechanical Testing Equipment	Consolidation apparatus ϕ 60mm, Motorized direct shear apparatus ϕ 60mm, Permeability test apparatus 100mm, Triaxial test apparatus ϕ 300mm, ϕ 100mm, Others	1set	Management and check tests for materials of work to use for polder rehabilitation

Concrete Materials Testing Equipment	Compression and tension testing apparatus and others	1set	Tests for checking strength of concrete and reinforcement for water gates
Water Quality Testing Equipment	Water quality tester etc	1set	For checking water quality to be used for concrete & others
Spare Parts		1ser	For repairing machinery

Based on the result of 2nd site study (conducted during the period from March 21st to April 10th 2012), alteration of a part of the contents in the original request was made, in which initially requested borehole drilling machine was substituted into pile driver (hydraulic vibration hammer to be attached to a back-hoe). The reason of this change stems from the change from the driving of cast-in-place concrete piles by drilling holes with a borehole drilling machine as initially planned to a vibration hammer because the groundwater level in the Delta area stays at high elevation and silt as well as clay predominate in the geologic formation of the foundation thus resulting in N-value (measured at standard penetration test) as low as 5 or less, showing that the wall of the holes to drive the piles are liable to collapse, thus failure to maintain the drilled holes until piles are driven into them was anticipated. From this reason, it was agreed that use of a pile driver was selected as a substitute in place of initially requested borehole drilling machine. Also, since steel sheet piles, round and square piles are used in the foundation works for water gates, it was decided to select relevant type of pile driver with which these types of piles can be driven.

As to various kinds of testing equipment, during the survey at ITC in the 2nd site study, additional request was made inclusive of platform type load tester, Los Angeles testing machine (for use of measuring quality on abrasion of concrete aggregates).

Taking all these results obtained in the 1st and 2nd site studies, the contents and the amounts of machinery / equipment to be procured in this project as agreed with Myanmar's side is shown in the following table.

Table 1-1-2 Contents and amounts of machinery / equipment

Name & Type	Specifications	Quantity	Usage
Back-hoe (Hydraulic excavator)	Power output of engine > 120kw (150HP) Volume of bucket > 1.0m^3	24	Excavation and embankment of polder embankment works, protective finish-up work on slope surface
Bulldozer	Power output of engine > 145kw (190HP) 20 ton class	12	Stripping, leveling and compacting of polder embankment works
Vibration Roller	Power output of engine > 80kw (110HP) Size of vibration Roller 12 ton class	2	Finish-up vibration compaction over the crest part in polder embankment works
Mobile Workshop	Power output of engine > 140kw (190HP) 4-wheel drive, hydraulic crane suspending 3 ton	2	For repairing work of heavy machinery

Hydraulic Vibration Hammer	Power output of engine > 100kw (140HP) Adaptable pipes: round section pile (ϕ 300mm×7m), angular section pile (300 ㎜×300 ㎜×7m), steel sheet piling	1	For foundation work of sluice gates
Soil Mechanical Testing Equipment	Consolidation apparatus ϕ 60mm, Motorized direct shear apparatus ϕ 60mm, Permeability test apparatus 100mm, Triaxial test apparatus ϕ 300mm, ϕ 100mm, Others	1set	Management and check tests for materials of work to use for polder rehabilitation
Concrete Materials Testing Equipment	Compression and tension testing apparatus and others	1set	Tests for checking strength of concrete and reinforcement for water gates
Water Quality Testing Equipment	Water quality tester etc	1set	For checking water quality to be used for concrete & others
Spare parts		1set	For repairing machinery

1-2 Natural Conditions

(1) Climate and meteorology

Ayeyawady Delta belongs to tropical monsoon area. Cool climate prevails during the period from December to March without effective rainfall. Then, the period from April to May is called pre-monsoon period in which highest atmospheric temperature prevails with monthly mean temperature recording over 30℃. At times influential cyclones occur that may give disastrous damages, and "Nargis" that brought about catastrophic damages to Delta areas also took place in May. Cumulative precipitation falling in this period amounts to about 13% of the annual rainfall. Monsoon period falls on the period from June to September. Following period from October to November is called post-monsoon period, during which many cyclones occur and approach from Indian Ocean, though they have comparatively weak influence. Cumulative precipitation during this period comes to around 9% of the annual rainfall. The annual rainfall is totaled at 2,000 ~ 2,500mm in northern part of the Delta, while shifting to southward it gradually increases reaching 3,500 mm in southeastern part of the Delta. Mean annual precipitation in Oathein, the core city in the Delta, is recorded at 3,040 mm.

(2) Hydrology

Ayeyawady River with its gigantic watershed area of 413 thousand km^2diverges itself into three distributaries in the vicinity of Seiktha, and the downstream area from this point of divergence is generally called Ayeyawady Delta. The distance from this diverging point to the Andaman Sea is 290 km. Annual total discharge of Ayeyawady River is reported as 40,000 million m^3. Fluvial discharge is highly variable throughout the year because of its monsoon climate, but the peak of the mean value comes to32,600 m^3/sec in August and the lowest thereof is recorded at 2,300 m^3/sec in February, annually averaged at 13,000 m^3/sec. The maximum value ever recorded in the past at Saitha was 63,900 m^3/sec in 1877. These divergent streams are again diverged at downstream side that are usually referred to as 9-armed, into Bassein, Thetkethaung, Ywe, Pyamalaw, Irrawaddy, Bogale, Pyapon, China Bakir and Yangon. However, 12 river mouths are actually distributed adding Pyinsalu, Thandi etc along deltaic

coast stretching for 250 km from the mouth of Bassein River located at the western edge to that of Yangon River. Ayeyawady River transports huge volume of mud/ sand to the Delta and it is said that that the delta grows southward at the velocity of 50m per year. Tides at the coast of the delta follow a semi-diurnal cycle, and the minimum tidal difference in height is recorded at 1.5 meter at the north of Pyapon River, while the maximum reaches about 5 meter at Elephant point situated at the mouth of Yangon River. Tidal phase has time difference of 6 hours from the mouth of Bassein River located at the western-most part of the delta to the mouth of Yangon River.

(3) Topography and physiography

Myanmar is roughly classified into 4 topographic classes, out of which Central Belt Zone is further sub-classified into Central Myanmar Zone and Ayeyawady Delta Zone. The latter zone extends about 290 km from the vicinity of Myanaung that is the limit of tidal influence to the Andaman Sea. The western side of the area has the wide fluvial deposits of this Ayeyawady River and it contacts with the southern edge of Arakan Mountain Range, while the eastern side contacts with Bago Mountain Range. Bassein River and Hlaing River that join at their uppermost stream with Ayeyawady River diverge 12% and 24% of the discharge of this main stream, respectively in rainy season, thereby contributing to minimization of flooding in the Delta sandwiched by these two distributaries.

Except for scattered remnant hills, Ayeyawady delta, extending around 31,000 km^2, has the elevation above sea level of lower than 15m, out of which the area of 5,200km^2 has the elevation of lower than the level of high tide. Most part of the area including middle and upper areas of Ayeyawady Delta has been utilized for rice paddy production This area was formerly vast wetland, but since mid 19^{th} century numerous people has immigrated who have developed construction of polder embankment and land reclamation, thus accelerated demographic growth. Construction of polder embankment by the hand of the government of Myanmar has started since 1861 then innumerable embankment were constructed during the period from 1880 to 1920. Related laws and regulations to the construction of embankment have also been developed in 1909. Currently, cumulative length of major embankment has reached 1,300 km that protect farmland of 600 thousand ha from floods. In this context, these embankments are considered effective for the floods with the return period of 20 years only.

(4) Soils and water quality

The whole Ayeyawady Delta has been formed by thick and comparatively new alluvial soils brought about by Ayeyawady River. Soils in this Delta mainly consist of three types, namely lowland gley-soils, wetland gley-soils and gley-soils derived from saline water. Homogeneity in soil properties can be recognized over the whole area of Ayeyawady Delta. In other words, other than exceptional cases, soil layers except for top soils comprise fine clay or silty clay, in most cases bearing pale hue. Soils in paddy fields distributed in Ayeyawady Delta are exceedingly suitable for cultivation.

Domestic water utilized by people living in Ayeyawady Delta depends on rain water and reserved water in reservoirs, and those who live in the areas relying on rainwater suffer shortage of water containers or have to receive water from other people during the long dry spell without any rainfall. Soon after "Nargis" threatened, they could not use water in their reservoirs due to invasion of saline water from the

sea and dead corpses of livestock flown into reservoirs, but in the following year it has almost become available to them. However, saline water remounts as far as 100 km upstream of the river mouth in the end period of dry season, problem arises and remains to use stream water for potable purpose for those who rely on river water.

(5) History of cyclones in deltaic areas

Cyclone "Nargis" that threatened Ayeyawady Delta in May 2008 brought catastrophic damages in the delta. As for so far experienced damages including neighbor countries, it is said that cyclone "Bhola" landed to Bangladesh in 1970 gave the largest damages in the past, however, "Nargis" is considered comparable to this record. In this connection, since tidal observation equipment is broken in 1979, no observation on tides etc has continued in Myanmar, thus it's impossible to analyze past records. Responding to the tsumani threatened in 2004 caused by large earthquakes occurred in Sumatra Island, Department of Meteorology and Hydrology (DMH) made a decision of resume tidal observation. in 2006, two tidal gauges have been installed by the assistance of Asian Disaster Preparedness Center(ADPC).

1-3 Environment and Social Consideration

In the case where rehabilitation works for polder embankment are implemented utilizing machinery and equipment procured by the proposed Grant Aid cooperation project, it becomes necessary to elevate the height of the embankment for the purpose of strengthening the function of polder embankment. For this reason, widths of the embankments shall be widened, then it will be required to acquire farmland for the public site for construction. Cultivation and habitation have been prohibited on the land area within 50 feet from the edge of the embankment in Ayeyawady Delta, by the instruction of staff of local offices and ID since the construction of polder embankment in 1981 because the area should be placed under the management of ID. However, this width was determined considering local characters and there is a possibility of difference among different polders. By this reason, it becomes necessary to identify the width of actual area that has been banned to cultivate or to dwell from the base of the existing embankment in implementing the rehabilitation works, thus judging the border of legality. Based on this verification, it is then required for the local office staff in charge to survey whether there are actually houses or cultivated fields around the planned polders for rehabilitation that have illegally occupied the public land.

In implementing rehabilitation works for polder embankment, it is required to consider the following items in order to mitigate detrimental effects on the environment, especially the inhabitants who live in and around the project site:

1) A committee is established including members of plural staff of government organizations such as staff of local administration offices with a view to keeping closer contact with the inhabitants concerned on the removal / evacuation and land acquisition, so that this committee can directly offer information services at village level.

2) In the case that private houses exist in the construction site, necessity of removal is confined to

the minimum extent by applying manual works etc.

3) The extent of the land area of the polder embankment is identified, and thoroughly inform the result to local inhabitants so that all of them are aware thereof.

4) In the verification project, works have been implemented based on the requests of the inhabitants so that borrowing pits could have been reutilized as reservoirs for village and schools. Such support for the inhabitants should be continued in these rehabilitation projects.

Chapter 2 Contents of the Project

Chapter 2 Contents of the Project

2-1 Basic Concept of the Project

(1) Superior Plans

Myanmar has placed the restoration of agricultural production in the damaged areas by the cyclone Nargis (May 2008) and the rehabilitation of the seriously damaged polder embankment as a high priority issue that pressingly needs recovering measures. Japan has cooperated with the formulation of a Development Plan with an objective of farmland conservation and recovery of agricultural production as well as rural life through the rehabilitation of polder dike, through "the technical cooperation of development plan study type: December 2009 ~ October 2011". ID is the implementing agency of these rehabilitation works. As to the damaged polder embankments, ID has established a plan to implement the said rehabilitation works based on this Development Plan.

34 polder embankments have been constructed in the whole area of Ayeyawady Division, while according to the contents of consultation with ID and referring to the information submitted by ID, out of the total 34 polders (total length thereof is measured at 941.83km) rehabilitation works for 15 polders (total length thereof is measured at 383.47km) have already been completed while the rest 19 damaged polders have not yet been rehabilitated or partially rehabilitated (in these cases the degree of progress of rehabilitation works ranges 0 ~ 52% of the planned works) as of 31 December 2011. The total length of the rehabilitated embankment is measured at 464.72km including the partially rehabilitated sections of polders mentioned above, while the total length of not yet rehabilitated polder embankment is totaled to 477.11km, and the volume of the embankment of the damaged polders to be rehabilitated hereafter is estimated at 7,754,550m^3 and it is considered that machinery / equipment can be procured through this project so that all the scheduled rehabilitation works can be completed within 5 years at the average annual rate of 1,550,910m^3 of the volume of the embankment. Dimensions including the length of each polder and the volume of embankment etc are shown in Table 2-1-1.

Table 2-1-1 List of Polder Embankment

Township	No	Name of Polder Dike	Sluice (nos.)	Slide Gate (nos.)	Slide Gate (Need to Replace) (nos.)	Estimated Paddy Area (Acres)	(1) Dike Length (mile)	Completed Length by ID (mile)	Completed Length by Contract-out (mile)	Average Existing ECL (ft)	(2) JICA Proposed ACL (ft)	(3) ID Design Volume (Sud)	(4) Progress for ID Design Volume (Sud)	(5)=(3)−(4) Remained Volume for ID Design (Sud)	(6) JICA Design Volume (Sud)	(7)=(6)−(4) Volume to be Implemented for JICA D.V (Sud)	(8) Progress for JICA Design Volume %	(9) Construction Groupings No.	Construction Schedule & Group (sud) 1st year No.5, No.6	2nd year No.1, No.4	3rd year No.3, No.10	4th year No.2, No.8	5th year No.2,7, 9	Completed Polders No.	Remained Polders No.	Volume Check (sud)
Labutta	1	Alegyun (1)	3	11	4	1,783.2	13.40	0.00		11.8	13.5	75,718	0	75,718	75,718	75,718	0	1		75,718					1	75,718
	2	Alegyun (2)	4	22	13	4,036.8	22.70	0.00		10.8	14.0	127,800	0	127,800	127,800	127,800	0	1		127,800					2	127,800
	3	Alegyun (3)	4	18	9	5,196.0	17.65	17.65		–	14.0	94,610	97,280	complete	0	0								1		
	4	Magyibinmadaukan	non			337.9	3.40	3.40		–	14.0	20,760	16,973	complete	0	0								2		
	5	Thingangyi	non			779.4	6.30	4.31		3.6	11.5	71,100	48,540	22,560	93,181	44,641	52.1%	2				44,641			3	44,641
	6	Zinywe	non			29.2	6.00	6.00		–	11.5	39,936	39,352	complete	0	0								3		
	7	Letkkwin	1	-	0	11.4	3.75	0.00		4.8	11.5	37,598	0	37,598	45,937	45,937	0	2				45,937			4	45,937
	8	Labutta (S)	3	17	0	2,453.2	20.20	0.00		5.2	11.0	260,930	0	260,930	194,236	194,236	0	1		194,236					5	194,236
	9	Labutta (N)	-	-	-	9,826.7	38.00	38.00			11.0	364,260	96,638	complete	0	0								4		
	10	U Gaungpu	non			106.6	5.20	0.00		1.8	12.0	62,055	0	62,055	107,572	107,572	0	2					107,572		6	107,572
	11	Bitud Island (1)	-	-	-	662.4	14.02	4.25		5.5	12.0	97,030	26,582	70,448	163,451	136,869	16.3%	3			136,869				7	136,869
	12	Bitud Island (2)	4	19	0	4,572.5	18.60	0.71		6.3	12.0	103,830	6,880	96,950	179,353	172,473	3.8%	3			172,473				8	172,473
	13	Bitud Island (3)	4	7	7	3,881.3	28.00	19.72		4.5	12.0	247,955	167,177	80,778	391,795	224,618	42.7%	4		224,618					9	224,618
	14	Bitud Island (4)	6	16	7	10,179.5	40.53	40.53			12.0	237,168	217,045	complete	0	0								5		
Bogalay	15	Daunggyi	6	44	14	12,997.7	37.00	4.81		8.0	12.0	58,651	9,687	48,964	186,739	177,052	5.2%	6	177,052						10	177,052
	16	Daunggyi (East)	3	25	25	18,809.7	33.90	0.00	9.77	6.4	12.5	124,936	45,078	79,858	371,292	326,214	12.1%	5	326,214						11	326,214
	17	Daunggyi (West)	4	20	0	15,145.4	31.60	31.60		–	12.0	96,110	96,093	complete	0	0								6		
	18	Daunggyi (Upper)	1	5	0	2,859.2	10.50	0.00		6.5	12.0	41,556	0	41,556	107,073	107,073	0	6	107,073						12	107,073
Phyapon	19	Dawnycin	1	8	4	990.2	14.00	14.00		–	12.5	32,600	32,596	complete	0	0								7		
	20	Myokone	2	10	4	3,082.3	17.00	5.40	11.60	–	12.5	59,285	54,038	complete	0	0								8		
	21	Kyetphamwezaun	7	57	36	26,028.7	46.00	4.17		5.7	12.5	190,178	11,198	178,980	480,780	469,582	2.3%	8				469,582			13	469,582
	22	Banbwezu	7	26	26	9,898.5	26.00	0.00		7.8	12.0	45,114	0	45,114	190,302	190,302	0	7					190,302		14	190,302
	23	Daydalu	1	7	2	2,165.5	13.00	13.00		–	12.5	61,949	57,800	complete	0	0								9		
	24	Lepanbin	4	22	5	6,671.3	20.00	20.00		–	12.5	70,208	70,158	complete	0	0								10		
	25	Zinbaung	4	17	3	5,437.7	15.00	2.76		7.8	12.5	22,806	4,172	18,634	119,233	115,061	3.5%	9					115,061		15	115,061
Daydaye	26	Myaseinkan	non			9,532.1	13.50	6.92	6.58	–	13.0	134,274	96,825	complete	0	0								11		
	27	Thandi	non			2,617.1	4.25	4.25		–	13.0	16,933	17,812	complete	0	0								12		
	28	Suchubbaluma	non			5,879.8	7.40	7.40		–	13.0	25,376	22,896	complete	0	0								13		
	29	Hleseikchaunggyi	non			1,742.8	7.40	0.00		11.0	13.0	26,400	0	26,400	21,262	21,262	0	10				21,262			16	21,262
	30	Tamatakaw	non			10,084.8	7.00	7.00		–	14.0	9,600	9,600	complete	0	0								14		
	31	Kyonsoat	non			403.4	5.00	5.00		–	14.0	14,950	14,198	complete	0	0								15		
Kyaiklatt	32	Maubin Island (N)	non			22,681.5	12.40	0.00		8.5	13.5	12,060	0	12,060	63,000	63,000	0	10				63,000			17	63,000
	33	Maubin Island (S)	non			10,575.9	4.40	0.00		9.3	12.0	659	0	659	8,525	8,525	0	10				8,525			18	8,525
	34	Thonegwakyun	6	29	0	15,765.1	22.25	0.00		10.3	13.5	70,450	0	70,450	132,189	132,189	0	10				132,189			19	132,189
Total	(Average Height)		75	380	159	227,194.8	585.35	260.88	27.95	7.1	12.5	2,954,845	1,258,618	1,357,512	3,059,438	**2,740,124**	10.4%		610,339	622,372	534,318	560,160	412,935	Average	sud	548,025
Length (km), Volume(m^3)							941.83	419.75	44.97			8,362,211	3,561,889	3,841,759	8,658,210	**7,754,551**	10.4%		1,727,259	1,761,313	1,512,120	1,585,253	1,168,606	Average	m^3	1,550,910

Length Data of Whole Polder:	Nos. of Sluice(Need to Replace) ↓	Paddy Area (Complete/ Uncomplete) ↓							
Polder 100% Completed Length (mile)	380/75=5 Slide Gates/One Sluice	82,141.2	238.33	Total Completed Length(mile)	288.83	Remained Length(mile)	296.52	Progress of Length	49.3%
Polder 100% Completed Length (km)	159/5=32 Sluices(Need to Replace)	145,053.6	383.47	Total Completed Length(km)	464.72	Remained Length(km)	477.11		

Total Volume 2,740,124 sud 7,754,551 m^3

Excavator_Each Year Necessary numbers						Average
	27	27	23	24	18	**24**

Note: 1. Progress is informed by ID as of end of December 2011. (Data from ID in Naypyitaw,18.02.2012)

2. 1sud= $2.83m^3$

3. Volume may change according to check result of ID survey team.

2-2 Outline Design of the Japanese Assistance

2-2-1 Design Policy

2-2-1-1 Basic Policy

This project aims at procuring construction machinery and testing equipment to contribute to the rehabilitation works for the damaged polder embankment. Taking the result of the consultation with ID into consideration, elaboration on how to meet Project goal was made based on the following principles;

1) Share and role of responsibility among related organizations are made clear so as to reflect the grasped information on the implementation plan,

2) Current state and progress of the rehabilitation works for the damaged polder embankment are elucidated and the remaining amount of the woks is identified again so that the amount of construction machinery and equipment is procured so as to enable to complete the remaining works within the next 5 years,

3) Current state of existing testing equipment held by ITC and testing methods for the rehabilitation works of damaged polders are grasped by the site study in order to examine the kinds, specifications and necessary quantity of the testing equipment,

4) Organizations, staff compositions, budgetary state, operation and maintenance costs of ID and ITC, the executing agencies of the rehabilitation works are taken into consideration for examining the kinds, specifications and necessary quantity of the testing equipments,

5) Contents and quantities of machinery and equipment are roughly decided in consultations with the government of Myanmar, however, they are later precisely fixed taking account of the result of the site reconnaissance survey scheduled later,

6) In selecting suppliers of construction machinery, whether they have dealing agents in Myanmar or not, readiness of hereafter procurement of spare parts, ability to cope with serious machinery troubles etc shall be taken into consideration,

7) In determining suppliers and quantities of spare parts, expendables etc of testing equipment, the fact that existing equipment held by ITC is made in Japan, currently no dealer of testing equipment in Myanmar shall be taken into account.

2-2-1-2 Considerations on Natural / Environmental Conditions

(1) Climatic and Meteorological Conditions

Annual precipitation in Ayeyawady Delta rangesv2,500～3,000 ㎜, most of which is concentrated in rainy season (May ~ October). Mean annual precipitation of the deltaic area (Pathein) is shown in Fig.2-2-1. In this regard, base on the recorded performances of rehabilitation works by the verification project during the period of formulating the Master Plan and what have been consulted with ID, it has been planned to implement rehabilitation works on polder only during dry season, assuming four month-period from December when reaping of rice paddy is completed until March when the fiscal year ends in

Myanmar, also assuming 100 days as working days during this work period. Work performances achieved in the verification study during the formulation of the Development Plan are attached to the Appendix-5.1 in the Appendix-5.

(mm)

Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Spt.	Oct.	Nov.	Dec.	Total
5	2	3	14	278	613	654	670	364	204	86	10	2,903

Fig. 2-2-1 Mean annual precipitation in deltaic area (Pathein)[1]

(2) Earthiness and Compaction Machinery

The whole Ayeyawady Delta has been formed by thick and comparatively new alluvial soils brought about by Ayeyawady River. Under the top soils fine clay and silty clay are distributed. According to the performances of soil mechanic tests for rehabilitation works during the formulation of Master Plan, soil moisture content in borrowing areas indicated 30%, almost equivalent to the optimum moisture content at 90% at wetter side. Therefore, a principle has been taken to employ excavated earth as the material of embankments. As to the type of compaction machine, bulldozer showed the most favorable workability by which quality of compacted embankment was satisfied among the performances of embankment works implemented one year before the verification project, thus a principle was adopted to use bulldozers for embankment. If the operating weight of the bulldozer is large, the number of times of compaction by bulldozer will decrease (efficiency of work). On the other hand, since the width of the crest of embankment is narrow (minimum width is 3.6 m), it will be difficult to make uniform compaction by large-sized bulldozer (Workability). Therefore, specification of bulldozer is decided that the operating weight should be 20-ton class.

In this connection, a survey on bearing capacity was conducted by a cone penetration test in the 2nd site study. the result of the site study showed that cone index was measured at qu=12 kg/cm^2 or higher value at the crest of the dike as well as at toe of slope inside and outside slopes of the dike, implying that traveling of back-hoe, bulldozer and dump truck is possible. Also, cone indices on used borrow-pit and the surface of paddy field were measured at qu=8 kg/cm^2 or higher, also meaning that back-hoe and bulldozer is trafficable.

[1] The source: WMO (World Meteorological Organization)

Photo-2-2-1 Cone penetrometer test

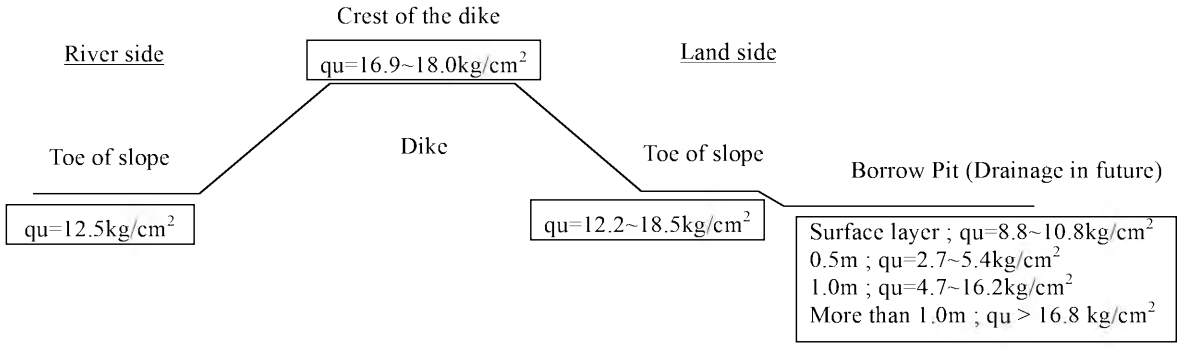


Fig. 2-2-2 Result of cone penetration tests at the site

Relationship between cone indices and trafficability (traveling possibility) is given in the following table.

Table 2-2-1 Relationship between cone indices and trafficability

Construction machinery	Cone index (kg/cm^2)
Middle-sized bulldozer (back-hoe)	Possible to travel at 5.0~6.0 or higher
Large-sized bulldozer	Possible to travel at 7.0~10.0 or higher
Dump truck	If higher than 10.0, traveling is possible, and if higher than 15.0constant travel velocity can be kept for considerably longer hours

2-2-1-3 Principles for Socio-Economic Status

Embankment works at the sites adjacent to houses where inhabitants live shall be worked by manual embankment so as not to induce detrimental effect of vibration and noises emitted from the operation of heavy machinery troubling the houses and living people. In this context, similar measures have been applied in the rehabilitation works implemented at the period of Master plan formulation.

2-2-1-4 Principles for Situations of Construction / Procurement

In the light of the necessity of aiming at earlier rehabilitation during the limited period in dry season, a principle was adopted to plan to implement the rehabilitation works during the whole day including both day and night. Taking the performances achieved during the verification study into consideration, it is assumed to set 12 hours operation for back-hoes and bulldozers in a day. Polder rehabilitation works are to be implemented on force account, coupled with the procurement of fuel and employment of drivers/ operators. In this regard, according to the hearing from ID, construction works during rainy season are difficult in deltaic areas, leading to the actual implementation during only dry season but works are performed during both day and night.

2-2-1-5 Principles for Operation and Maintenance

(1) Operation and Maintenance System of Construction Machinery

The construction machinery and spare parts procured by the project must be used exclusive for the rehabilitation works of damaged polders in the area of Ayeyawady Delta. But after the completion of the rehabilitation works, these machinery can be used for other works. Construction Circle (9) (hereinafter referred to as "Con (9)") and Maintenance Division (Ayeyawady Region) are responsible for rehabilitation works of polder embankment, and it is in charge of operation and maintenance of the construction machinery and equipment procured by this Project. It is to be supported by Mechanical Division (1) (hereinafter referred to as "Mech:Div (1)") in the cases of major inspection or of serious troubles / breaks of the construction machinery. In this regard, necessary staff and budget (fuel cost / transportation cost etc) are to be provided by ID. And after the completion of the rehabilitation works, operation and maintenance will be performed in the same system (Con (9)).

Photo-2-2-2 The place for construction machinery (the left) and the workshop (the right) of Mech:Div (1)


Photo-2-2-3 The workshop (the left) and the warehouse for spare parts (the right) of Mech:Div (1)

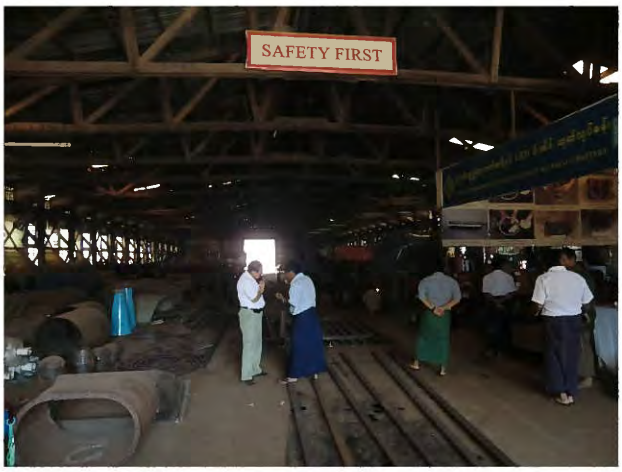


Photo-2-2-4 The workshop and the warehouse for spare parts of Con (9)

(2) Operation and Maintenance System of Testing Equipments

The testing equipment procured by the project will be used with priority in the rehabilitation works of damaged polders in the area of Ayeyawady Delta. More than 2 decades has elapsed since the testing equipments held by ITC have been provided in 1988, however, due to lack of private dealer that can sell, maintain or inspect testing equipments in Myanmar, staff of ITC have so far performed maintenance / inspection and alignment in their laboratories. From this fact, it can be judged possible for the staff to take initiative of performing these services after the procurement for consolidation of testing equipments within the frame of the annual budget available to ITC. At present, staff of ITC conduct tests from comparatively easy one (such as grain size analysis, permeability test, specific gravity of soil particle etc) to the tests which requires advanced technology (such as triaxial compression test, consolidation test etc). If the Japanese engineer guide to the staff of ITC, it will be possible to keep the good operation system of the test after procurement of testing equipments. Besides, the staffs of ITC are fully aware of necessity of operation and maintenance of their testing equipments. Considering such past performances, and also judging from their achievement of having maintained their equipments for over 20 years, these staffs surely have thorough capacity of keeping maintenance and operation services. Therefore it is expected that sufficient maintenance and operation services will be given to the testing equipment, operation and maintenance will be performed in the same system (ITC). Progress of construction material tests are attached to the Appendix-5.2 in the Appendix-5.


Photo-2-2-5 Irrigation Technology Center (ITC)


【Large Triaxial Machine】 【Consolidation Apparatus】

Photo-2-2-6 Existing testing equipments of ITC

2-2-1-6 Installation of Sluice Gates

This aid Project mainly aims at procuring necessary construction machinery and equipment for rehabilitating polder embankments, while sluice gates are to be improved through budgetary measures of Myanmar's side. Existing sluice gate structures have structurally vulnerable zone inside which is induced by differential settlement. Therefore pile driving works will be adopted in the foundation works of sluice gates for avoiding the differential settlement. And a principle was adopted to procure a hydraulic vibration hammer for pile driving in this Project.

【Damaged sluice by cyclone "Nargis"】

【Restored sluice (Pilot Project)】

Photo-2-2-7 Dike and sluice

2-2-2 Basic Plan (Equipment Plan)

2-2-2-1 Overall Plan

This project aims at procuring construction machinery and testing equipment to contribute to the rehabilitation works for the damaged polder embankment. Taking account of the results of consultations with the government of Myanmar, machinery and equipment to be procured has been planned as follows:

(1) Contents of the Request and Finally Agreed Draft

The contents and the quantities of machinery and equipment that are selected based on the result of 2nd site study and finally agreed with Myanmar side are shown below. What has been altered from initial request is that initially requested borehole drilling machine is replaced with a pile driver (hydraulic vibration hammer to be attached to a back-hoe). It had initially been planned to employ a borehole drilling machine for foundation works of water gates for drilling holes in which cast-in-place concrete piles are driven. However, as a result of checking again the working method and geologic state of the deltaic area, it has been concluded that pile driver is more suitable and compatible. Also, as to the quantity of bulldozers and back-hoes has been adjusted through revised evaluation of future volume to be worked in polder embankment, and the difference found in the workability of back-hoe after examining data on the performance achieved in the rehabilitation works implemented in the verification project during the period of Master Plan formulation.

Table 2-2-2 Comparison between the requested contents and agreed draft of aid project

Type of Machine	Requested items (identified at 1st site study)	Final draft of aid Project	Reason of alteration
Back-hoe (Hydraulic excavator)	28	24	The volume of works was re-evaluated through the data obtained from ID during the 1st site study.
Bulldozer	14	12	Ditto
Vibration Roller	2	2	Assessed as 2 by the examination of estimated work volume as well in the consultations with ID.
Mobile Workshop	2	2	—
Hydraulic Vibration Hammer	1	1	Initial request had included borehole drilling machine, but late, the request was altered into Hydraulic vibration hammer during 2nd site study.
Soil Mechanic Testing Equipment	1set	1set	—
Concrete Materials testing Equipment	1set	1set	—
Water Quality Testing Equipment	1set	1set	—
Spare Parts	1set	1set	—

(2) Major Specifications, Quantities and Objective of Use of Each Machinery / Equipment

Major specifications, quantities and objective of use of each machinery / equipment are summarized into the table below:

Table 2-2-3 Specifications and quantities of machinery and equipment to be procured

Type of machinery	Specifications	Quantity	Objective of use
Back-hoe (Hydraulic excavator)	Power output of engine > 120kw (150HP) Volume of bucket > 1.0m^3	24	Excavation and embankment of polder embankment works, protective finish-up work on slope surface
Bulldozer	Power output of engine > 145kw (190HP) 20 ton class	12	Stripping, leveling and compacting of polder embankment works
Vibration Roller	Power output of engine > 80kw (110HP) Size of vibration Roller 12 ton class	2	Finish-up vibration compaction over the crest part in polder embankment works
Mobile Workshop	Power output of engine > 140kw (190HP) 4-wheel drive, hydraulic crane suspending 3 ton	2	For repairing work of heavy machinery
Hydraulic Vibration Hammer	Power output of engine > 100kw (140HP) Adaptable pipes: round section pile (φ300mm×7m), angular section pile (300 ㎜×300 ㎜×7m), steel sheet piling	1	For foundation work of sluice gates

Soil Mechanical Testing Equipment	Consolidation apparatusφ60mm, Motorized direct shear apparatusφ60mm, Permeability test apparatus 100mm, Triaxial test apparatusφ300mm, φ100mm, And others	1set	Management and check tests for materials of work to use for polder rehabilitation
Concrete Materials Testing Equipment	Compression and tension testing apparatus and others	1set	Tests for checking strength of concrete and reinforcement for water gates
Water Quality Testing Equipment	Water quality tester etc.	1set	For checking water quality to be used for concrete & others
Spare parts		1set	For repairing machinery

2-2-2-2 Construction Machinery

(1) Back-Hoe (Hydraulic Excavator)

Rehabilitation works on polder embankment were implemented (at Labutta polder L=38.6km) in the verification project during the period of Master Plan formulation in which technical instruction / transfer was made on implementation techniques and quality control. Favorable result was obtained in this verification project on the work techniques and quality control. Thus, rehabilitation works hereafter planned are to be implemented in a similar manner. This method of works is shown in Fig. 2-2-3. Borrow-areas and temporary storing yard are placed at the side of embankment at the inner side (paddy field) then excavation in borrow-area ~ temporary storage ~ excavation of original embankment / temporary storage are wrought by a back-hoe while spreading and grading ~ compaction are wrought by a bulldozer.

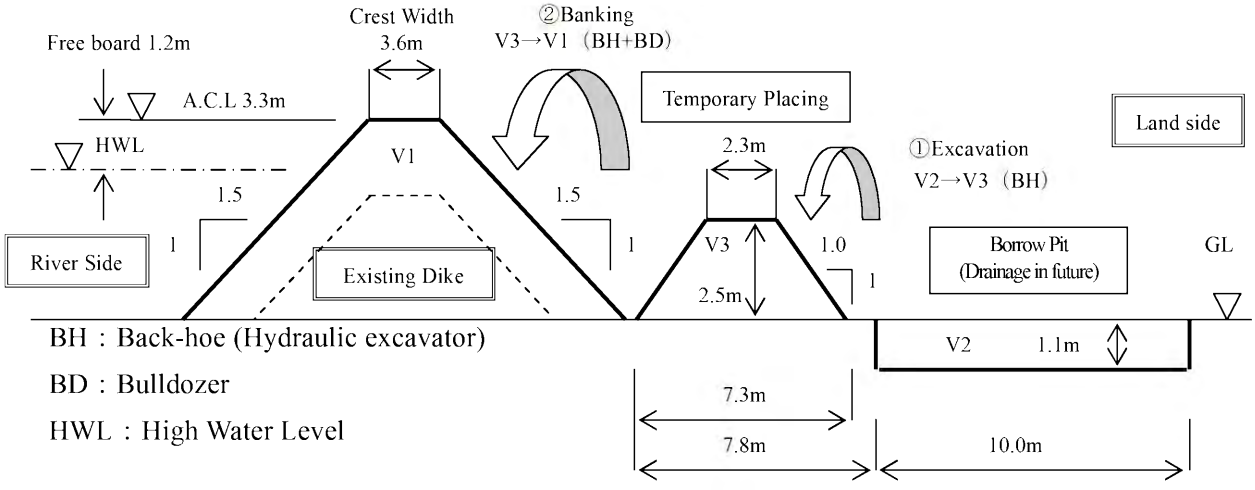
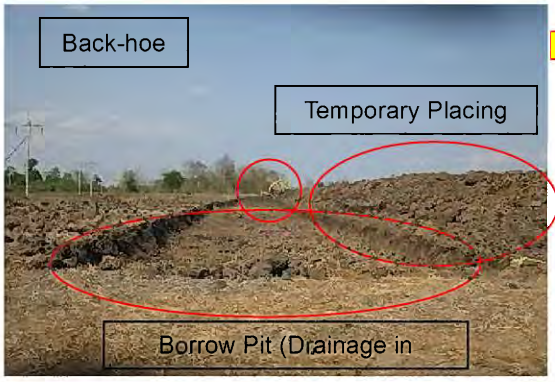


Fig. 2-2-3 Proposed Typical Cross section of Dike Embankment

The following pictures show rehabilitation works on polder embankment in the pilot project;



Borrow Pit (width is about 10m, depth is about 1.2m)

Temporary Placing (left side of back-hoe)

Slope finishing work by back-hoe

Stripping, leveling and compacting of polder embankment works by bulldozer

As to construction works, excavation in borrow-area / temporary stock-pile (refer to Fig 2-2-3) shall be wrought in advance, after a few days, earth deposited in temporary stock-pile is filled over the embankment, grading, compaction, trimming of the slope (as illustrated in ② of the above Fig. 2-2-3) are then followed over the section where soil moisture content adjustment has been completed. Because the works shown in the above Fig. ① and ② are simultaneously performed on the different place, a few hundred meter away from each site, basic machinery combination shall consist of 2 back-hoes per 1 bulldozer.

The quantity of back-hoe required in these works shall be calculated from its workability. The following workability was obtained from the performances of polder rehabilitation works in the verification study:

- Annual quantity of earth work by a back-hoe : 1,550,910 m^3/year (annual average in 5 year-plan)
- Workability of a back-hoe (quantity of earth work per hour) : 54m^3/hr (as performance in the verification project in 2010)
- Operating hours/ back-hoe : 12hr/day (ditto)
- Operating days/ back-hoe : 100day/year (ditto)

Referring to the above construction performances, required quantity of back-hoes are calculated at 24 unit.

∴ Required quantity = 1,550,910 m^3/year ÷ (54m^3/hr×12hr/day×100day/year) = 23.93 ⇒ **24 unit**

(2) Bulldozer

Simultaneous with embankment works by back-hoes, bulldozers work for earth-spreading/ leveling and compaction. 20 ton class bulldozers are employed for these works, where works were operated by a bulldozer coupled with 2 back-hoes. Since similar works will be planned hereafter, it is estimated that 12 bulldozers are necessary to carry out these works.

(3) Vibration Roller

The crest of embankment is compacted by vibration rollers. 6 times of compaction is necessary to secure the required density as a road bed. Therefore vibration roller should make three round trips (6 times of compaction) in the crest surface. As to the progress of rehabilitation works on polder embankment, either rehabilitation works have not been completed or the rehabilitation works are progressing but have not been completed in 19 polders of 34 polders. And total length of non-completed embankments amount to 477.11km.

Moreover, the crest width checked in the second survey was 3.5m-9.8m (average width is 6.65 m). On the other hand, roller width is 2.13 m, if crest width is made into the average value (B= 6.65 m), vibration roller shall go to the compaction work for 3 round-trip x3 lane = 9 in the construction section. Based on the above-mentioned conditions, the number of vibration roller which can complete the construction of the un-completed polders in five years is calculated from the following capacity for work.

Daily operation hours of vibration roller [1]	: 8hr/day
Compaction speed of vibration roller	: 3km/hr
Operation distance per 1km of polder embankment	: 1km×6 times×3 lane=18km/km
Daily construction distance of polder embankment	: 8hr/day×3km/hr÷18km/km＝1.33km/day
Construction distance at one time [2]	: 1.33km
Annual operation days of vibration roller [3]	: 50day/year
Annual construction distance of polder embankment	: 1.33km/day×50day/year＝66.5km/year

Notes
1: Considering the move in the polder and the time of preparation, daily operation hours of vibration roller is fixed on 8hr/day.
2: Polder embankments need to be compacted immediately, because the inhabitant of the area use the polder embankments as a road for living and farm activity.
3: Annual operation days of vibration roller is 50days in the work days of dry season (100days), because the of compaction work needs two days (compaction work 1day + movement between polders 1day = 2days).

Referring to the above construction capacity, required quantity of vibration rollers are calculated at 2 unit.

∴ Required quantity＝477.11km ÷ 5year ÷ 66.5km ＝1.43 ⇒ **2 unit**

(4) Mobile Workshop

Troubles of construction machinery, such as engines, electric systems and oil pressure systems lead to fatal failure and special tools and apparatus are needed for repair. When the construction machinery fail at the site, it is necessary to carry to the Mech:Div (1) of Yangon. By introducing the mobile workshops, it becomes possible to check and repair machinery which was not able to respond at the site until now. Therefore, the measuring apparatus, such as tachometer, tester, micro meter etc will be equipped in mobile workshops to avoid troubles in advance. In addition, since the main equipments of embankment works are back-hoe and bulldozer, the tool and repair apparatus will be equipped for the repair, especially engines, electric systems and the oil pressure systems.

Since the polder rehabilitation works are targeted at 3～6 sites in every year, mobile workshop will be requested to mobilize from several sites. Although access to each polders is performed through the non-paved road branched from maim roads (paved national road etc), there are many cases that mobile workshop have to return to the national road when the mobile workshop move to other polder. Therefore, two or more mobile workshops are necessary considering the road condition of the site and the necessity for mobilization to several sites. As a result, two mobile workshops are provided to Myanmar side. Myanmar requested two mobile workshops to Japan side.

(5) Hydraulic Vibration Hammer

During wet season, rainwater is accumulated inside the polder then water is drained to the river outside of the polder through the sluice gate. Existing sluice gates have become too old and damaged by cyclone Nargis. And many sluices are in the bad condition such as leakage, disappearance of gates, and breakage of switchgear of gates including basic concrete. At present, there are 32 sluices in 34 polders which need to remove and build including foundation structure.

Rehabilitation works for the damaged sluices shall be borne by Myanmar's side, and it has been scheduled to put it into practice in compliance with the execution plan by ID. One pile driver will be provided to Myanmar side because foundation work includes pile driving work. At first, ID planed to place the concrete piles in the bore-hole bored by auger. And bore-hole drill was requested from Myanmar side. However, bore-hole is assumed to collapse owing to the high ground water level and soft foundation (N value is less than 5) which mainly consists of silt and clay. As a result of discussing with ID, one hydraulic vibration hammer are provided to Myanmar side instead of bore-hole drill.

Since the concrete piles employed in the sites are circular section or rectangular section, the type of vibration hammer shall be suitable one equipped with corresponding chucks (apparatus for fixing a pile by pinching it). In this context, as the result of consultations with ID, the type of the vibration hammer that can be attached to the base machine (back-hoes) is to be procured coupled with a back-hoe.

2-2-2-3 Test Laboratory Equipments

As regards testing equipments, apparatuses and equipments that are necessary for maintaining quality of rehabilitation works on polder embankments shall be procured. Since the completion of the facility of ITC in 1988, testing equipment has never been renewed despite that dilapidation of the equipments proceeds and some of them have got out of order. Under such a condition, staff of ITC themselves have practiced regular inspection and repairing, thus many of their equipments are still utilized. In spite of such current dilapidated situation of the equipment, over two decades has passed since it had been procured without any re-inspection and verified certification by their producers. Continued use of many dilapidated or almost torn-out equipment by their own regular inspection and mending troubles may affect the accuracy of the measurement results. Table 2-2-4 gives the equipment to be procured including the present state of those held by ITC.

Table 2-2-4 Specifications and contents of the testing equipments to be procured

No.	Testing equipments	Specification	State of those held by ITC	Testing purpose etc
Soil Mechanics Tests				
1	Sieves (Grain size analysis) made of stainless steel	53.0, 37.5, 26.5, 19.0, 9.5mm 4750, 2000, 850, 425, 250, 106, 75μm 12 sieves set	These tools have been made use of for over 20 years without any renewal. Particularly, sieves nets with smaller meshed have been clogged or partly torn. Sieves are needed for laboratory use and quality control tests	These sieves sets are used in sieving in soil grading tests. they are also used in sieving tests for concrete aggregates test
	Sieves (Aggregate sieving tests) made of stainless steel	106, 75, 63, 53, 37.5, 31.5, 26.5, 19, 16, 9.5mm, 4750, 2360, 1700, 1180, 600, 300, 150, 75μm with receiving vessels and caps		
	Spares	75μm		
2	Filter	Filter for permeability tests with a mesh of 0.074mm, φ10cm	ditto	These sieves sets are used as filter in permeability tests
		Filter for permeability tests with a mesh of 0.42mm, φ10cm		
3	Permeability test apparatus	φ10cm	This has been used for over 20 years without any renewal.	To identify perme-ability coefficient in quality control testing.
4	Hydrometer and its cylinder, Mechanical analysis stirrer		This has been used for over 20 years without any renewal.	These are used for measuring specific gravity of soil particles in soil grading tests and soil mechanical analysis. reagents are used for dispersing soil colloid in samples.
	H_2O_2 reagent Na_2SiO_3 reagent	Materials for dispersing soil colloids in soil grading tests. Since these reagents are possibly dangerous, careful packaging is required.	So far, reagents made in Myanmar have been employed but they are not effective for the required purpose.	
5	Large triaxial machine	φ300mm, attached with automatic rammer and mold for permeability test	Since it has been used for over 20 years, measurement of water pressure in soil pore is impossible by pore pressure gauge. Because if lack of regular evaluation inspection on stress, there is concern for degradation of measurement accuracy. Pore pressure meter is no more repairable.	This is used to test and identify strengths of materials for drain and filter in the work on polder embankment, and also in the tests for identifying strength of embankment materials of gravel mixture.
	Rubber sleeve	φ300mm in diameter, 900mm in height	This is an expendable for use of triaxial test and now always in lack of stock	For use in triaxial test

6	Triaxial machine	φ100mm	Since it has been used for over 20 years, measurement of water pressure in soil pore is impossible by pore pressure gauge. Because if lack of regular evaluation inspection on stress, there is concern for degradation of measurement accuracy. Pore pressure meter is no more repairable.	This is used for the test to identify the strength of embankment materials
	Rubber sleeve	φ100mm, height: 340mm	Expendable for use of triaxial test, currently always lack of stock	Used for triaxial test
	Porous stone, filter paper		An expendable	Used for triaxial test
7	Compaction apparatus		Since it has been used for over 20 years, rod of the hammer etc has fairly been torn out.	Used for consolidation test
	Mold φ10cm		No renewal has been made for over 2 decades.	
8	Large drying oven	1200×800×1000mm	Inner compartment wall has been broken. Though thermometer has been mended, it can hardly keep constant and stable state.	Used for measuring moisture ratios.
	Drying oven	970×600×750mm		
9	Cylindars	100ml	These are expendables and most of them currently held are broken or with some breakage	Used for the measurement of moisture contents
		500ml		
		1000ml		
10	Precision balance (Electronic type)	Maximum weighing weight: 4100 g	Since no renewal has been made for over 20 years, nor made any inspection on the accuracy of the apparatus.	For quantitative measurement
11	Vacuum pump	Electrically driven	Broken and no more use	Used for permeability test
12	Compressor	For permeability test		
13	Soil grinder	Electrically driven		For treating samples
14	Enamel butt	S-33-18A 36x26 cm	Expendables	For treating samples
		S-33-18B 24x20 cm		
		S-33-18C 45x35 cm		
15	Auger	Post-hole, screw	No renewal has been made for over 20 years	A tool for identifying soil mechanical character at the sites
16	Sprayer		ditto	Used for adjusting moisture ratio
17	Shrinkage limit set		ditto	Used for shrinkage limit test
18	Consolidation apparatus, 6-fold	φ60mm、6 - fold	Since no renewal has been made for over 20 years, nor made any inspection on the accuracy of the apparatus.	Used for consolidation test
	Porous stone, filter paper		An expendable	Used for consolidation test
19	Motorized direct shear apparatus with automatic recording system	φ60mm	Since no renewal has been made for over 20 years, nor made any inspection on the accuracy of the apparatus.	Used for direct shear test
20	Plate bearing set, three point type	φ300mm	ditto	To measure load bearing capacity of foundation, and deformity coefficient

Concrete Tests				
21	Brain air-permeability test apparatus	H-3420 Manometer Liquid Filter	The apparatus has not been functioning by breakage	Used for specific surface test (test for measuring pulverized degree of cement particles)
22	Scratch hardness tester	Pencil - shaped	An expendable	Used for testing soft rocks
23	Schmidt test hammer		Only one hammer is now available	To measure strength of concrete
24	Mixing Bowl and spoon		Expendables	Mixing and kneading of samples
25	BS Mold	Angular shape	Expendables	To prepare testing samples
26	Cylinder Mold	C19-A φ15x30cm	Expendables	ditto
27	Vicat apparatus			Used for cohesiveness test
28	Flasc 500cc		Expendables	Used for measuring samples
29	Compression and universal testing machine, combination type	Tension: 1000kN Bending apparatus at equally divided into 3 angles, Deformed bar chuck (D6-D25, D29-D38, D41-D51, bending test apparatus for sheath pile and round section pile/ peg, that for deformed rod/ pile, compression testing machine for precise correction, data-logger	His has been utilized for over two decades, oil leakage is observed.	Used for tests of compaction & tension test for concrete and reinforcement
30	Colorimeter tube for Organic matter test	H-3493	An expendable	Used for testing contents of organic impurities in sand materials
31	Platform scale 100kg		Since no renewal has been made for over 20 years, nor made any inspection on the accuracy of the apparatus.	To measure samples' weights
32	Weight type scale 50kg		ditto	ditto
33	Large electronic precision balance 100kg		ditto	ditto
34	Electronic precision balance 200g		ditto	ditto
35	Reaction container	Made of stainless steel	ditto	Alkaline reaction
36	Portable concrete mixer	Tilting Mixer	Not functioned	To prepare test samples
37	Hot plate		Not functioned	Sample preparation
38	Capping apparatus		Not functioned	Sample shaping
39	Capping compound warmer		Not functioned	ditto
40	Agitation container		Expendable	Used for aggregate washing test
41	Stopwatch	(refer to photo)	Expendable	For measuring time
42	Cart		Expendable	Carrying samples
43	Los Angels testing machine		Since no renewal has been made for over 20 years, breakage develops at counter	Abrasive test by Los Angels testing machine
44	Cement paste soundness test set		Since no renewal has been made for over 20 years, breakage develops at counter	Used for stability test for cement
45	Geological survey hammer		This is an expendable, now stock has run out	Used for test by casting concrete

Water Quality Tests				
46	Multi-parameter water analysis set		This set cannot be used any more because testing reagents has run out. Since no renewal has been made for over 20 years, nor made any inspection on the accuracy of the apparatus.	Used for water quality tests
47	Distilled water producing set			Manufacturing distilled water for testing
48	pH Meter (laboratory use) (portable)	Both portable type and laboratorial apparatus	Since no renewal has been made for over 20 years, nor made any inspection on the accuracy of the apparatus.	Used for measuring pH of water samples
49	Conductivity meter		Since no renewal has been made for over 20 years, nor made any inspection on the accuracy of the apparatus.	Used for measuring water electric conductivity

2-2-3 Outline Design Drawing

No design figure is available.

2-2-4 Construction Plan / Procurement Plan

2-2-4-1 Principle of Construction / Principle of Procurement

(1) Principle of Procuring Construction Machinery and Equipment

The construction machinery and equipment to be procured by this Project consist of back-hoes, bulldozers, a vibration roller, mobile workshops, a hydraulic vibration hammer and spare parts. As to the production origin, ID desires to purchase those made in Japan from the viewpoint of quality. In this regard, since 4 agents of Japanese construction machinery producers are located in Yangon City, repairing facility and spare parts supplying system are well provided. Judging from these facts, and considering operation and maintenance hereafter, follow-up system as well as stable supply of spare parts, a principle is adopted to select those made in Japan as a rule.

(2) Principle of Procuring Testing Equipments

ITC was established in 1986 by Japanese Grant Aid Project. Over 20 years have elapsed since the testing equipments were provided. During this period, no renewal of these equipments has ever been made, or re-inspection by their producers/ agents for the procured equipments hasn't ever been made. Therefore, staff of ITC themselves had to be engaged in maintenance, inspection and management of their equipment and testing laboratories. From these facts, selection of testing equipments to be procured shall be made taking account of period of past usage up till now, state of break or getting out of order, accuracy of measurement results etc. Also, as regards producing countries of these equipments, those made in Japan shall be procured because currently utilized ones are made in Japan, and also ID desires to introduce Japanese equipments. In addition, since there is no dealer of these equipments exists in Myanmar, the quantities of spare parts and related expendables of testing machine material secures the quantity assumed to be required in a rehabilitation work period (for five years).

2-2-4-2 Items to Regard in Construction / Procurement

(1) General Situations on the Construction Works

According to the communication by ID, labor days and labor hours of its staff has been ruled out as follows:

- Labor days: 2 holidays per week (Saturday and Sunday, every week)

  Notwithstanding, if necessary arises holiday services can be ordered by the judgment of section chief in charge. Also, in the construction sites, holiday services of machinery operators are allowed so that the scheduled works can be completed within the programmed deadline.

- Labor hours: 7 hours / day (9:30a.m. ~16:30 p.m.)

  In the cases where some emergent states arise, it is allowed to order labor at night. Besides, in construction sites, it is allowed to ask operator's labor at night for the purpose of completing works within the deadline.

Judging from these regulations and customs, a principle was adopted to employ both day-and-night shifts in the planned polder rehabilitation works aiming at an early restoration.

(2) Transportation of Construction Machinery and Equipment

Construction machinery and equipment shall be transported by means of mounting vessels held by ID to the sites of polder embankment to be repaired. The Ayeyawady deltas can be reached from Yangon City through channels and rivers such as Yangon River, Pyapon River and Ayeyawady River. Therefore, the mounting vessel will be carried to the construction sites through Yangon River and appropriate channel and river. It is possible to load 3 machinery if they are lighter than 20t / machinery in a mounting vessel, and 2 machinery if they are heavier than 20t but lighter than 30t. At least 2 days are necessary to carry them from Yangon to the sites of construction. In this connection, transportation cost incurred to transport them from their motor-pool to polder embankment shall be borne by ID.

2-2-4-3 Work Sharing and Procurement / Installation Sharing

In this Project, sharing between Japanese side and Myanmar side is given in Table 2-2-5.

Table 2-2-5 Share of works / share of procurement

Japanese side	Myanmar side
1. Procurement and transportation of construction machinery to the yard of Mechanical Division (1) of ID 2. Procurement, transportation and installation of testing equipments to ITC 3. Provision of instructions or initial operation / those of application and management	1. Acquisition of land for assembling construction machinery 2. Hiring operators of the procured construction machinery 3. Procurement of fuel for the procured construction machinery 4. Transportation of the procured construction machinery to polder embankment 5. Procurement of testing staff, sources of electricity etc.

2-2-4-4 Operation control / Procurement Control Plan

Based on the operational system of Japanese Grant Aid cooperation, Japanese consultant recommended by JICA performs procurement control of the following design and supervising services for procuring machinery and equipments with a contract with Myanmar side.

(1) Design supervision (including bid)

To provide detailed design and tender document on the procurement of machinery and equipment based on this plan.

(2) Procurement supervision by the consultant

As regards the delivery destinations of the procured machinery and equipment, they are Yangon City for construction machinery and equipments, and Bago City for testing equipments. For procurement supervision, engineers with ample experiences will be dispatched to these two delivery destinations so as to perform operation control and quality control.

(3) Assembling yard for construction machinery

Procuring of assembly yard for construction machinery shall be borne by Myanmar side.

2-2-4-5 Quality Control Plan

Embankment on dikes and concrete structures of water gates are considered as the structures that need proper quality in the polder rehabilitation works. Various tests are relevantly performed according to the dealing quantities of materials etc.

(1) Quality Control of Embankment

Quality control of embankment will be made employing the control of D value in compaction curve (a curvilinear relationship between soil moisture ratio versus soil density) as shown in Fig. 2-2-4 as a base. D value is indicated as a rate between embanked soil density and the maximum density obtained by laboratorial compaction tests, and D value = 90% is employed as a standard control value to be applied to general road foundation and reservoir dikes. This value was also employed in the embankment works in the verification project, yielding favorable result on quality control without arising any particular problem. from this experience, D value = 90% will be adopted as a target value in hereafter quality control. In this context, for the sections where manual works are required, D value = 85% will similarly be employed as the lower limit value for quality control as employed in the verification project.

As site (in situ) testing in the verification project, density tests and soil moisture ratio tests were conducted everyday for embankment works, and soil moisture ratio tests only was carried out also everyday in the borrow area. At the same time, specific gravity test of earth, soil grading test, liquidity / plasticity test, compaction test, permeability test, consolidation test, triaxial compression test etc were relevantly made in ITC. These tests shall similarly be conducted for hereafter rehabilitation works.

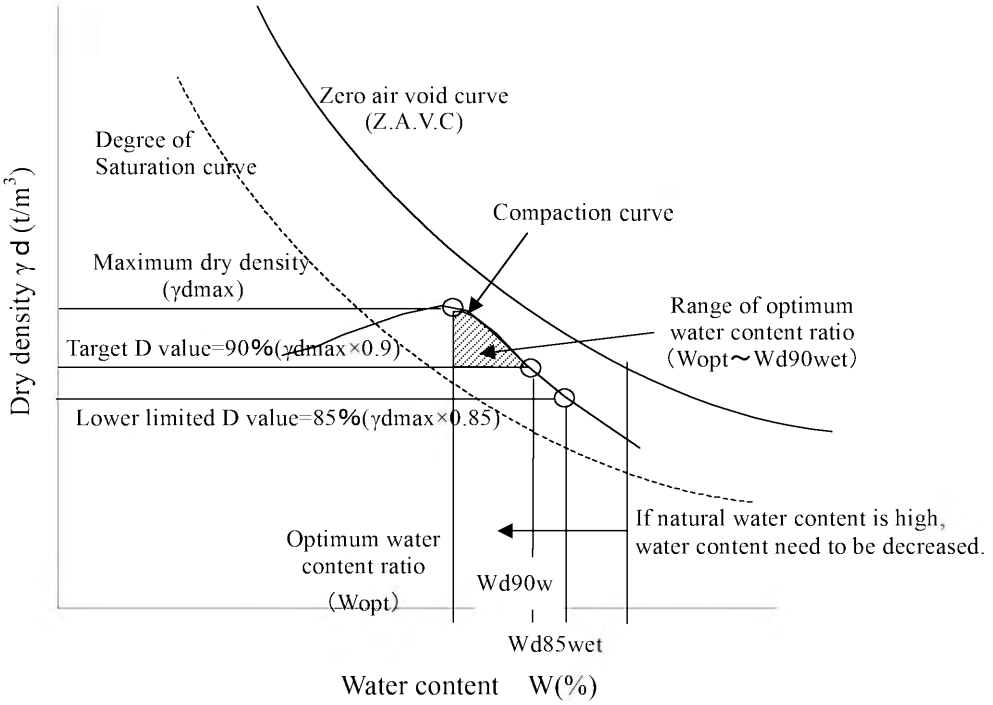


Fig. 2-2-4 Compaction curve

(2) Quality Control on Coarse Grade Embankment Materials

In implementing polder rehabilitation works, it is necessary to work embankment by installing drain over old stream bed or on weak foundations (refer to photo-2-2-8). Gravel materials are utilized for coarse grade materials to provide drain. Such gravel materials are available at a quarry located at 1 mile east of the middle point between Labutta and Myaungmya（refer to photo-2-2-9, -2-2-10）. In the case of working for embankment using these gravel materials, it is required to identify their quality by means of a large triaxial machine.

Fig. 2-2-5 shows an example of section in the case of construct drain with gravel materials, while Fig. 2-2-6 illustrates an example of work without drain. Similarly, reinforced embankment with gravel materials is applied to the dikes contacting with flowing water (refer to photo-2-2-11).

Photo-2-2-8 Enclosed site of tributary flow near Danechaung Water gate

Photo-2-2-9 A quarry (crusher made in Japan)

Photo-2-2-10 A quarry (sieving machine)

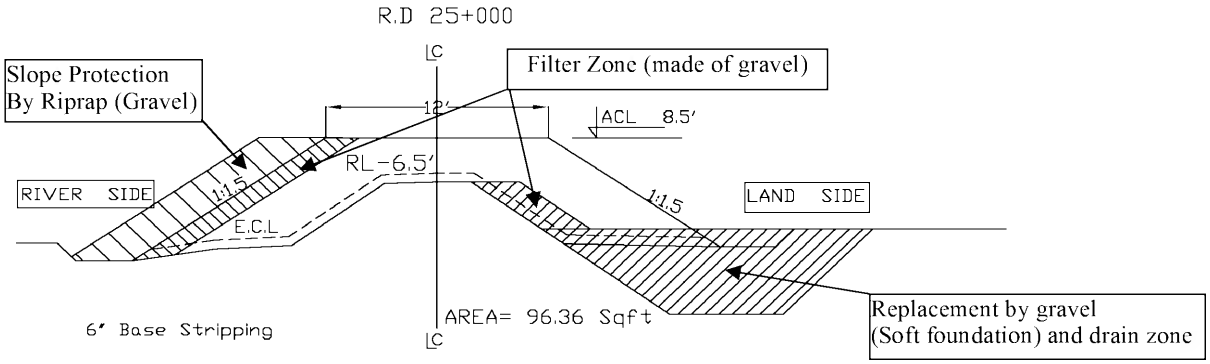


Fig. 2-2-5 Typical section of polder over old stream-bed and weak foundation

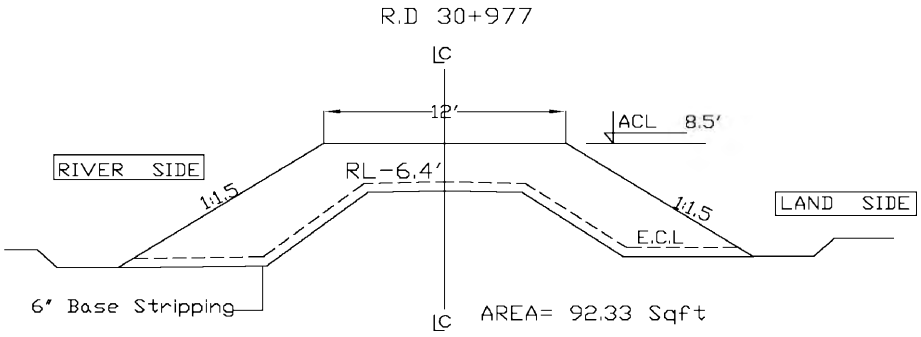


Fig. 2-2-6 A section of polder embankment without working drain

Photo-2-2-11 Reinforcement of embankment with gravel materials

(3) Objective and Frequency of the Tests on Embankment Materials

As the tests performed as quality control tests on the earth of embankment in implementing polder works, two types of the tests have been performed including such in-situ physical tests as soil moisture ratio test, density test and soil grading test as well as such laboratorial, mechanical tests for measuring and identifying strength or permeability. Physical tests shall be conducted almost everyday at the site of construction sites. Mechanical tests to be conducted in the laboratory to identify whether there is any change in the characteristics of embankment materials or not, frequency of which shall be once per 50,000 m^3 of embankment quantity or once or twice per annum. Objective and frequency of major tests are as follows:

- Consolidation test is done for the purpose of judging quantity of settlement/ subsidence of embankment earth, its frequency is to test once ~ twice a year per polder.
- Direct shear test is conducted for identifying strength of materials of embankment and basement foundation. It is to be tested once or twice per annum per polder.
- Permeability test has an objective of judging water permeability inside the embankment materials, serving as an indicator of generating leakage from and piping in the embankment. It is to be conducted once or twice per year per polder.
- Triaxial test is performed to judge strength of embankment as well as foundation materials, and the test uses triaxial test apparatus in the case of measuring only soil mechanical materials on one hand, large triaxial test apparatus is to be utilized in the cases of including such gravel materials as drain materials, on the other. Tests for identifying strength are to be performed once ~ twice a year for every polder.

(4) Testing Equipments for Concrete Materials

Water gates are a kind of concrete structure and various tests shall relevantly be carried out in order to control quality of their materials including cement, aggregate and reinforced steel bar.

(5) Water Quality Testing Equipments

Water quality tests are performed to identify suitability of water quality to be used for kneading concrete, testing pH and contents of admixture. Also, electric conductivity tests are employed for the purpose of clarifying the extent of soil salinity in deltaic areas.

Summarizing the above-description, Table 2-2-6 shows frequencies of major quality control tests to be performed for polder embankment rehabilitation works.

Table 2-2-6 Items and frequencies of quality control tests (draft)

Controlling item	Testing method	Testing frequency	Remarks
Soil particle density	JIS A 1202	Once per 50,000m^3	Laboratory test
Site density	Conventional test	Once per 5,000m^3	Site embankment
Site permeability	Conventional test	Once per 50,000m^3	Site embankment

Moisture ratio	JIS A 1203 or Conventional test	Once per 5,000m^3	Site embankment laboratory
Grading	JIS A 1204	Once per 50,000m^3	Laboratory test
Liquidity / plasticity limit	JIS A 1205	Once per 50,000m^3	Laboratory test
Gravel density/ Water absorption ratio	JIS A 1110	As need arises	Laboratory test
Compaction	JIS A 1210	Once per 50,000m^3	Laboratory test
Permeability test	JIS A 1218	Once ~twice a year	Laboratory test
Consolidation test	JIS A 1217	Once ~twice a year	Laboratory test
Triaxial compression test	JGS 0521,0523	Once ~twice a year	Laboratory test
Concrete material test	Various tests are to be applied as need arises on such materials as cement, concrete and reinforced steel bar. Concrete compressive test will be performed once per one sluice construction.		
Water quality test	Apply as need arises to samples of water for concrete kneading as well for identifying water quality at site.		

2-2-4-6 Procurement Plan of Machinery and Equipment

(1) Places of Procurement

ID has so far procured a lot of construction machinery made in Japan, thus it highly trusts them. Considering the reasons that local agents (dealing with 4 Japanese construction machinery producers) hold ample inventory of spare parts and also providing well-installed workshops that make maintenance of machinery enough possible, the place of procuring machinery and equipment is decided in Japan.

As to the possibility of procuring them in the third country, although factories producing backhoes and bulldozers are located in Thailand and Indonesia, types of machinery they are producing have small horsepower, or their specifications are confined to use for forestry, thus they do not suit the required specifications in this Project and it was decided not to procure them in the third countries.

Table 2-2-7 Places of procurement of machinery and equipment

Type	Country of origin			Remarks
	Local	Japan	The third country	
Construction machinery				
Back-hoe (Hydraulic excavator)		○		
Bulldozer		○		
Vibration Roller		○		
Mobile Workshop		○		
Hydraulic Vibration Hammer		○		
Spare Parts		○		
Testing machinery				
Soil Mechanical Testing Equipment		○		
Concrete Material Testing Equipment		○		
Water Quality Testing Equipment		○		

(2) Transportation

Machinery and equipment procured in this aid Project consist of construction machinery and testing equipments, with a plan to procure all these in Japan. These machinery and equipments transported by sea carriage are landed in Yangon Port, then construction machinery is further transported by land transportation along the distance of 33km to the yard of Mech:Div (1) of ID. Also, testing equipments are transported from Yangon Port via Yangon City streets to ITC in Bago City along the distance of 113km by land transportation. The land transportation is made along trunk roads paved by asphalt with favorable surface condition, but traffic jam is anticipated depending on the time of transport.

These machinery and equipment will be landed in Myanmar during the period of wet season. Most of the spare parts of construction machinery and testing equipment will be transported in containers, however, those large sized apparatus such as large scale triaxial machine, normal sized triaxial machine, automatic compaction machine, consolidation apparatus, and compression and universal testing machine will be transported as load in bulk on tracks. It is required to prevent rain water from soaking into the packed apparatus during loading and unloading. The countermeasure against the rain water soaking is to prevent the damage of packing material by tightening the package to the track and to provide the double sheet cover. It is especially important to avoid the rain soaking for these testing equipment because they are precision machines.

2-2-4-7 Plan on the Instructions of Initializing Operation / Application of Management

(1) Construction Machinery

Construction machinery is to be assembled in the yard of Mech:Div (1) of ID in Yangon. The said Division has a yard with an area of 2.4 ha, and it holds crane trucks, generators, air compressors and a multiple tools in its workshop, thus it is equipped with enough space and facility to assemble construction machinery.

At the assembling, experts dispatched from the producers of machinery serve as instructors. 24 back-hoes and 12 bulldozers are planned to deliver after assembling them in Japan, and it'll take each 7 days for additional local assembly (mounting bucket and blade board etc), check of the state of driving, adjustment and test driving/ operation, handling instruction, application/ management instruction, inspection and delivery.

Only one vibration roller is planned to deliver the identification of driving state, adjustment/ test operation of which takes only a short period, thus 3 days are planned to cover these operations including operation/ handling instruction, application / maintenance instruction, inspection and delivery.

As to the delivery of mobile workshops and a hydraulic vibration hammer, it takes long time for the instruction on operation, application and maintenance, thus it takes each 7 days to cover the series of procedure from the carrying of machinery to the inspection / delivery.

In this connection, inspection and delivery of these machinery and equipment is performed by the engineers of related machinery producers jointly with the contracted consultant.

(2) Testing Equipments

Local instruction for the testing equipments is performed by 3 experts dispatched by the agents who supplied equipments (consisting of a mechanic engineer, an electric engineer and a soft-ware engineer).

It'll take 14 days to clear all the delivery procedures including unpacking, carrying-in, supervision on installing work (foundation work for large equipment), connecting /coupling work to tap-water and drainage pipes, wiring cables, connection of communication circuits, electronic machines/ apparatuses and soft-wares etc. Besides, 14 days are planned to finish the identification inventory /inspection of machinery bodies, spare parts and expendables as well as inspection / hand-over that are performed jointly with the contracted consultant. in this context, Japanese engineer in charge gives instruction on the installment of large testing equipment at its delivery. The laboratory of ITC currently holding a lot of testing apparatuses has still enough space to carry in and install procured testing equipments.

21 days are scheduled to cover the procedures including identification of driving / accuracy of testing equipments performed by the mechanic engineer and the electric engineer, check of soft-ware control performed by the soft-ware engineer, identification / adjustment of data collecting procedure. In this context, these trial works will be carried out jointly with staff of ITC in charge, so that the instructions on operation, application and maintenance can be made in the course of this delivery work. In addition, 7 days are planned for the instructions on testing application (training lecture) performed by the mechanic and the electric engineers, instructions on operation and maintenance, explanation and operational demonstration on calibration and measurement methods by soft-ware offered by the soft-ware engineer.

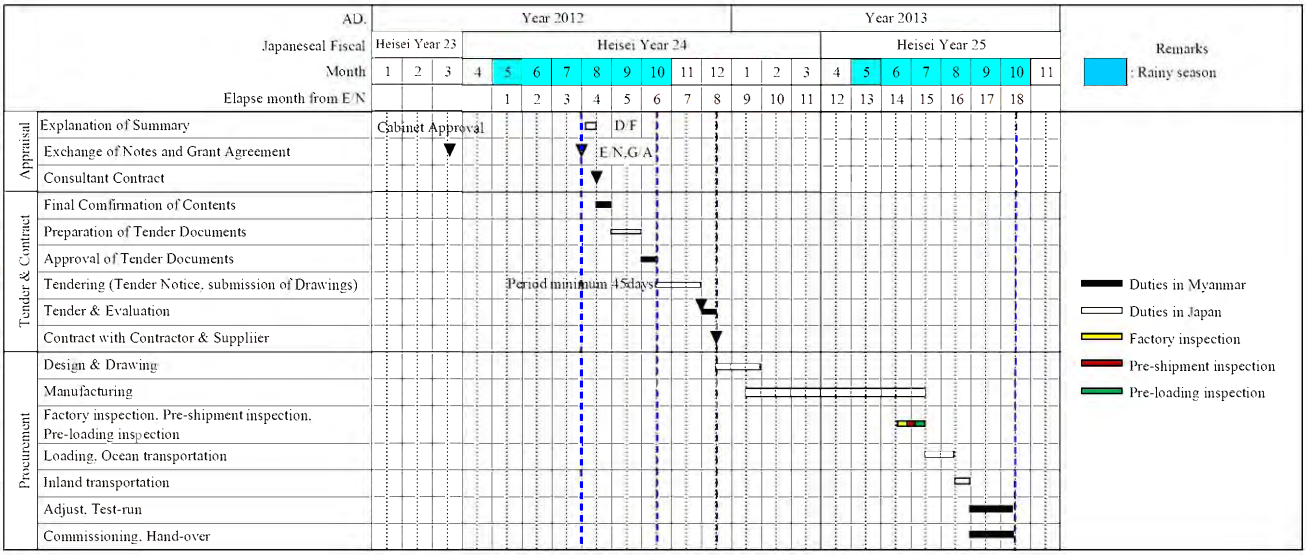
2-2-4-8 Soft Component Plan

After delivery of the machinery and the equipment, those works of installation, adjustment, test operation, guidance of operation and maintenance will be carried out consistently by the manufacturers and the consultants. No soft-component is planned in this Project.

2-2-4-9 Work Operation Schedule

As to the operation schedule of this Project, detailed design will be implemented by contracting with a consultant after the completion of E/N (Exchange of Note) and it'll take 7 months to provide detailed design and tender document, followed by the bid by the participating agents and contract for procurement. It will take another 7 month-period for the procurement of machinery and equipment including provision of machinery provision figures, factory manufacturing and pre-inspection before marketing, and the Project will be completed after clearing mechanical adjustment / test-driving or operation followed by application instructions as well as final inspection and delivery. Table 2-2-8 shows the project implementation schedule.

Table 2-2-8 Project implementation schedule



2-3 Obligations of the Government of Myanmar

In implementing this Project, it is required for Myanmar side to promptly pursue the following sharing items:

1) Banking arrangements), prompt clearance of banking procedure including an Authorization to pay (A/P) etc. in compliance with the Grant Aid System (B/A).

2) Payment of commissions for correspondence and payment toward the bank with which the government concluded the contract.

3) Guaranteed import tax exemption on the imports of the procured machinery and equipment.

4) Securing entry into Myanmar, sojourn for the purpose of performing official services and keeping safety for Japanese national who are in charge of the procurement of the procured machinery and equipment

5) Securing space of delivering procured machinery and equipment and arrangement of receiving system at Myanmar's side on the management instructions of these machinery and equipment.

2-4 Operation and Management Plan of the Poject

(1) Construction Machinery and Equipment

Con (9) in charge of polder rehabilitation works manages the procured construction machinery and equipment and is responsible for their routine and regular inspection in its construction sites. 86 mechanic engineers and technicians, 6 electric engineers and technicians are stationed in the entire Con (9). Many drivers (29 persons) and heavy machine operators (256 persons) are assigned in Con (9) and are ready to operate those procured machinery and equipment. The construction machinery is

transported from Con (9) to the construction sites by mounting vessels in the construction period (from early December to end of March) and transported again to Con (9) for inspection and maintenance in wet season (from May to October).

In cases that machinery gets out of order in the construction sites, mobile workshops are mobilized. In cases that serious trouble takes place on the machinery, the troubled machinery is towed to Yangon City and then it is inspected and repaired in the workshop of Mech:Div (1). In this Division, 27 mechanic engineers and 3 electric engineers have been assigned, also equipped with cranes, welders and a host of work-shop tools. In Yangon, there are agencies of 4 Japanese heavy machine manufacturers and are ready to supply spare parts and accept to their repair workshops.

(2) Testing Equipments

The member of ITC (management 23, staff 116, total 139 person) themselves have practiced regular inspection and repairing, thus they manage to use many of their equipment. Since no private agent dealers with, inspects and maintains testing equipments in Myanmar, the staffs of ITC are responsible for the management, inspection, operation and maintenance of the procured testing equipments as it is. It can be judged that staffs of ITC have high sense / awareness of operation and maintenance of their equipment and from their past performances they are judged to be equipped with high technical capacity. But many testing equipments differ from existing testing equipments as to specification and operation method etc, therefore local inspection for the testing equipment is performed by Japanese engineer. Japanese engineer consists of mechanic engineer, electric engineer and soft-ware engineer. Japanese engineer will guide ITC staffs in installing work, operation (approval of preciseness), management and maintenance etc. By this guidance, consistent operation and maintenance system will be kept in ITC.

Judging from the present social situation, it might be expected that a private manufacture company establish an agent in Yangon City and take responsibility for repair of serious damage and periodically approval of the testing equipment.

2-5 Project Cost Estimation

2-5-1 Initial Cost Estimation

2-5-1-1 Conditions of the Cost Estimation

- Time of the estimation: April 2011
- Currency exchange rate: 1US$ = 79.38Yen
- Period of construction / procurement: The period of the detailed design and construction works is the same as shown in the project implementation schedule
- Others: The cost estimation is carried out according to the institution of grant aid cooperation by Japanese Government.

2-5-1-2 The Cost to be borne by Japan and by Myanmar

(1) The Cost to be borne by Japan

The overall project cost required to implement the proposed aid Project is ----- million yen. This amount does not indicate the ceiling amount of the Grant Aid as described in E/N. Table 2-5-1 gives the total project cost.

Table 2-5-1 Total project cost under grant aid

	Item	Amount (million yen)	Remarks
Machinery/ equipment procurement cost		-----	
	Machinery / equipment cost	-----	
	Packaging / transportation cost	-----	
	Installation work cost	-----	
	Procuring management cost	-----	
	General management cost	-----	
Design / supervising cost		-----	
	Project design coat	-----	
	Procurement supervision cost	-----	
Total		-----	

(2) The Cost to be borne by Myanmar

In implementing this aid Project, items and the amount of the cost to be borne by Myanmar are summarized in the table below:

Table 2-5-2 Cost to be borne by Myanmar (Unit; million Kyat)

Items to be borne	Cost	Remarks
Bank commission required for banking arrangement	19	
Total	19	

2-5-2 Operation and Maintenance Cost

2-5-2-1 Operation and Maintenance Cost for Construction Machinery

The running cost for five years (fuel, oils and fats, Operation and repair, inland transportation of heavy machinery from Yangon to the construction sites etc) of the construction machinery is given in the following table.

Table 2-5-3 Operation and maintenance cost to be borne by Myanmar (Unit ; ,000 Kyat)

Items to be borne	Cost		Remarks
	Annual	5 years	
Fuel, oil and lubricant cost for heavy machinery	1,163,525	5,817,625	
Operation and repair	80,000	400,000	
Allowances of heavy machinery operators	0	0	Heavy machinery operators are staff of ID already employed, thus no additional expenditure would be evolved
Securing the work space for assembling of heavy machinery	0	0	Making use of the yard of Mechanical Division 81) of ID (A=2.4ha).
Inland transportation of heavy machinery from Yangon to the construction sites	81,600	408,000	Transporting with mounting vessels held by ID
Total	1,325,125	**6,625,625**	

⇒ **6,625 (million Kyat)**

The cost of each items are estimated as follows;

(1) Fuel, Oil and Lubricant Cost

The annual cost of fuel ,oils and fats for the construction machinery is estimated at 1,163,525 (thousand kyat/year). Therefore, the total cost of fuel ,oils and fats for 5 years comes to 5,817,625 (thousand kyat).

・1,163,525 (thousand kyat/year)×5 (year)＝5,817,625 (thousand kyat)

Table 2-5-4 The annual cost of fuel, oil and lubricant

	①	②	③	④=①*②*③	⑤	⑥	⑦=⑤+⑥	⑧=④*⑦	⑨	⑩=⑧*⑨
Type	Annual fuel consumption per unit				Cost of fuel, oil and lubricant				Annual fuel consumption	
	Fuel efficiency ※1 (lit/ hr)	Daily operating hour (hr/day)	Annual operating hour (day/year)	Annual fuel consumption per unit (lit/year・unit)	Cost of fuel ※2 (kyat/ lit)	Cost of oil and lubricant ※3 (kyat/ lit)	Subtotal (kyat/ lit)	Annual fuel consumption per unit (,000 kyat/year)	Number of unit (unit)	Annual cost fuel (,000 kyat)
Back-hoe	22.0	12	100	26,400	1,050	53	1,103	29,119	24	698,856
Bulldozer	27.0	12	100	32,400	1,050	53	1,103	35,737	12	428,844
Vibration roller	16.0	8	50	6,400	1,050	53	1,103	7,059	2	14,118
Mobile workshop	6.6	5	80	2,640	1,050	53	1,103	2,912	2	5,824
Hydraulic vibration hammer	18.0	10	80	14,400	1,050	53	1,103	15,883	1	15,883
Total									41	1,163,525

※1 Fuel efficiency is calculated by JCMA(Japan Construction Machinery and Construction Association).
※2 According to ID, fuel cost is 4,200 kyat/gallon. And 1 gallon=4.0 liter.
※3 Cost of oil and lubricant set into 5% of fuel costs.

(2) Operation and Repair Cost

The annual cost of operation and repair for the construction machinery is estimated at 80,000 (thousand kyat/year). Therefore, the total cost of operation and repair for 5 years comes to 400,000 (thousand kyat).

・80,000 (thousand kyat/year)×5 (year)＝400,000 (thousand kyat)

Table 2-5-5 The annual cost of operation and repair

	①	②	③	④=②/③	⑤	⑥	⑦	⑧	⑨=①*④/100 *⑥*⑧/⑦	⑩	⑪=⑨*(100-⑩)/100
Type	Number of unit (unit)	Operation and repair rate (%) ※1	Period of durability (year) ※2	Annual operation and repair rate (% year・unit)	Unit cost of machinery (,000 JP yen)	Unit cost of machinery (kyat) ※3	Period of rehabilitation work (year)	Operating period of machinery ※4	Annual operation and repair cost (Including personnel expense) (,000 kyat/year)	Rate of personnel expense (%) ※5	Annual operation and repair cost (Without personnel expense) (,000 kyat/year)※6
Back-hoe	24	45	16.0	2.8	15,500	161,000		5 (500days)	108,000	65	37,800
Bulldozer	12	60	16.0	3.7	24,500	255,000		5 (500days)	113,000	65	39,550
Vibration roller	2	40	28.0	1.4	10,800	112,000	5 (500days)	2 (200days)	1,000	65	350
Mobile workshop	2	45	21.0	2.1	18,700	194,000		2 (200days)	3,000	65	1,050
Hydraulic vibration hammer	1	45	16.0	2.8	35,400	368,000		2 (200days)	4,000	65	1,400
Total	41								229,000		80,150

⇒ **80 (million Kyat)**

※1 Operation and repair cost is calculated by JCMA(Japan Construction Machinery and Construction Association).
※2 Period of durability is set up from "Equipments / Machineries Condition of Irrigation Department "which came from ID
※3 From the exchange rate which is announced by JICA in June 2012, 1 kyat is 0.096 Japanese yen.
※4 The actual operated period for machinery in rehabilitation period (5 years).
※5 Personnel expenses for operation and repair.
※6 Expendable of machinery, tools, storing expenses of machinery, office expenses of operation & management, etc.

(3) Inland Transportation of Construction Machinery from Yangon to the Construction Sites

Cargo boat will be used for the inland transportation from Yangon to the construction sites. Cargo boat can load three machinery if the weight of machinery is less than 20ton. And if the weight of machinery is between 20ton and 30ton, it can load two. Thus the number of cargo boat for transportation of machinery is as follows (mobile workshops are not loaded into cargo boat because it can move to sites itself);

- Bach-hoe (23ton class) : 24 unit ÷ 2 unit/unit = 12 unit
- Bulldozer (20ton class) : 12 unit ÷ 3 unit/unit = 4 unit
- Vibration roller (12ton class)+Hydraulic vibration hammer : (2 unit+1 unit) ÷ 3 unit/unit = 1 unit

Total 17 unit

Thus the average transportation cost from Yangon to the construction sites (one way) is 2.4 (million kyat), the annual transportation cost (round trip) comes to 81.6 (million kyat).

- 2.4 (million kyat/unit)×17 (unit)×2(times)=81.6 (million kyat)

Therefore, the total cost of transportation for 5 years comes to 408.0 (million kyat).

- 81.6 (million kyat/year)×5 (year)=408.0 (million kyat)

2-5-2-2 Operation and Maintenance Cost for Testing Equipments

Management and operation / maintenance for testing equipments have so far been carried out by the staff of ITC. Also, it is plausible that hereafter they continue to manage them. Most of the operation / maintenance cost are expenses for wages of ITC staff, lighting and fuel. Therefore the expenditure is assumed to same as the present condition after providing the testing equipments.

Mechanical testing equipments (Triaxial Test Apparatus, Consolidation Apparatus, Compression and Universal Testing Machine etc) and analytical testing equipments (Multi-parameter Water Analysis Set, pH Meter, Conductivity Meter etc) need periodically measurement of precision. Mechanical testing

equipments can take periodically measurement of precision by using the measurement apparatus for proofread which is attachment for Compression and Universal Testing Machine. Mechanical testing equipments have result of inspection (measurement list of precision and conversion table of load etc) which is conducted before shipment, and these tables will be standard for periodically measurements of precision and proofreading. Analytical testing equipments can take periodically measurement of precision by using the standard liquid which is attachment for each of equipment. Measurement of precision and proofreading will be guided by Japanese engineer.

ITC staffs can repair slight broken equipments. But ITC imported substitute equipments from another country when the serious troubles of the equipments occurred. There is no private company or agent in existing Myanmar, ITC assume to import substitute equipments from Japan or third country. It is conceivable that the cost will be borne by ITC within its annual budget.

Chapter 3 Project Evaluation

Chapter 3 Project Evaluation

3-1 Preconditions

The premised conditions of the implementation of the Japanese Grant Aid project are listed as follows:

① Prompt realization of such banking procedure in compliance with the system of the grant Aid Cooperation as Banking Arrangements (B/A) and Authorization to Pay (A/P) etc.

② Charged payment of informing and payment commissions to the bank with which the government came to a contract on B/A.

③ Guarantee of import tax exemption for the imports of the procured machinery and equipment under the Project.

④ Securing entry to and sojourn in Myanmar of Japanese nations who undertake services of procuring machinery and equipment under the Project and guarantee of safety during their stay in Myanmar.

⑤ Improvement of the system of receiving te procured machinery and equipment by ID to secure the space of delivery of the procured machinery and equipment and the arrangement of management instructions for these machinery and equipment.

3-2 Necessary Inputs by Myanmar side

The items that Myanmar side has to approach in order to manifest and sustain the effects of the Project are as follows:

(1) Items that Myanmar bears toward polder rehabilitation works

This aid Project aims at procuring construction machinery and equipment as well as testing equipments necessary for rehabilitating polders. Accordingly, in implementing rehabilitation works, Myanmar is to bear the costs of carriage of the procured and delivered construction machinery and equipment to the sites, purchase of fuels for heavy machinery, payment of allowances to the operators of heavy machinery. Similarly, the cost of conducting various tests for the purpose of securing quality of the works, payment to employed testing staff are also borne my Myanmar side.

(2) Installation of water gates

As this project aims at procuring construction machinery and testing equipments, rehabilitation works for water gates are to be executed by the budgetary appropriation of Myanmar side.

(3) Measures on environment and social consideration

In the case where rehabilitation works for polder embankment are implemented utilizing machinery and equipment procured by the proposed Grant Aid cooperation project, it becomes necessary to elevate the height of the embankment for the purpose of strengthening the function of polder embankment. For this reason, widths of the embankments shall be widened, then it will be required to acquire farmland for the public site for construction. Cultivation and habitation have been prohibited on the land area within 50

feet from the edge of the embankment in Ayeyawady Delta, by the instruction of staff of local offices and ID since the construction of polder embankment in 1981 because the area should be placed under the management of ID. It is required for the local office staff in charge to survey whether there are actually houses or cultivated fields around the planned polders for rehabilitation that have illegally occupied the public land. Besides, it is necessary to take relevant measures against possible detrimental effect evolved from the rehabilitating works, in particular in order to mitigate these effects to the inhabitants living around the sites

(4) Operation and maintenance after the completion of the rehabilitation works

It is required for the public agencies in charge within the jurisdiction of Ayeyawady Delta to operate and maintain the rehabilitated embankment bodies and water gates for ever in the future.

3-3 Important Assumptions

The following indicates the external conditions to manifest and sustain the effects of the Project:

① Any abnormal meteorological phenomenon does never take place to such an extent as to exceed the height of wave as elaborated in the Master Plan (the height of the wave and free board height determined by the analysis and the calculation of meteorological data offered from ID based on the design high water level (H.W.L.))

② Budget allocating measures will be taken by the government of Myanmar to meet the cost of operation and maintenance during the rehabilitation and after the completion periods.

③ Economic state in Myanmar comes to get stabilized for a long time in future, without occurring unexpectedly enormous price escalations so that requirement for operation and maintenance can be procured.

3-4 Project Evaluation

3-4-1 Relevance

The implementation of the target project of applying this grant Aid cooperation is judged feasible from the following points:

① Cyclone "Nargis" that had landed on the coastal area of the Myanmar in May 2008 caused a heavy toll of casualty including death or missing of over 138 thousand inhabitants living there as well as catastrophic damages on their life and production activities. Inhabitants in Ayeyawady Delta have ever lived and been engaged in farming within the areas surrounded by polder-embankment that have prevented sea-water invasion. However, the cyclone "Nargis" destroyed these polder embankment and washed paddy field area of totally 770 thousand hectare away, immediately after the destruction invasion or inundation of salt water took place during high-tide period that severely affected paddy yields, thus depriving damage-prone farmers of such production means as seed, livestock, farm machinery etc. Through the polder rehabilitation works facilitated by the implementation of this aid Project, it is considered possible to minimize the hereafter damages brought about by future high tides and cyclones.

② Most of the construction machinery and equipment currently managed by ID has already been dilapidated and their life has already been expired. Such an aged situation has led to frequent machine troubles with susceptibility of getting out of order. Thus, need of construction machinery's renewal has been identified so as to steadily facilitate the rehabilitation works as they are planned. The procured testing equipments is considered further available even after the completion of the planned rehabilitation works to contribute to other land consolidation projects in Myanmar.

③ In order to keep the quality of polder rehabilitation works testing and identification of various mechanical characteristics and soils and materials by qualified testing equipments are indispensable. Since the completion of the facility of ITC in 1988, testing equipment has never been renewed despite of its dilapidation and troubles of getting out of order. Under such a condition, staff of ITC themselves have practiced regular inspection and repairing, thus they manage to use many of their equipment. In spite of such current dilapidated situation of the equipment, over twenty years has passed since it had been procured without any re-inspection and verified certification by their producers. Continued use of many dilapidated or almost torn-out equipment by their own regular inspection and mending troubles may affect the accuracy of the measurement results. Progress of construction material tests by ITC are attached to the Appendix-5.2 in the Appendix-5. Implementation of this aid project enables to secure the quality of rehabilitation works and the procured equipments are also usefully contributed to hereafter implemented land consolidation projects in Myanmar.

3-4-2 Effectiveness

The following effects are expected in the rehabilitation of the damaged polders through the implementation of this aid Project.

(1) Quantitative effects

Indexes	Base year (2012)	Target year (2017) (The completion time of rehabilitation work in 34 polders)
The length of rehabilitation embankment (Total 34 polders)	383.47 km (Rehabilitation work completed in 15 polders as of 31 Dec. 2011)	Total 941.83 km (for remaining 19 polders : 477.11 km)
Conservation of paddy fields	0.0 acres (0.0 ha)	145,053.6 acres (58,703.2 ha) (remaining 19 polders)
The number of test ・Compaction test ・Density test ・Concrete test	 32 times / year 311 times / year 1 time/1 sluice rehabilitation work	 160 times (for 5 year) 1,555 times (for 5 year) 32 times (32 spots for 5 year)

(2) Qualitative effects

- The desirable quality of the works can be guaranteed by performing the tests with the procured testing equipment in implementing rehabilitation works for damaged embankment.
- After the completion of the rehabilitation works for damaged polder embankment, awareness of the inhabitants toward the preventive effect against the damages by high-tiding / floods will be enlightened.