Ministry of Health (MOH)
Democratic Socialist Republic of Sri Lanka

PREPARATORY SURVEY REPORT
ON
THE PROJECT
FOR
THE STABILIZATION OF POWER SUPPLY USING RENEWABLE ENERGY AT HOSPITALS
IN
THE DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA

NOVEMBER 2023

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

YACHIYO ENGINEERING CO., LTD.

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PREFACE

Japan International Cooperation Agency (JICA) decided to conduct the preparatory survey and entrust the survey to Yachiyo Engineering Co., Ltd.

The survey team held a series of discussions with the officials concerned of the Government of the Democratic Socialist Republic of Sri Lanka, and conducted field investigations. 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 Sri Lanka for their close cooperation extended to the survey team.

November, 2023

Hiroo TANAKA

Director General,

Infrastructure Management Department

Japan International Cooperation Agency

SUMMARY

1. Overview of the Country

Sri Lanka is located in the Indian Ocean, southwest of the Bay of Bengal.

It covers an area of 65,610 km^2. The distance from the Jaffna, Northern Province to Gale, Southern Province is about 450 km in a straight line. The northern part of the island is flat, while the southern part is more mountainous. The mountainous includes areas above 2,000 meters such as Mount Pidurutalagala, and Peak Wilderness Sanctuary. Lengths of sixteen rivers in total is above 100 km. The longest river is the Mahaweli River, which flows northeast into the Bay of Bengal. Costal areas below 30 meters are mainly sandy beach whilst northeast and southern costal areas forms with cliffs and bays.

The growth in power demand in Sri Lanka is remarkable, and a high average growth rate of 6.2% has been maintained for the five years from 2014 to 2018. According to the report of the Ministry of Power, "Progress 2021Program 2022", power demand in Sri Lanka grew at an annual rate of 5.5% in 2021. The growth rate of peak demand is 3.7% per year. The peak demand for the period from January to September 2021 was recorded at 2,801.62 MW.

2. Background of the Project

In order to meet the increasing demand, Sri Lanka has been working to develop new power sources. However, most of the major hydropower resources have already been developed, and thus the shortfall in supply has been compensated by thermal power generated by fossil fuel. Power generation costs are high. In 2022, fuel imports for thermal power generation will be significantly delayed due to increases of international oil prices and Sri Lanka's shortage of foreign currency. Under the situation, it became necessary to implement rolling blackouts. In addition, the electricity tariff being raised by 75% compared to the previous year, the tariff is forecasted to remain high in the future.

This situation has also had a major impact on the medical field, especially in large hospitals that consume a lot of electricity. Due to the increase of fuel prices, there is a need to turn off air conditioning and turn off lighting to save power, which may limit medical services themselves.

Given on the above, Sri Lanka expressed its intention to seek a plan to reduce electricity costs and improve medical services by introducing a solar power generation system.

3. Outline of the study findings and Project contents

JICA dispatched the Survey Team to Sri Lanka from April 15 2023 to May 9 2023 (the first field survey) in order to discuss the contents for implementation with related agencies on the Sri Lankan side, survey the Project sites, and gather related materials and data.

Upon returning to Japan, the Survey Team examined the necessity, social and economic impacts and validity of the Project based on the field survey materials and compiled the findings into the draft preparatory survey report. In addition, JICA conducted the second field survey from August 21 2023 to August 23 2023 (online) in order to explain and discuss the draft preparatory survey report (outline explanations) and reach a basic agreement with the Sri Lankan side.

Outline of the Project Components

Main component	Quantity
1. Sri Jayewrdenepura General Hospital (SJGH)	
Procurement and Installation	
(1) Photovoltaic (PV) modules and accessories	443kW
(2) Power conditioner and accessories	100kW x 4 set
(3) Power cables and terminals	One lot
(4) Fire detectors	One lot
(5) Foundation for installed equipment	One lot
(6) Rehabilitation of existing roof	One lot
Procurement	
(1) Maintenance tools	One lot
(2) Spare parts	One lot
2. Teaching Hospital Ratnapura (TH Ratnapura)	
Procurement and Installation	
(1) PV modules and accessories	184kW, 67kW
(2) Power conditioner and accessories	100kW x 2 sets, 100kW x 1 set
(3) Power cables and terminals	One lot
(4) Fire detectors	One lot
(5) Foundation for installed equipment	One lot
(6) Rehabilitation of existing roof	One lot
Procurement	
(1) Maintenance tools	One lot
(2) Spare parts	One lot
3. Teaching Hospital Kurunegala (TH Kurunegala)	
Procurement and Installation	
(1) PV modules and accessories	240kW
(2) Power conditioner and accessories	100kW x 3 sets
(3) Power cables and terminals	One lot
(4) Fire detectors	One lot
(5) Foundation for installed equipment	One lot
Procurement	
(1) Maintenance tools	One lot
(2) Spare parts	One lot

4. Project implementation schedule and cost estimation

In the case where the Project is implemented under the Government of Japan's Grant Aid scheme, the project implementation duration will be 24 months after the conclusion of Grant Agreement (G/A). The total cost of the Project will be *confidential*. The costs to be borne by the Sri Lankan side will be approximately 192,685 US Dollars. The main items to be borne by the Sri Lankan side are the exemption of customs duties, internal taxes, and other fiscal levies with respect to the purchase of the products and/or the services (153,600 US Dollars), decommissioning of existing unused incinerator and leveling work at TH Kurunegara (5,000 US Dollars) and commissioning fees for the banking arrangement (B/A) (*confidential*). In the case where the Project is implemented under the Government of Japan's Grant Aid scheme, the project implementation duration will be 24 months following the conclusion of the Grant Agreement (G/A).

5. Project Evaluation

5.1 Validity

As is indicated below, since the Project will contribute to the realization of Sri Lanka's development plans and energy policy as well as benefit the general population, it is deemed to have high relevance as a grant aid undertaking.

(1) Urgency

Reduction of payment for the power tariff contribute to the financial status of the Ministry of Health (MOH). MOH is responsible for health related policies in Sri Lanka. The benefit is positively affect all of the people of Sri Lanka.

(2) Benefits

According to the Annual performance report (2020) of Ministry of Health, one of objectives of MOH is to develop new strategies to reduce out-of-pocket spending and reduce financial risk.

Priority areas (Mid-term target) of Japan's Country Assistance Policy to Sri Lanka (June, 2013) includes Mitigation of vulnerabilities. Under this item, the Country Assistance Policy states 'Japan will assist in the improvement of the social service system specifically by improving the facilities and capacity building in the health sector. Japan will also assist to improve the efficiency of disaster management system of the Government of Sri Lanka.'

The PV system to be procured and installed under this Project will contribute to the reduction of out-of-pocket spending by generation of energy. Also, this PV system will strengthen the power supply capacity of each hospital, which will lead to the improvement of the social service system by improving the facilities in the health sector. Therefore, this project matches to policies of both Sri Lanka and Japan.

5.2 Effectiveness

(1) Quantitative effects

The anticipated quantitative effects are shown in the table below.

Quantitative effects of the Project

Indicator	Reference value (2023)	Target value (2028)
Net electric energy generated by the PV system	0	1,269.4MWh (8.6% of the present power consumption of hospitals)
GHG reduction	0	820t-CO_2 (11.1% reduction of CO_2 emission casued by power consumption)
Reduction of payment for the electricity	0	25.5 million SLR/year (8.7% reduction the present electricy bill of hospitals)

Note: Based on the result of questionnaire conducted in 2022, power tariffs of SLGH, TH Ratnapura and TH Kurunegala are assumed as 22.6 SLR/kWh, 18.0SLR/kWh and 17.6SLR/kWh respectively.

(2) Qualitative effects (project-wide)

Qualitative effects of the Project is indicated in the table below.

Qualitative effects

Current conditions and problems	Project countermeasures	Degree of Project effects and improvement
1. Renewable Energy Master Plan targets the 70% of energy generated by renewable sources by 2030.	Installation of 900kWp of grid-connected PV system to each hospital.	The total generation capacity of this Project is approximate mega solar class and contribute to the achievement of the goal.
2. MOH conduct health related policy with the limited budget.	Indirectly increase the budget for health related policy by reduction of payment for power tariff to CEB.	According to the Annual Performance Report (2020) of MOH, the budget for recurrent expenses is 127,606 million SLR. The reduction of payment for CEB is 21.8 million SLR. According to the interview held at the first field survey, the reduction of payment is anticipated to be used for the implementation of health policy in Sri Lanka.

CONTENTS

Preface
Summary
Contents
Location Map
List of Figures & Tables
Abbreviations

Chapter 1 Background of the Project
1-1 Current Status and Challenges 1-1
1-1-1 Overview 1-1
1-1-2 Current Status and Challenges in the power sector 1-1
1-1-3 Development Plan 1-2
1-1-4 Socioeconomic conditions 1-3
1-2 Natural Conditions 1-4
1-2-1 Location and terrain 1-4
1-2-2 Geology 1-4
1-2-3 Climate 1-5
1-2-4 Humidity 1-5
1-2-5 Precipitation 1-6
1-2-6 Wind speed 1-7
1-2-7 Earthquake 1-8

Chapter 2 Contents of the Project
2-1 Basic Concept of the Project 2-1
2-2 Outline Design of the Japanese Assistance 2-2
2-2-1 Design Policy 2-2
2-2-1-1 Basic Policy 2-2
2-2-1-2 Plan for Natural Conditions 2-3
2-2-1-3 Plan for Socioeconomic Conditions 2-4
2-2-1-4 Plan for Procurement/Construction Conditions 2-4
2-2-1-5 Plan for utilization of local companies and local materials 2-5
2-2-1-6 Plan for operation and maintenance capacity of the Implementing Agency 2-5
2-2-1-7 Plans for Setting Grades for the Facilities and Equipment 2-6
2-2-1-8 Plan for Construction, procurement method and work period 2-6
2-2-1-9 Plan for Consultant Supervision 2-7
2-2-1-10 Plan for Safety Measures 2-7
2-2-2 Basic Plan (Equipment Plan / Facility Plan) 2-7
2-2-2-1 Basic Plan (Equipment Plan) 2-7
2-2-2-2 Basic Plan (Facility Plan) 2-35
2-2-3 Outline Design Drawing 2-50
2-2-4 Implementation Plan 2-51

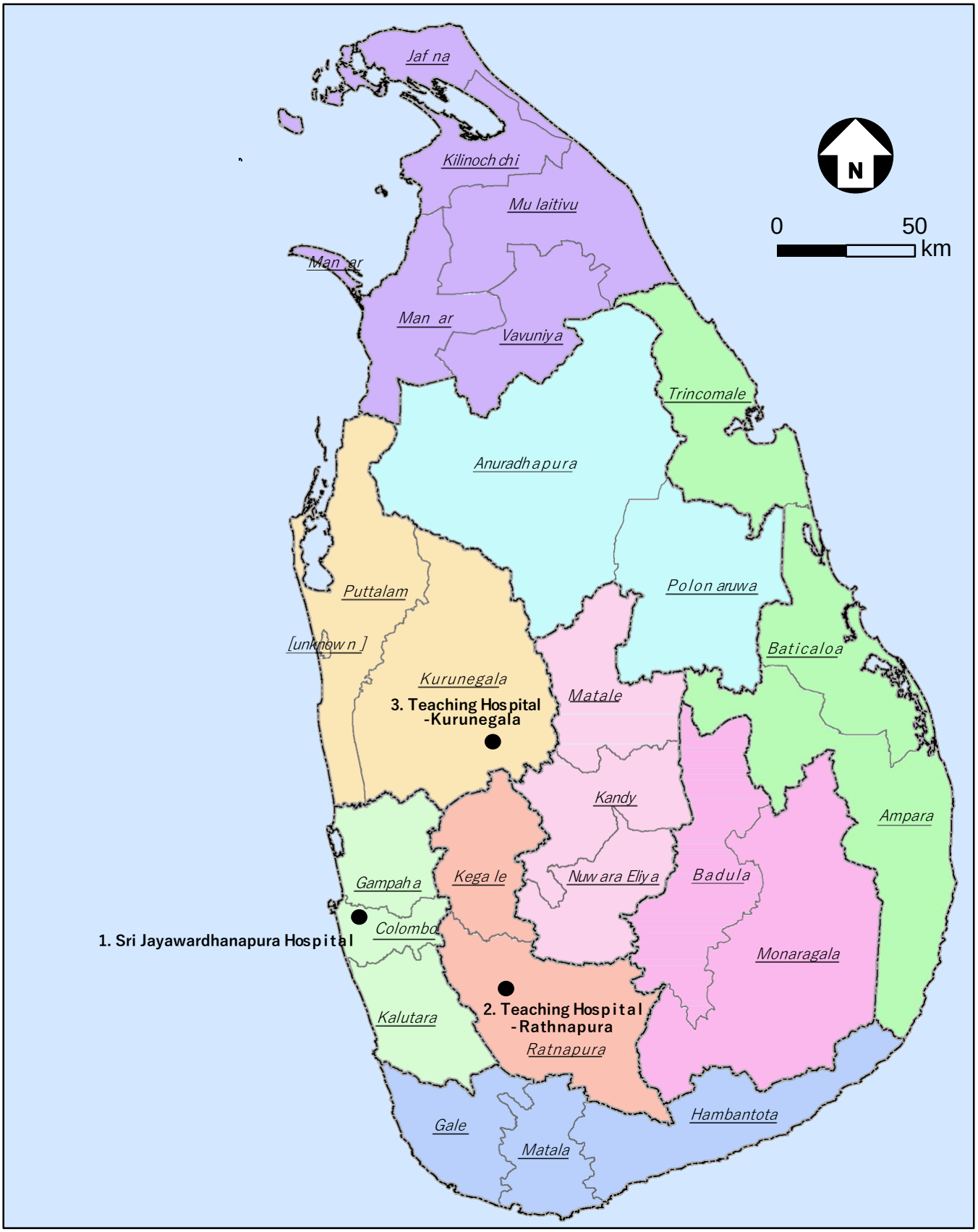
2-2-4-1 Implementation Policy 2-51
2-2-4-2 Implementation Conditions 2-52
2-2-4-3 Scope of Works 2-54
2-2-4-4 Consultant Supervision 2-54
2-2-4-5 Quality Control Plan 2-55
2-2-4-6 Procurement Plan 2-57
2-2-4-7 Operational Guidance Plan 2-58
2-2-4-8 Soft Component (Technical Assistance) Plan 2-60
2-2-4-9 Implementation Schedule 2-60
2-3 Security Plan 2-61
2-4 Obligations of Recipient Country 2-61
2-4-1 Works to be borne by the Recipient Country 2-61
2-4-2 Tax and tax exemption 2-63
2-5 Project Operation Plan 2-65
2-5-1 Basic Plan 2-65
2-5-2 Routine inspection and periodical inspection items 2-65
2-5-3 Spare Parts Procurement Plan 2-67
2-6 Project Cost Estimation 2-68
2-6-1 Initial Cost Estimation 2-68
2-6-1-1 Cost Borne by Japan 2-68
2-6-1-2 Cost Borne by Recipient Country 2-69
2-6-1-3 Condition of the Cost Estimation 2-70
2-6-2 Operation and Maintenance Cost 2-70

Chapter 3 Project Evaluation

3-1 Preconditions 3-1
3-2 Necessary Inputs by Recipient Country 3-1
3-3 Important Assumptions 3-1
3-4 Project Evaluation 3-2
3-4-1 Relevance 3-2
3-4-2 Effectiveness 3-2

[Appendices]

1. Member List of the Survey Team
2. Study Schedule
3. List of Parties Concerned in the Recipient Country
4. Minutes of Discussions (M/D)
5. Field Report
6. Outline Design Drawing
7. Photos of present conditions of buildings
8. Result of Schmidt Hammer Test
9. Result of JICA Climate-FIT-Mitigation
10. Presentation regarding the analysis on the addition of Battery System





[Legend]

- Province border
- Central
- Eastern
- North Central
- NorthWestern
- Northern
- Sabaragamuwa
- Southern
- Uva
- Western

LOCATION MAP

List of Figures & Tables

Chapter 1

Figure 1.1 Population and growth rate in Sri Lanka (2000-2021) 1-3
Figure 1.2 Gross domestic product per capita (in US dollars) of Sri Lanka (2000-2021) 1-4
Figure 1.3 Average temperatures for each location (Average temperatures for each month from 2020 to 2021) 1-5
Figure 1.4 Humidity for each location (1991-2021) 1-6
Figure 1.5 Rainfall for each location (1991-2021) 1-7
Figure 1.6 Average wind speeds at each location (Monthly average wind speeds from 2020 to 2023) 1-7

Table 1.1 Power generation system development plan 1-2
Table 1.2 Average temperatures for each location (Average temperatures for each month from 2020 to 2023) 1-5
Table 1.3 Average humidity for each location (Average humidity for each month from 1991 to 2021) 1-6
Table 1.4 Rainfall for each location (Average Monthly Rainfall from 2020 to 2023) 1-6
Table 1.5 Average wind speeds for each location (Monthly average wind speeds from 2020 to 2023) 1-7
Table 1.6 Earthquake records in Sri Lanka over a 50-year period 1-8

Chapter 2

Figure 2.1 Photovoltaic power generation system overview 2-7
Figure 2.2 Time chart of the pattern 1 2-10
Figure 2.3 Time chart of the pattern 2 2-10
Figure 2.4 Time chart of the pattern 3 2-10
Figure 2.5 Layout plan of Sri Jayewardenepura General Hospital 2-11
Figure 2.6 Connection diagram for PV system (SJGH) 2-12
Figure 2.7 Layout plan of Teaching Hospital Ratnapura 2-13
Figure 2.8 Single line diagram of Blood Bank Building 2-14
Figure 2.9 Single line diagram of JICA Building 2-15
Figure 2.10 Layout plan of Teaching Hospital Kurunegala 2-16
Figure 2.11 Single line diagram of main system (TH Kurunegala) 2-17
Figure 2.12 Single line diagram of Maternity Building 2-18
Figure 2.13 Hospital site plan (SJGH) 2-34
Figure 2.14 Site plan of the hospital (TH Ratnapura) 2-35
Figure 2.15 Hospital site plan (TH Kurunegala) 2-36
Figure 2.16 Structural Strength Verification Flow 2-37
Figure 2.17 Existing roof plan of solar panel and photographs 2-38
Figure 2.18 Cross-section of building (Block B) 2-38

Figure 2.19 Roof plan and building cross section (Ratnapura JICA Building) 2-40
Figure 2.20 Roof plan and building cross section (Ratnapura A&E Building) 2-42
Figure 2.21 Roof plan and building cross section (Ratnapura Blood Bank Building) 2-44
Figure 2.22 Exterior and Interior Photographs, Building Cross Section and Truss Section (Kurunegala Maternity Building 2-46
Figure 2.23 Project Relation Diagram 2-50
Figure 2.24 Implementation Schedule (Draft) 2-58

Table 2.1 Outline of the Project 2-1
Table 2.2 Operation record of EDG 2-2
Table 2.3 Weather conditions at the project sites 2-3
Table 2.4 Study on method of operating the PV system in the case of a commercial grid outage 2-9
Table 2.5 Overview of remote monitoring system 2-19
Table 2.6 Planned location for remote monitoring system 2-19
Table 2.7 Location of monitor installation 2-20
Table 2.8 Natural condition 2-21
Table 2.9 Applicable standards and regulations 2-21
Table 2.10 Specification of Supporting structure and fitting material for PV module 2-22
Table 2.11 Specification of PV Module 2-22
Table 2.12 Specification of Junction Box 2-22
Table 2.13 Specification of Collecting Box 2-22
Table 2.14 Specification of Power Conditioner 2-23
Table 2.15 Specification of DC Connecting Panel 2-23
Table 2.16 Specification of Cable Connecting Panel 2-23
Table 2.17 Specification of Insulation Transformer 2-23
Table 2.18 Specification of Weather Data Collection System 2-24
Table 2.19 Specification of Control and Monitoring System 2-24
Table 2.20 Specification of Remote Monitoring System 2-24
Table 2.21 Specification of Container 2-25
Table 2.22 Specification of Low Voltage Distribution Board 2-25
Table 2.23 Specification of Low Voltage Distribution Box (TH Ratnapura) 2-26
Table 2.24 Specification of Low Voltage Distribution Box (TH Kurunegala) 2-27
Table 2.25 Specification of Cable Terminal Box (TH Ratnapura) 2-27
Table 2.26 Specification of Cable Terminal Box (TH Kurunegala) 2-28
Table 2.27 Specification of Power, Control Cable and others (SJGH) 2-28
Table 2.28 Specification of Cabling Materials (SJGH) 2-29
Table 2.29 Specification of Power, Control Cable and others (TH Ratnapura) 2-30
Table 2.30 Specification of Cabling Materials (TH Ratnapura) 2-30
Table 2.31 Specification of Power, Control Cable and others (TH Kurunegala) 2-31

Table 2.32 Specification of Cabling Materials (TH Kurunegala) 2-32
Table 2.33 Specification of Earthing Materials 2-32
Table 2.34 Specification of Fire Detection System 2-32
Table 2.35 Viewpoints of Investigation and Decision Items in Target Building Selection 2-33
Table 2.36 Solar Power System Generation Output of SJGH 2-34
Table 2.37 Results of concrete compressive strength test of SJGH 2-34
Table 2.38 Photovoltaic System Generation Output of TH Ratnapura 2-35
Table 2.39 Photovoltaic System Generation Output of TH Kurunegala 2-36
Table 2.40 Results of concrete compressive strength measurements for TH Kurunegala 2-37
Table 2.41 Structural Design Conditions Obtained from Existing Design Drawings (Block-B) 2-39
Table 2.42 Structural Design Conditions Obtained from The Existing Design Drawings and The Original Basic Design Survey Report at the Time (Ratnapura JICA Building) 2-41
Table 2.43 Results of structural strength verification of TH Ratnapura/JICA Building 2-41
Table 2.44 Structural Design Conditions Obtained from The Existing Design Drawings (Ratnapura A&E Building) 2-42
Table 2.45 Results of structural strength verification for A&E Building of TH Ratnapura 2-43
Table 2.46 Structural Design Conditions Obtained from The Existing Design Drawings (Ratnapura Blood Bank Building) 2-44
Table 2.47 Results of structural strength verification for Blood Bank Building of TH Ratnapura 2-45
Table 2.48 Structural Design Conditions Obtained from Existing Design Drawings (Kurunegala Maternity Building) 2-47
Table 2.49 Structural Strength Verification Results for Maternity Building of TH Kurunegala 2-47
Table 2.50 Main Quality Control Items 2-54
Table 2.51 Material and Equipment Procurement Sources 2-55
Table 2.52 Major undertakings 2-59
Table 2.53 Results of Interviews with Japanese Company 2-63
Table 2.54 Routine inspection items 2-64
Table 2.55 Periodic inspection items 2-64
Table 2.56 Replacement intervals and inspection contents of major equipment (Recommended cases) 2-65
Table 2.57 Spare parts to be procured 2-66
Table 2.58 Replacement intervals and costs of replacement parts 2-66
Table 2.59 Test equipment and maintenance tools 2-66
Table 2.60 Costs for works to be borne by Sri Lanka 2-67
Table 2.61 Annual O&M Costs 2-68

Chapter 3

Table 3.1 Quantitative effects of the Project 3-2
Table 3.2 Condition of calculation of power generation by PV system 3-3
Table 3.3 Anticipated monthly power output 3-4
Table 3.4 Anticipated reduction amount of power tariff 3-5
Table 3.5 Qualitative effects 3-5

Abbreviations

Abbreviation	English
ASTM	American Society for Testing and Materials
ATS	Automatic Transfer Switch
BS	British Standard
CEB	Ceylon Electricity Board
CECB	Central Engineering Consultancy Bureau
CIDA	Construction Industry Development Authority
CVVS	Control-use Vinyl insulated Vinyl Sheathed cable
DTTP	Department of Trade and Investment Policies
EDG	Emergency Diesel Generator
E/N	Exchange of Notes
FEP	Flexible Electric Pipe
G/A	Grant Agreement
GFATM	The Global Fund to Fight AIDS, Tuberculosis and malaria
IEC	International Electromtechnical Commission
ISO	International Organization for Standardization
JCS	Japanese Cable Makers' Association Standard
JEC	Japanese Electrotechnical Committee
JEM	Japan Electrical Manufacturer
JIS	Japanese Industrial Standards
JICA	Japan International Cooperation Agency
KfW	Kreditanstalt für Wiederaufbau
KOFIH	Korea Foundation for International Healthcare
KOICA	Korea International Cooperation Agency
M/D	Minutes of Discussion
MOH	Ministry of Health
MOP	Ministry of Power
MOLEF	Ministry of Labour and Foreign Employment
MOUDH	Ministry of Urban Development & Housing
NCDs	Non-Communicable Diseases
NDC	Nationally Determined Contributions
NS	Nominated Subcontractor
ODA	Official Development Assistance
PCS	Power Conditioner System
PV	Photovoltaic
SJGH	Sri Jayewrdenepura General Hospital
TH	Teaching hospital
UNFCCC	United Nations Framework Convention on Climate Change
VP	Vinyl Pipe

Chapter 1 Background of the Project

Chapter 1 Background of the Project

1-1 Current Status and Challenges

1-1-1 Overview

The growth in power demand in Sri Lanka is remarkable, and a high average growth rate of 6.2% has been maintained for the five years from 2014 to 2018. According to the report of the Ministry of Power, "Progress 2021 Program 2022", power demand in Sri Lanka grew at an annual rate of 5.5% in 2021. The growth rate of peak demand is 3.7% per year. The peak demand for the period from January to September 2021 was recorded at 2,801.62 MW.

In order to meet the increasing demand, Sri Lanka has been working to develop new power sources. However, most of the major hydropower resources have already been developed. Thus the shortfall in supply has been compensated for by the thermal power generated by fossil fuels. Power generation costs are high. In 2022, fuel imports for thermal power generation will be significantly delayed due to increases in international oil prices and Sri Lanka's shortage of foreign currency. Under these circumstances, it became necessary to implement rolling blackouts. In addition, with the electricity tariff being raised by 75% compared to the previous year, the tariff is forecasted to remain high in the future.

This situation has also had a major impact on the medical field, especially in large hospitals that consume a lot of electricity. Due to the increase of fuel prices, there is a need to turn off air conditioning and turn off lighting to save power, which may limit medical services themselves.

Based on the above, Sri Lanka expressed its intention to seek a plan to reduce electricity costs and improve medical services by introducing a solar power generation system. Sri Lanka submitted a formal request for the implementation of this project to the Japanese government in August 2023.

1-1-2 Current Status and Challenges in the power sector

(1) Power generation expansion plan

In terms of power generation capacity in Sri Lanka, hydropower is the largest with 31%,followed by oil-fired power at 23% and coal-fired power at 20%. Renewable energy generation (mini-hydro, wind, solar, biomass) accounts for 26%. Rooftop solar power accounts for 8% of renewable energy generation.

The two largest sources for power generations are coal(40%) and hydropower (28%). The percentage of rooftop solar power generation is 2%.

The NDC (Nationally Determined Contribution) of Sri Lanka ratified by the UNFCCC (United Nations Framework Convention on Climate Change) in September 2016 aims to reduce greenhouse gas emissions by 4% unconditionally and 16% conditionally by 2030. According to the Ministry of Power (MOP) report (Progress 2021 Program 2022), Sri Lanka's basic energy policy for future power generation planning is based on the following three policy initiatives:

- Realize 30% of electricity generated by renewable energy by 2030.
- Achieving carbon neutrality by 2050.
- Do not plan new coal-fired power plants.

(2) Long term generation expansion plan

The Ceylon Electricity Board (CEB), a state-owned company, is a subordinate organization of the Public Utilities Commission of Sri Lanka.

In the Long Term Generation Expansion Plan 2023-2042, the CEB describes rooftop solar power generation facilities as having a low environmental impact and playing a strong role in promoting power supply.

The "Net Energy Metering Facility" is a framework introduced in 2010 through CEB and Lanka Electric Company (LECO). This framework allows any electricity consumer to participate in generating electricity using renewable energy and to send surplus electricity to the grid. Surplus power is returned to each power consumer in the form of credit, and is deducted from the power usage charges incurred in the following months.

Furthermore, in 2016, CEB introduced two new frameworks, "Net Accounting" and "Net Plus", to promote

the introduction of rooftop solar power generation.

Net accounting sets fixed electricity tariffs for 20 years for electricity sold from consumers to the grid. 22.0LKR/kWh for the first 7 years and 15.5LKR/kWh for the next 13 years.

With Net Plus, all electricity generated from a consumer-installed PV system can be sent to the grid within contractually agreed capacity. Unlike Net accounting, Net Plus does not assume self-consumption.

The application of the above three frameworks is limited to low-voltage line-connected rooftop PV systems. Also in 2019, the Sri Lankan government signed a US$50 million loan agreement with the Asian Development Bank (ADB) to promote rooftop solar power generation (up to 5 kW capacity) for industrial and commercial use in the country. Through this loan agreement rooftop solar power generation capacity equivalent to 44MW has been procured by 2021.

(3) Present situation and challenges

As of the end of 2020, the capacity of rooftop solar power installed under the three frameworks described in (2) reached 374 MW.

According to data obtained from the Sustainable Energy Authority in May 2023, 650MW of the rooftop solar power system was installed by 2021. Therefore, the new installed capacity in 2021 alone is considered to be 276MW. The power generation system developments obtained from the Sustainable Energy Authority are shown in Table 1.1. The target for the introduction of rooftop solar power generation facilities in 2030 is 1,513 MW. In order to achieve the goal, it is essential to continue and promote the procurement and installation of rooftop solar power generation systems

Considering the current installation performance, it is necessary to continue to introduce 95 MW of new rooftop solar power generation facilities each year by 2030. On the other hand, considering the average lifetime of a photovoltaic power generation system is 20 years, some installed systems may need to be decommissioned, so the actual size of PV modules to be installed will be larger than this amount. The challenge is maintaining the installation of photovoltaic power generation system at the average of 100MW.

Table 1.1 Power generation system development plan

Resource	Installed Capacity	2022	2023	2024	2025	2026	2027	2028	2029	2030
Biomass	54	54	64	70	75	80	85	90	95	100
Major Hydro	1,383	1,538	1,538	1,568	1,568	1,568	1,568	1,568	1,568	1,568
Mini Hydro	429	464	610	669	678	692	720	720	720	720
Solar Rooftop	650	841	1,016	1,141	1,241	1,341	1,441	1,313	1,413	1,513
Solar Ground Mounted	140	418	873	1,274	1,679	1,859	2,034	2,314	2,564	2,749
Floating Solar				200	400	500	600	700	800	900
Wind	249	249	269	524	789	919	1,169	1,299	1,474	1,649
Wind Offshore						500	1,000	1,500	1,500	2,000
Geothermal									10	30
Wave								5	5	10
Total Capacity (MW)	**2,905**	**3,563**	**4,370**	**5,446**	**6,429**	**7,459**	**8,617**	**9,509**	**10,149**	**11,239**
Total Generation (GWh)	**8,293**	**9,666**	**11,170**	**13,333**	**15,245**	**18,033**	**21,187**	**23,740**	**25,045**	**28,075**

Remarks: The yellow highlight indicates the introduction of the rooftop solar power generation, which the Project contributes.
[Source] Sri Lanka Sustainable Energy Authority

1-1-3 Development Plan

According to the Annual performance report (2020) of Ministry of Health (MOH), one of objectives of MOH is to develop new strategies to reduce out-of-pocket spending and reduce financial risk.

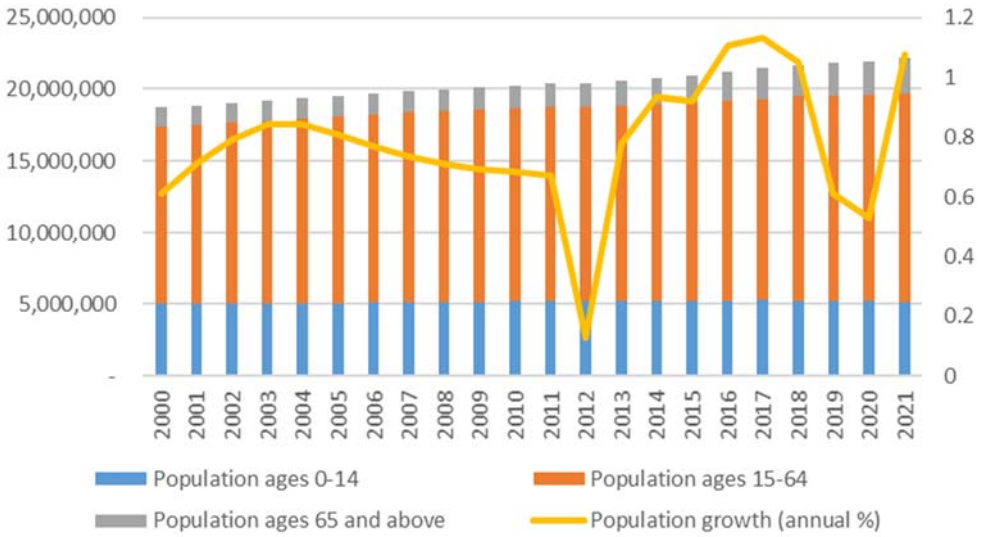
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of vulnerabilities. Under this item, the Country Assistance Policy states 'Japan will assist in the improvement of the social service system specifically by improving the facilities and capacity building in the health sector. Japan will also assist to improve the efficiency of disaster management system of the Government of Sri Lanka.'

1-1-4 Socioeconomic conditions

(1) Population

Figure 1.1 shows Sri Lanka's population composition and growth rate by age group for the period 2000-2021. The population growth rate was 0.8% on average during this period. Sri Lanka has a high proportion of the population aged between 15 and 64. On the other hand, the population growth rate of the elderly aged 65 and over has remained at 3%. During this period, life expectancy increased from 70.4 years in 2000 to 76.4 years in 2020.

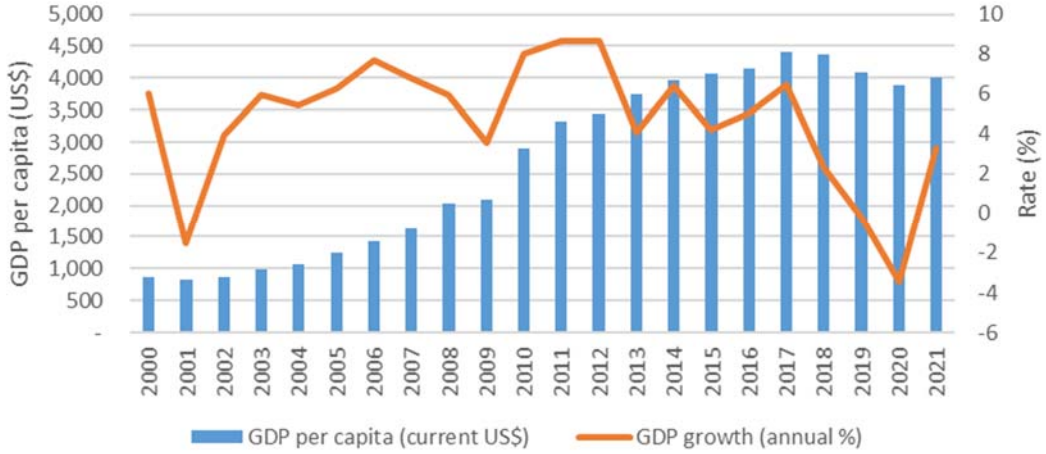


[Source] The World Bank

Figure 1.1 Population and growth rate in Sri Lanka (2000-2021)

(2) Economy

Figure 1.2 shows the gross domestic product per capita (in US dollars) of Sri Lanka, economic growth rate, and inflation rate. Due to reconstruction demand and revitalization of economic activities following the end of the conflict in 2009, the gross domestic product growth rate from 2010 to 2012 recorded an average of 8.4%. After that, it remained stable at around 4 to 6% until 2017, but when the growth rate slowed to 2.3% in 2018, it fell to 0.2% in 2019, partly due to the impact of the serial terrorism attacks that occurred in the same year. Furthermore, in 2020, due to the spread of the new coronavirus infection, there was a negative growth of 3.5%.



[Source] The World Bank

Figure1.2 Gross domestic product per capita (in US dollars) of Sri Lanka (2000-2021)

(3) Present condition of hospitals

Sri Jayawardenepura General Hospital (SJGH) was built in 1983. It has 1,060 beds and 19,803 outpatients (2021). This hospital maintains medical services by collecting medical fees from patients in addition to budget allocation from the Ministry of Health. The number of employees is 1,983 (2022). The hospital is well-organized and well-run. However, medical charts are not computerized and are managed in files and document racks. The hospital was constructed by a Japanese construction company.

Ratnapura Teaching Hospital was established in 1877. It has 1,488 beds and 424,850 outpatients (2021). The hospital site is 0.25km^2, which is the largest site (density) for the number of beds among the three target hospitals in this project. Because the hospital is located on a slope, there are many slopes and stairs on the hospital premises. Medical expenses are basically free. The number of employees is 3,598 (2022). A nursing school is also located on the hospital premises. In 2004, the OMF building (Oral and Maxillo Facial Unit) was constructed with JICA grant aid (Ratnapura General Hospital Development Project (Phase 2)).

Kurunegala Teaching Hospital was established in 1890. The number of beds is 2,548, which is by far the largest among the three hospitals. The number of outpatients is 246,118 (2021). On the other hand, the hospital site is 0.14km^2, which is not much different from the 0.12km^2 of Sri Jayawardenepura General Hospital. As a result, there are many buildings on the sick site, making it the most densely packed environment among the three hospitals in this project. Medical services are basically provided free of charge.

1-2 Natural Conditions

1-2-1 Location and terrain

Sri Lanka is located in the Indian Ocean, southwest of the Bay of Bengal.

It covers an area of 65,610 km^2. The distance from the Jaffna, Northern Province to Gale, Southern Province is about 450 km in a straight line. The northern part of the island is flat, while the southern part is more mountainous. The mountainous includes areas above 2,000 meters such as Mount Pidurutalagala, and Peak Wilderness Sanctuary. Lengths of sixteen rivers in total is above 100 km. The longest river is the Mahaweli River, which flows northeast into the Bay of Bengal. Costal areas below 30 meters are mainly sandy beach whilst northeast and southern costal areas forms with cliffs and bays.

1-2-2 Geology

The geology of Sri Lanka consists mostly of Precambrian basement rocks, with the exception of coastal areas. These are classified from the west into the Wanni, High Rhine, and Vijayan bodies according to the features of the constituent rocks. The Wanni body is dominated by migmatitic to granitic gneisses and pomegranitic biotite gneisses. The High Rhine body contains charnockite, granitic gneiss, and muddy gneiss, as well as marble and quartzite. The Vijayan body is dominated by granitic and migmatitic rocks. Granitic gneisses are widely distributed, and landslides are

common.
Visual inspection of the building perimeters of the surveyed hospitals did not reveal any cracks or damage to the building frames that would indicate the occurrence of land subsidence in any of them.

1-2-3 Climate

Table 1.2 shows average temperatures for several regions of Sri Lanka. The climate of Sri Lanka is tropical, hot and humid. The average annual temperature in the coastal and lowland areas is 27°C to 28°C, while Nuwara Eliya, located at an altitude of approximately 1,890 m, has a warm climate all year round with an average annual temperature of 22°C.

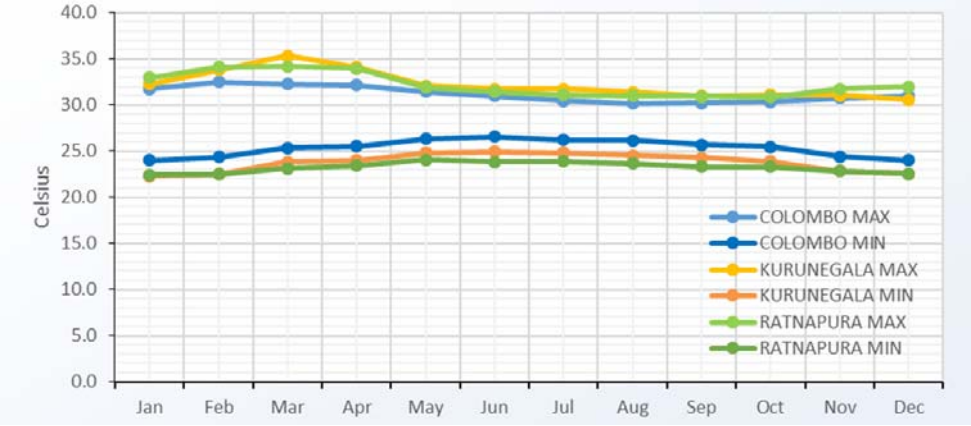
Figure 1.3 shows the average maximum and minimum temperatures in each of the target areas, with an average maximum temperature of 31°C to 32°C and an average minimum temperature of 23°C to 25°C in all three areas.

Table 1.2 Average temperatures for each location
(Average temperatures for each month from 2020 to 2023)

Unit：°C

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
Colombo Average Max. Temperature	31.7	32.5	32.3	32.2	31.4	31.0	30.5	30.2	30.2	30.3	30.7	31.0	31.2
Colombo Average Min. Temperature	24.0	24.4	25.4	25.5	26.4	26.6	26.2	26.2	25.7	25.5	24.4	24.0	25.3
Kurunegala Average Max. Temperature	32.3	33.8	35.4	34.2	32.1	31.8	31.7	31.4	31.0	31.1	31.0	30.6	32.2
Kurunegala Average Min. Temperature	22.3	22.5	23.8	24.0	24.8	24.9	24.8	24.5	24.3	23.9	22.8	22.5	23.8
Ratnapura Average Max. Temperature	32.9	34.1	34.2	33.9	31.9	31.4	31.1	31.0	30.9	30.9	31.7	32.0	32.2
Ratnapura Average Min. Temperature	22.4	22.5	23.1	23.4	24.1	23.8	23.9	23.7	23.3	23.3	22.9	22.6	23.2

［Source］Prepared by the survey team based on data provided by Department of Meteorology



［Source］Prepared by the survey team based on data provided by Department of Meteorology

Figure 1.3 Average temperatures for each location
(Average temperatures for each month from 2020 to 2023)

1-2-4 Humidity

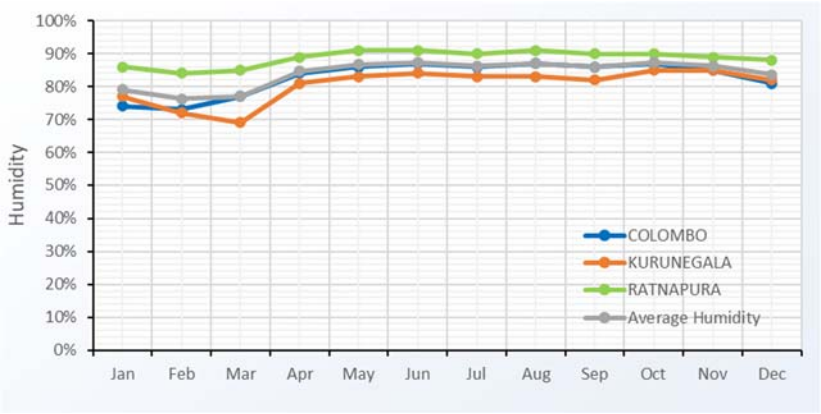
The average humidity in each area where the target hospitals are located is shown in Figure 1.4. The annual average humidity in the three areas ranges from 81% to 89%, which is almost constant and high throughout the year.

Table 1.3 Average humidity for each location
(Average humidity for each month from 1991 to 2021)

Unit：%

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
Colombo	74	73	77	84	86	87	86	87	86	87	85	81	83
Kurunegala	77	72	69	81	83	84	83	83	82	85	85	82	81
Ratnapura	86	84	85	89	91	91	90	91	90	90	89	88	89

［Source］Climate Data



［Source］Climate Data

Figure 1.4 Humidity for each location (1991-2021)

1-2-5 Precipitation

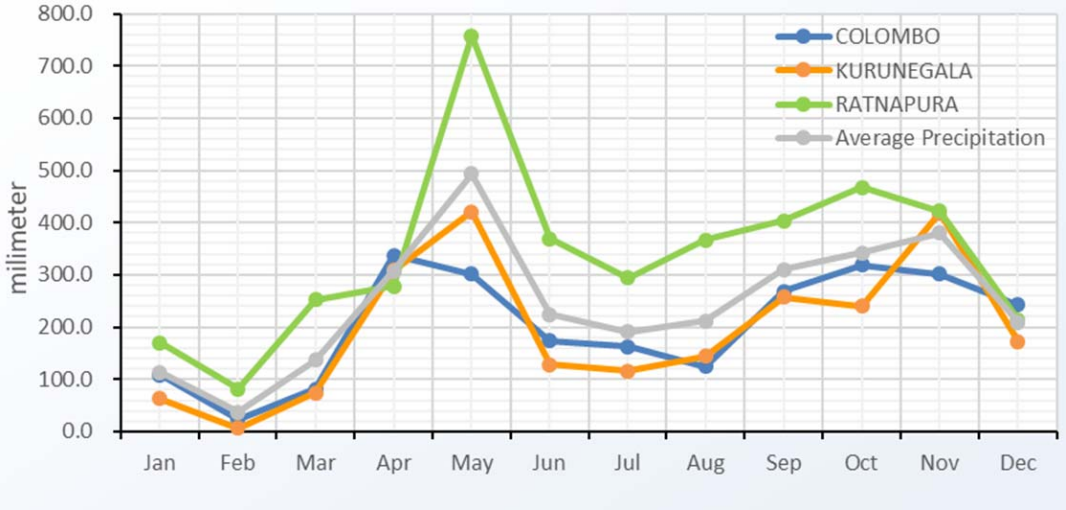
Sri Lanka's climate is strongly influenced by the monsoon, with the southwest and northeast monsoons occuring twice a year, causing rainfall to vary with the seasons. Table 1.4 shows the rainfall for each location. The southwest monsoon period from May to September brings heavy rainfall to the southwestern part of the island as the winds are interrupted by the mountainous areas. Rainfall is particularly heavy from April to May, and slightly less from June to September. From October to December, the weather becomes unstable due to windless conditions and air masses, and rainy days continue throughout the island. During the northeast monsoon season from November to March, the southwestern part of the island experiences the least rainfall in a year. Figure 1.5 shows the amount of rainfall in the regions where the target hospitals are located. All regions receive the highest amount of rainfall from April to May, especially Ratnapura, which has the highest May rainfall of 757.9 mm.

Table 1.4 Rainfall for each location
(Average Monthly Rainfall from 2020 to 2023)

Unit：mm

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
Colombo	108.1	23.6	81.6	337.4	301.1	173.4	162.3	124.9	268.6	318.8	301.2	242.4	203.6
Kurunegala	63.4	6.4	74.4	308.4	420.7	128.5	115.8	143.7	257.6	240.6	417.9	172.2	195.8
Ratnapura	170.2	81.4	252.8	278.7	757.9	369.7	293.9	366.6	403.5	467.0	422.4	214.4	339.9

［Source］Prepared by the survey team based on data provided by Department of Meteorology



［Source］Prepared by the survey team based on data provided by Department of Meteorology

Figure 1.5 Rainfall for each location (2020-2023)

1-2-6 Wind speed

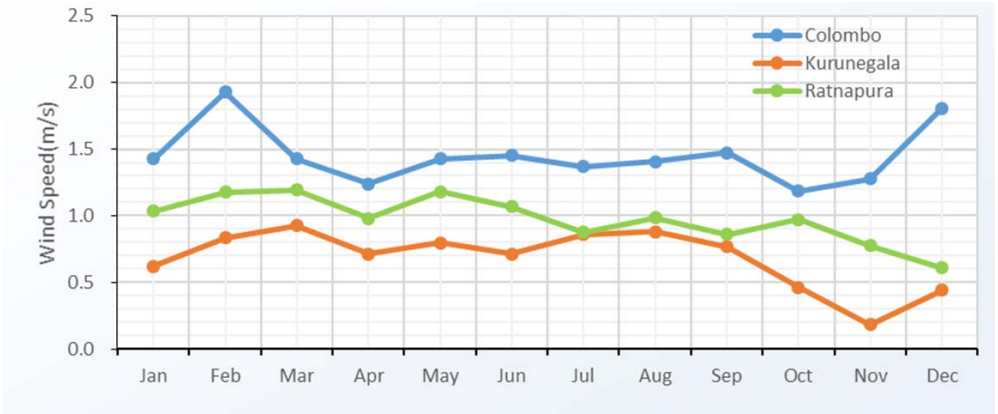
The average annual wind speed in each of the target hospital areas ranges from 0.7 to 1.5 m/s, with lower wind speeds during October and November. Colombo is located near the coast and has higher wind speeds throughout the year than Kurunegala and Ratnapura, with an annual average of 1.5 m/s. However, the maximum wind speed is almost the same as in Ratnapura. Table 1.5 and Figure 1.6 show the average wind speeds in each region.

Table 1.5 Average wind speeds for each location
(Monthly average wind speeds from 2020 to 2023)

Unit：m/s

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average	Maximum Wind Speed
Colombo	1.4	1.9	1.4	1.2	1.4	1.5	1.4	1.4	1.5	1.2	1.3	1.8	1.5	2.1
Kurunegala	0.6	0.8	0.9	0.7	0.8	0.7	0.9	0.9	0.8	0.5	0.2	0.4	0.7	1.3
Ratnapura	1.0	1.2	1.2	1.0	1.2	1.1	0.9	1.0	0.9	1.0	0.8	0.6	1.0	2.0

［Source］Prepared by the survey team based on data provided by Department of Meteorology



［Source］Prepared by the survey team based on data provided by Department of Meteorology

Figure 1.6 Average wind speeds at each location
(Monthly average wind speeds from 2020 to 2023)

1-2-7 Earthquake

Sri Lanka has a low incidence of earthquakes. The most recent recorded earthquake of magnitude 4.4 occurred off the southwest coast of Ceylon in September 2021. In the 50-year record of earthquakes in Sri Lanka (Table 1.6), there are no records of earthquakes of magnitude 7.0 or greater occurring in the country. It should be noted that according to research data from the 2004 Sumatra earthquake (magnitude 9.0), Sri Lanka, which is located approximately 1,600 km west of the epicenter, experienced a tsunami, but the tremors were barely perceptible.

Table 1.6 Earthquake records in Sri Lanka over a 50-year period

Date of Occurrence	Magnitude	Epicenter of earthquake
September 24, 2021	4.4	Off the southwest coast of Ceylon
April 15, 2009	4.5	Off the eastern coast of Ceylon
December 7, 1993	5.2	Off the western coast of Ceylon
August 31, 1973	5.9	Off the eastern coast of Ceylon

［Source］ Earthquake Track

Chapter 2 Contents of the Project

Chapter 2 Contents of the Project

2-1 Basic Concept of the Project

2-1-1 Project Overview

(1) Upper goal and project goal

The Government of Sri Lanka prepared the 'General Policy Guidelines on the Electricity Industry (January 2022)' and the 'National Energy Policy and Strategies of Sri Lanka (2019)'. These documents are the basis of the 'Long Term Generation Expansion Plan (2023-2042)'. In this Plan, the Government of Sri Lanka endeavors to realize renewable energy target of 70% to be met by 2030 and carbon neutrality by 2050. This Project will contribute to the achievement of the above goal through the installation of grid-connected PV system.

(2) Outline of the Project

The purpose of this Project is to reduce expenses of power tariffs through the power generation from grid-connected rooftop PV system. MOH is expected to extend the services through the use of residue of the budget and eventually improve the health indices of Sri Lanka people. The outline of Project is shown in Table 2.1.

Table 2.1 Outline of the Project

Main component	Quantity
1. Sri Jayewrdenepura General Hospital (SJGH)	
Procurement and Installation	
(1) Photovoltaic (PV) modules and accessories	443kW
(2) Power conditioner and accessories	100kW x 4 set
(3) Power cables and terminals	One lot
(4) Fire detectors	One lot
(5) Foundation for installed equipment	One lot
(6) Rehabilitation of existing roof	One lot
Procurement	
(1) Maintenance tools	One lot
(2) Spare parts	One lot
2. Teaching Hospital Ratnapura (TH Ratnapura)	
Procurement and Installation	
(1) PV modules and accessories	184kW, 67kW
(2) Power conditioner and accessories	100kW x 2 sets, 100kW x 1 set
(3) Power cables and terminals	One lot
(4) Fire detectors	One lot
(5) Foundation for installed equipment	One lot
(6) Rehabilitation of existing roof	One lot
Procurement	
(1) Maintenance tools	One lot
(2) Spare parts	One lot
3. Teaching Hoispital Kurunegala (TH Kurunegala)	
Procurement and Installation	
(1) PV modules and accessories	240kW
(2) Power conditioner and accessories	100kW x 3 sets
(3) Power cables and terminals	One lot
(4) Fire detectors	One lot
(5) Foundation for installed equipment	One lot
Procurement	

Main component		Quantity
(1)	Maintenance tools	One lot
(2)	Spare parts	One lot

[Source] JICA Survey Team

2-2 Outline Design of the Japanese Assistance

2-2-1 Design Policy

2-2-1-1 Basic Policy

This project aims for the reduction of expenses on power tariffs through the installation of grid-connected PV system for three public hospitals to contribute to the financial status of the Ministry of Health. Simultaneously, this project will promote the national goal of 70% installation of of renewable energy by 2030 and shall reduce the emission of CO2.

As this project will be conducted under the JICA Grant Aid Scheme, the component of this project shall be comprised of minimum required equipment such as PV modules, junction boxes, connection boxes, power conditioner and other items so that operation and maintenance can be properly carried out by each hospital after the handover.

At the same time, the power generation indication board for visitors/patients will be procured and installed so that those who visit hospitals will be aware of the system and comprehend the project.

Scope of battery energy storage system (BESS)

At the beginning of the 1st Field Survey, JICA Survey Team considered the addition of a battery energy storage system as a component to the outline design of this project. However, due to three observations listed below, JICA Survey Team judges the component of BESS is not necessary and opted to not to add to the project components. JICA Survey Team had a technical discussion with MOH regarding the BESS component and obtained consent by MOH. Explanatory materials are attached as Appendix-10.

(1) Situation of power supply from CEB to hospitals

Frequent power outage which generally occurred after the financial crisis in 2022 (approx. 300hours/month) has been improved. Table 2.2 shows the operation record of emergency diesel generators (EDG) from 2020 to 2022 at each hospital. The operation time tends to decrease.

Table 2.2 Operation record of EDG

Year	SJGH	TH Ratnapura	TH Kurunegala
2018	49:41	-	-
2019	37:16	-	32:00
2020	37:16	45:17	84:00
2021	37:16	55:10	56:00
2022	49:42	35:25	27:00
2023	24:30	31:09	0:21

Note: Values in Year 2023 is converted from the actual operation record from 1st January 2023 to the date of the 1st survey to the annual operation time.
[Source] JICA Survey Team

This table includes operation time for routine functional inspection of EDG (trial run). Therefore, the actual operation time caused by actual power outage is inferred to be shorter.

Also, according to the interview with CEB Kurunegala Branch, since the hospitals are regarded as important social infrastructure, CEB constructs dedicated distribution line to increase the power supply reliability compared to general consumers.

Through the above observations, the power supply to hospitals from CEB is confirmed to have been improved.

(2) Application of Uninterruptible Power Supply (UPS)

At present, individual equipment such as medical treatment equipment which directly affect lives are furnished with UPS (BESS). Equipment regarded as important are considered, including refrigerator for drugs, illumination and air conditioners. However, through the survey, it was found that planned outage was not conducted and, though instant power outages occur, power supply from CEB is generally stable.

Also, since EDGs are observed to be regularly maintained, a majority of loads in hospital shall receive power supply during long-period power outage. Accordingly, due to the present power supply system combining power supply from CEB and EDGs, the necessity of installation of BESS is low and thus the backup system of BESS is not necessary.

(3) Power tariff system in Sri Lanka

In Sri Lanka, power tariff system which changes hourly (time) is not applied. Therefore, the reduction of power tariffs by shifting the period of power consumption is not realized.

2-2-1-2 Plan for Natural Conditions

(1) Policy for temperature and humidity conditions

The climate in Sri Lanka is tropical, hot and humid, with an average maximum temperature of 31°C to 32°C and an average minimum temperature of 23°C to 25°C in the various regions where the target hospitals are located.

It is strongly influenced by the monsoon, with the southwest and northeast monsoons, which are monsoons that occur twice a year, bringing varying amounts of rainfall according to the season. The southwest monsoon period from May to September is known as the yala season, when winds are blocked by mountainous areas and bring heavy rainfall to the southwestern part of the island. Rainfall is particularly heavy from April to May, and slightly less from June to September. During the yala season, the northern and northeastern parts of the island become dry and experience downwind conditions. From October to December, the weather becomes unstable due to windless conditions and air masses, and rainy days continue throughout the island. During the northeast monsoon season from November to March, rainfall is heavy, especially in the northeast, until January. At this time, the southwestern part of the country experiences the least rainfall of the year. Rainfall in the regions where the target hospitals are located is heaviest from April to May, especially in Ratnapura, which has the highest May rainfall of 757.9 mm.

Based on the meteorological data collected by Department of Meteorology and the average humidity data from Climate Data (which can be viewed online), the climatic conditions for the subject site are summarized in Table 2.3.

Table 2.3 Weather conditions at the project sites

Item		Value		
		Colombo	Kurunegala	Ratnapura
Height above sea level		7m	116m	86m
Ambient temperature	Maximum	33.3℃	36.7℃	35.4℃
	Minimum	23.7℃	22.1℃	22.0℃
	Average	31.2℃	32.2℃	32.2℃
Maximum humidity		95%	95%	95%
Maximum wind speed		2.1m/s	1.3m/s	2.0m/s
Annual precipitation		2,443mm	2,209mm	4,078mm

The equipment to be procured for this project shall take into account the above-mentioned climatic conditions. In addition, since the temperature inside the container in which the equipment is installed will rise due to heat generated by the equipment, the temperature inside the container shall be maintained at 30°C or lower so as not to impair the operation and maintenance of the equipment.

(2) Policy for precipitation and lightning strikes

Since lightning is a concern during the rainy season, sufficient consideration will be given to the construction process involving work at high elevations, and since photovoltaic power generation equipment (PV modules) will be installed at high elevations, lightning rods will need to be installed. Sri Jayawardenapura General Hospital does not require a new lightning rod because it is within the protection angle of the existing lightning rod, but TH Ratnapura and TH Kurunegala will install a new lightning rod.

(3) Policy for seismic conditions

Sri Lanka has a low occurrence of earthquakes. The most recent recorded earthquake of magnitude 4.4 occurred off the southwest coast of Ceylon in September 2021, but no earthquake of magnitude 7.0 or greater has been recorded in Sri Lanka in the past 50 years. According to research data on the 2004 Sumatra earthquake (magnitude 9.0), a tsunami was generated in Sri Lanka, which is located approximately 1,600 km west of the epicenter, but the tremors were barely perceptible. Therefore, it is our policy not to consider earthquakes in the design.

(4) Policy for geological and topographical conditions

This project will install solar panels on top of the roof of an existing hospital. Since the existing buildings were constructed based on the geological and topographical conditions, the feasibility of installing solar panels was determined based on the drawings obtained and visual inspection of the existing building conditions.

Based on the results of the condition check, no significant cracks of note were found in any of the buildings to be installed. Specifically, although there were some micro cracks on the surface of the building frame due to age-related deterioration, there was no impact on the building frame, and no cracks were found due to earthquakes, ground subsidence, poor construction, or structural planning defects.

2-2-1-3 Plan for Socioeconomic Conditions

Sri Lanka's economic growth rate in 2020 fell to -3.6%, and in July 2022, declared "national bankruptcy". Moreover, shortages of gasoline and diesel fuel are smoldering public anxiety about the government. Taking into account the fragility of Sri Lanka's economy and society, it is necessary to plan the construction schedule efficiently and avoid lengthy schedule extensions.

2-2-1-4 Plan for Procurement/Construction Conditions

(1) Plan for Relevant Laws and Standards

Sri Lanka has its own standards for photovoltaic equipment. The standards are mainly based on those set by the International Electrotechnical Commission (IEC), the globally recognized international standard for power equipment. However, Japanese manufacturers do not conform to the IEC, but to Japanese standards such as JIS. Since it would be difficult to adopt Japanese products when complying with Sri Lankan standards in this project, the JICA Survey Team consulted with Ministry of Power (MOP) and Sri Lanka Sustainable Energy Authority and requested that Japanese standards be applied. On May 2, 2023, the Agency issued a letter stating that it accepts the equipment to be procured by the grant aid will comply with Japanese standards. By applying Japanese standards, differences may arise in equipment design due to different insulation distances based on the specified rated voltage and applicable dimensions (e.g., conductor cross-sectional area of cables) required for the equipment. Although care will be required in terms of compatible spare parts, there will be no major problems in terms of normal operation of the equipment after installation.

In Sri Lanka, the Sri Lanka Standard 876 (SLS), which is based on the British Standards (BS), is applied for the design and construction of the roof repair work for the building where the solar panels are installed. The project is designed in accordance with the Japanese Building Standard Law while referring to the SLS. In addition, the Ministry of Urban Development & Housing (MOUDH) has issued "Guidelines on Safety and Health in Construction" as a safety standard for construction work. In this project, construction planning conducted with reference to these guidelines and the "The Guidance for the Management of Safety for Construction Works in Japanse ODA Projects” issued by JICA.

(2) Plan for Procurement of Materials and Equipment

Photovoltaic power generation systems are widely distributed in Sri Lanka and used in ordinary households. PV modules and power conditioners, which are the main equipment for PV systems, are not manufactured in Sri Lanka, but are procured from third countries. While the PV modules distributed are inexpensive, there are concerns about forced labor in the supply chain. In the procurement of PV modules for this project, human rights issues should be taken into account, and procurement requirements should be defined so that products and companies involved in forced labor can be excluded. Specifically, since the Japan Photovoltaic Energy Association (JPEA) has issued a "Declaration of Commitment to Human Rights Issues in the Photovoltaic Industry," companies belonging to JPEA will be the main suppliers of equipment. As a side note, major Japanese PV module manufacturers are among the

members of the association.

(3) Plan for Construction Conditions and Labor

In Colombo, many construction projects of large-scale facilities such as high-rise buildings and large shopping centers have been carried out, and it is relatively easy to procure experienced local engineers and skilled workers. For this reason, the policy is to procure labor for roof repair work on buildings where solar panels are to be installed from subcontractors (local contractors) of Japanese contractors.

The Ministry of Labor and Foreign Employment (MOLEF) has set the legal minimum wage for each industry. However, it should be noted that there is a gap between wages for simple laborers and remuneration for engineers, and also a gap between the standard unit price for public works and the unit price for engineers in private-sector construction work.

2-2-1-5 Plan for utilization of local companies and local materials

(1) Local Consultant

Since there are a limited number of suitable local consultants in Sri Lanka, it is policy to assign Japanese consultants as resident supervisors (equipment engineers) and short-term dispatched supervisors (construction engineers).

(2) Local Construction Company

Although there is no permit system for construction projects in Sri Lanka, local construction comapnies are required to register with the Construction Industry Development Authority (CIDA). In Colombo, construction of large-scale facilities such as high-rise buildings and large shopping centers can be seen, and the policy is to utilize local construction companies with accumulated experience and technical capabilities as subcontractors to Japanese contractors.

(3) Local Materials and Equipment

In Sri Lanka, procurement of materials and equipment for roof repair work on buildings where solar panels are to be installed is possible, including cement, rebar, and aggregate, which are the main materials, as well as metal folded-plate roofing materials. While cement and wood are produced domestically, and rebar is also manufactured domestically. Steel frames are mainly imported from India and Pakistan. The material standards are in accordance with BS standards, and there are no problems with specifications. Therefore, it is the policy to adopt and procure locally available materials and equipment.

2-2-1-6 Plan for operation and maintenance capacity of the Implementing Agency

This project will install a solar power generation system in the hospital. Each hospital has an electrical engineer who operates and maintains the low-voltage power receiving equipment from the CEB, so they have technical experience in basic electrical equipment operation and maintenance. In order to maximize the effect of this photovoltaic power generation system, it should be possible to operate it with the current personnel and technical experience, and the technology of the electrical engineers of each hospital should be taken into consideration so as not to complicate the configuration.

2-2-1-7 Plans for Setting Grades for the Facilities and Equiopment

(1) Facility plan

In this project, roofing work and painting work will be carried out depending on the situation of the building to be installed with solar panels. In addition to the need to work in high places for roof maintenance, the installation of solar panels makes it difficult to touch the roof surface, making maintenance even more difficult. Materials and paintings shall be graded with an emphasis on durability.

(2) Equipment plan

In designing the photovoltaic power generation system to be constructed and procured in this project, the technical level of the engineers who will operate and maintain it after the provision of the system will be based on the existing

equipment configuration and the technical level of maintenance engineers belonging to each hospital.

2-2-1-8 Plan for Construction, procurement method and work period

(1) Construction, Procurement Method and Work Period for Facility Construciton

Roof repair work on the building where the solar panels are to be installed shall be planned and designed so that local materials and equipment can be procured. In consideration that hospitals are in operation during this project, the plan for the construction method is as follows.

- The roof of the building (Building B) at SJGH has a tile roof over a slate roof. It is difficult to fix solar panels on the tiles and many tiles are broken, so the tiles will be removed and a metal folded-plate roofing will be installed. Since the slate roof contains asbestos, the slate roof will not be modified and new anchor bolts will be used to secure the metal folded-plate roof to the existing purlin, using the existing anchor bolt holes.
- The roof of JICA Building at TH Ratnapura is covered with asbestos-containing roofing sheets. Therefore, a new steel frame base fixed with anchors will be installed on the beam in the balcony area where the sheet roofing is not installed, and the metal folded plate roof will be fixed on the steel frame base.
- The roofs of A&E Building and Blood bank Buildng at TH Ratnapura are metal folded plate roofs of the buildings. They are more than 10 years old since completion, so the existing metal folded plate roofs will be re-painted after high pressure washing.
- The roof of Maternity Building at TH Kurunegala will not be renovated as it is a metal folded plate roof on a building completed in 2019.

In addition, the following temporary construction method is assumed for the existing hospital facility because these renovations are required while the facility is in operation.

- External scaffoldings are installed around the buildings subject to the installation work.
- Protective shelves are installed on the external scaffolding.
- Roof scaffolding is installed on the roof surface of the buildings.
- Since there is no workspace for a truck crane and outriggers around the buildings, pulleys and temporary lifting equipment for lifting materials and equipment are installed.
- The plan for developing a construction period is shown below.
- Since the construction work is to be performed in the hospitals that are in operation, the installation period of temporary facility shall take safety into account.
- The preparation period shall be considered, taking into account the time required for the procedures to purchase materials and equipment customs clearance and that the construction efficiency will be significantly reduced during the rainy season.
- Prepare a critical path for the work related to the following and develop a process based on appropriate workforce and construction equipment placement.
    - ✓ The metal folded plate roofing of the Building B at SJGH
    - ✓ The steel sheathing installation (for new metal folded plate roofing material) of the JICA building at TH Ratnapura and,
    - ✓ The high-pressure cleaning and repainting of the existing metal folded plate roof of the A&E Building and Blood Bank Building at TH Ratnapura, and develop a process based on appropriate workforce and construction equipment placement.

(2) Transportation of Equipment

When equipment is transported from Japan or a third country to Sri Lanka, it will be transported by sea to the Port of Colombo. Upon arrival at the Port of Colombo, after customs clearance (expected to take up to 15 days), the container

can be trucked to the respective sites of SJGH, TH Ratnapura, and TH Kurunegala (expected to take about one week). During customs clearance, the containers will remain at the container terminal in the Port of Colombo.

2-2-1-9 Plan for Consultant Supervision

In order to establish a thorough quality control system for the implementation of this project, a plan for the installation of equipment and a plan for the renovation of the building roofs where the solar panels will be installed shall be established. A Japanese consultant shall be assigned as a resident supervisor (equipment engineer) and a short-term dispatched supervisor (construction engineer).

2-2-1-10 Plan for Safety Measures

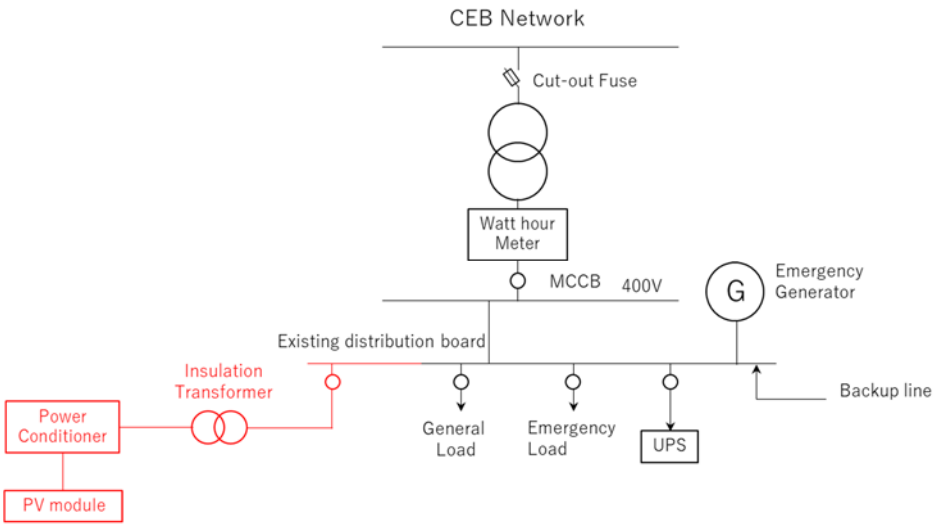
Unlike the construction of a new facility at a construction site where third parties such as hospital staff and patients are not allowed to enter, this project will be an on-site installation in a hospital that is in operation. Therefore, it is the plan for the project to formulate a "Safety Plan" and a "Safety Construction Plan" and to assign personnel for the safety management. A supplier who will perform the installation work for this project are expected to be Japanese electrical contractors that are Nominated Subcontractors (NS) to the trading companies, or Japanese construction companies. The head offices of these companies will dispatch "safety personnel" to conduct safety seminars and safety patrols.

2-2-2 Basic Plan (Equipment plan / Facility plan)

2-2-2-1 Basic Plan (Equipment plan)

(1) Outline of the System

The project will install roof-mounted PV systems for three hospitals: Sri Jayewardenepura General Hospital, Ratnapura Teaching Hospital and Kurunegala Teaching Hospital. Since the grid outage times of each hospital have been improving since 2022, as described in Figure 2.1, the originally planned storage batteries and EMS for charge/discharge control were excluded from the project component, and the study proceeded with the installation of photovoltaic panels, power conditioners (PCS) for grid interconnection, and other ancillary equipment (hereinafter collectively referred to as the System). An outline of the System is provided below.



[Source] JICA Survey Team

Figure 2.1 Photovoltaic Power Generation System Overview

The System consists of photovoltaic panels, PCS consisting of inverters with a maximum power point tracking control function & DC/AC conversion function, isolation transformers for interconnection to the existing switchgear, and distribution panels. The three hospitals are equipped with power receiving and distribution facilities that can receive and distribute all the power needed within the hospitals from the CEB commercial grid, and the power is supplied

from emergency generators only when the CEB commercial power is unavailable. Although the Ratnapura and Kurunegala Teaching Hospitals have small-capacity PV systems being installed, most of the electricity consumed is provided by the CEB commercial grid, and the installation of the System is expected to reduce significantly the amount of electricity purchased from the commercial grid.

The DC power generated by the photovoltaic panels during the daytime is converted to AC power by the PCS, which then supplies the power to the existing distribution board via an isolation transformer. The PCS in the System is interconnected (synchronized) with the CEB commercial grid during normal operation, and supplies power to the load while performing follow-up control to maximize output power that fluctuates with solar radiation intensity, solar panel temperature, and other factors. In the event of a commercial power outage, the standby mode is activated by the stand-alone operation detection function, which instantly stops operation. After the commercial grid is restored, switching operation from the emergency generator to the commercial grid is manually made in each hospital, and the PCS resumes interconnection operation after the switchover.

Each hospital is considered to have backup power supply by emergency generators to all electrical loads in the hospital in the event of a commercial grid outage. Uninterruptible switching backup power supply function is provided by uninterruptible power supplies (UPS) for the particularly most critical life-supporting loads. In facilities such as those mentioned before, where redundancy in power supply is fully considered and high reliability is ensured for medical facilities, renewable energy power sources, which are unstable power sources due to weather conditions, are connected in parallel with commercial power sources instead of being used independently to supply power to hospital loads, to have a role in supporting the amount of power supply. The photovoltaic facilities will supply the available power to the existing load and purchase the remaining necessary power from the CEB commercial grid. The output of the photovoltaic panels that can be installed on the building planned for this project is small enough to meet the electricity demand of the hospitals, so there is no risk of excess photovoltaic power flowing into the commercial power grid outside the hospital. However, since this is a private power generation facility that operates while connected with the grid, a watt-hour meter at the grid connection point that can measure both in and out flow directions shall be installed, and mounted under the hands of the CEB, but the cost is borne by the hospital.

(2) Method of operating the photovoltaic generation system in the case of a commercial grid outage

Each hospital has an in-house power supply system configuration in which emergency generators are activated to supply power to the hospital electrical appliances in the event of a commercial grid outage, and the method of operation of the photovoltaic power generation system to be installed in this project during commercial grid outage was studied.

1) Precondition

- In the event of commercial grid outage, the EDG starts up in a dozen seconds and begins supplying power to the loads that have lost power. After commercial grid power is restored, the EDG is manually shut down by the operator after switching from the EDG to the commercial grid. (Current hospital operation)
- PCSs for photovoltaic power generation manufactured in Japan are standardly equipped with a stand-alone operation detection function to meet the technical requirements guideline for grid interconnection, so that the PCS will automatically shut down in the event of a commercial grid outage.
- Since the System will be part of the ancillary facilities of the hospitals, the configuration of equipment that assumes constant monitoring should be avoided, and the PCS shall have a function to re-synchronize automatically to the commercial grid after the power is restored.

2) Contents of study

The following three patterns of PCS operation manner in the case of commercial grid outage have been studied.

- **Pattern 1**: During a grid outage, the PCS is synchronously interconnected with the operating EDG and supplies PV power (automatic operation).
- **Pattern 2:** During a grid outage, the PCS is stopped and placed in standby mode, and after the commercial grid power is restored, it is re-interconnected to the commercial grid (automatic operation).
- **Pattern 3**: PCS startup after a grid power outage is performed at the decision of the engineer (manual operation)

Table 2.4 summarizes the results of the study of the above three patterns in terms of impact on existing facilities, operability, PV generation contribution time, etc.

Table 2.4 Study on method of operating the PV system in the case of a commercial grid outage

	Pattern 1	Pattern 2	Pattern 3
Outline	PCS startup (incl. interconnection operation) and shutdown are performed automatically. (1) PCS stops during CEB commercial power (grid) outage. (2) PCS starts interconnected operation with EDG after EDG startup starts feeding power. (3) When the grid is restored, PCS stops upon completion of EDG to Grid switchover. (4) After switching back to the normal power supply from the grid, PCS restarts grid interconnected operation.	PCS startup (incl. interconnection operation) and shutdown are performed automatically. (1) PCS stops during the grid outage. (2) PCS prevents interconnection operation during EDG is feeding power. (3) After switching back to the normal power supply from the grid which has been already restored, PCS restarts grid interconnected operation.	PCS startup and shutdown are basically performed manually. (1) PCS stops during the grid outage. (Activation of protection function for independent operation detection) (2) After switching back to the normal power supply from the grid which has been already restored, PCS is restarted by operation of an engineer for grid interconnected operation.
Time chart	Refer to Figure 2.2	Refer to Figure 2.3	Refer to Figure 2.4
Advantages	・ Maximize use of solar power ・ Reduce EDG fuel burning. ・ Reduce the burden of an engineer by automatic start operating, re-interconnecting & shutting down the System	・ No technical concerns with synchronous operation with EDG ・ Reduce the burden of an engineer by automatic start operating, re-interconnecting & shutting down the System	・ Operation can be freely performed at the decision of an engineer.
Disadvantages	・ Modification of existing facilities is required (to take in switching signals during EDG operation) ・ Need to resolve technical concerns about stable power supply for synchronized operation of PV PCS and EDG in small-scale grid in the event of commercial grid power outage.	・ Solar power cannot be used during EDG operation. ・ No contribution to EDG fuel burning reduction. ・ Modification of existing facilities is required (to take in switching signals during EDG operation)	・ Concerns that the avoidance of synchronous operation with EDG is only at the decision of an engineer, and that this may cause problems due to human error (the interlock circuits created in Pattern 2 needs to be configured for security purpose). ・ Concerns about reduction of solar power generation use time due to forgotten PCS restart operation after grid restoration.

[Source] JICA Survey Team

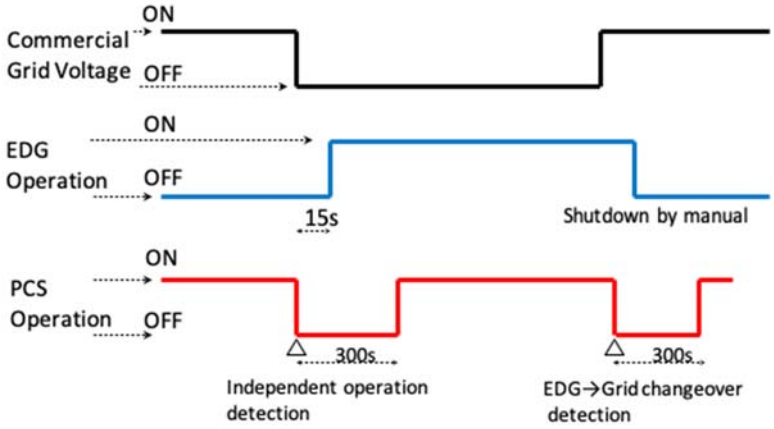


Figure 2.2 Time chart of the pattern 1

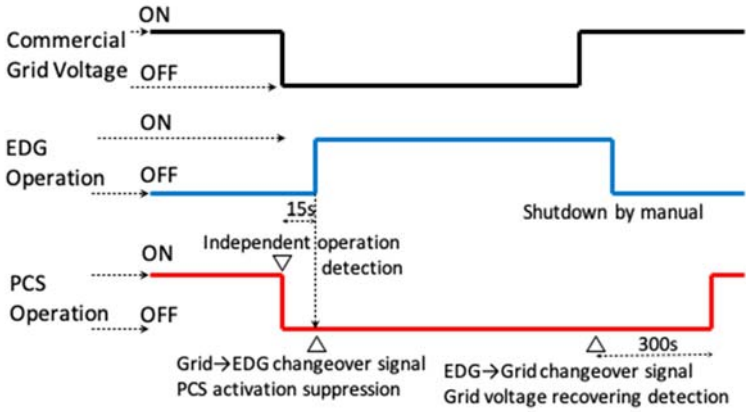


Figure 2.3 Time chart of the pattern 2

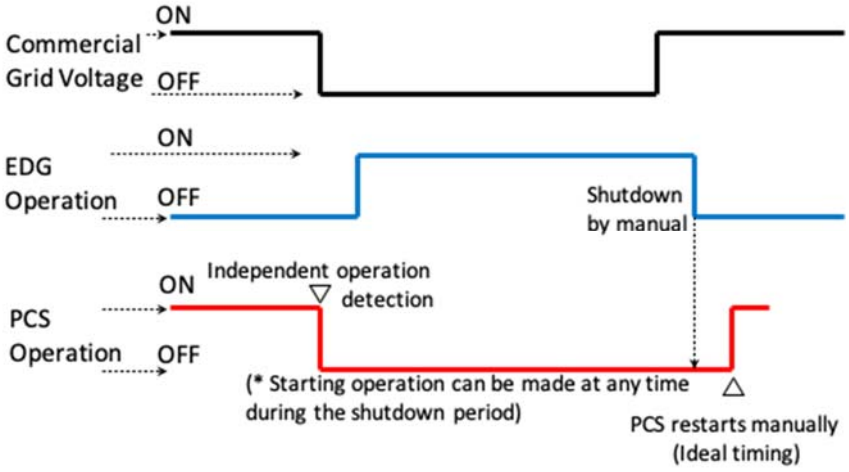


Figure 2.4 Time chart of the pattern 3

3) Conclusion of the study

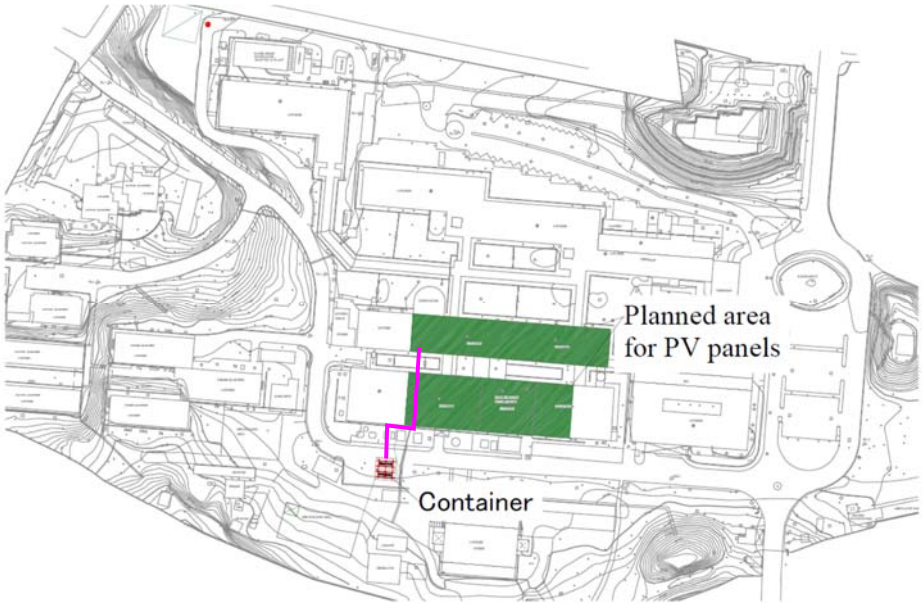
From the standpoint of power supply reliability, the equipment configuration is planned with equipment configuration that enable automatic operation of Pattern 2, which is least likely to adversely affect existing facilities and is superior

in terms of operability. However, since operation by an engineer is required during maintenance and inspections, the System shall be equipped with an automatic/manual mode switching function to allow manual operation.

(3) System outline of each hospital

1) Sri Jayewardenepura General Hospital

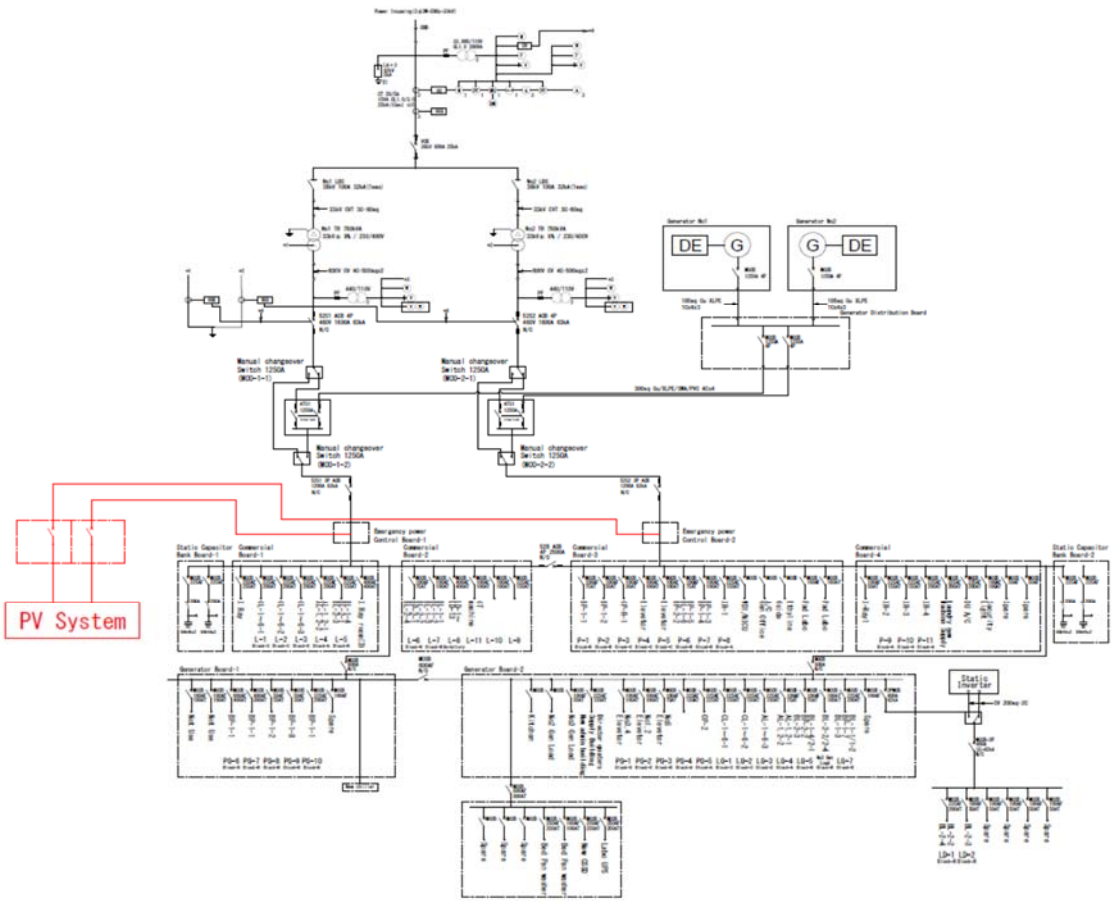
Figure 2.5 shows the overall layout and the System layout plan of Sri Jayewardenepura General Hospital.



[Source] JICA Survey Team

Figure 2.5 Layout plan of Sri Jayewardenepura General Hospital

The new PV panels are planned to be installed on the roof of the existing B block building (approximately 2,750m^2), and the capacity is expected 440kW. The container containing the PCS is planned to be installed in the green zone on the opposite side of the road from Building B. At the time of preparatory survey, old containers were installed at the planned location. Therefore, the old container shall be demolished by Sri Lanka side before the bid announcement. The pink line in Figure 2.6 shows illustrates the new cable route. The PV power converted by the PCS will be connected to the existing main distribution board which is installed in the electrical room of Block B-building, but since there is no place to install the MCCB required for connection on the distribution board, the new distribution board equipped with MCCB will be installed in the electrical room in this project, and will be connected to the existing main distribution board bus via a cable. The figure shows single line diagram of existing facilities and planned new PV system.



[Source] JICA Survey Team

Figure 2.6 Connection diagram for PV system (SJGH)

By connecting this PV system to the bus bars on the secondary side (400 V side) of two main transformers in the hospital, PV power will be supplied to both Commercial and generator bus bars, which is expected to reduce the load factor of the existing transformers and the amount of power purchased from the CEB system. In the event of a failure of the System, the faulty equipment will be disconnected from the grid and automatically stopped, so the power supply from the solar power system will be reduced or stopped. However, the power distribution system maintained by CEB grid, and the emergency generator + UPS configuration are roll of backup, so it does not lead to a decrease in the reliability of the power supply in the hospital.

2) Teaching hospital Ratnapura

In the teaching hospital Ratnapura, the PV panels plan to be installed on the roof of Blood bank, A&E and JICA building. Since each building is far away and it is difficult to place containers in one place from the viewpoint of voltage drop, two containers will be installed at a suitable point. The roof area and expected PV output of each building are as follows.

- Blood bank building: 30 kW (434 m^2)
- A&E building: 37 kW (529 m^2)
- JICA building: 184 kW (1,168 m^2)

(i) PV system for Blood bank and A&E building

The power generated by the solar panels installed in both buildings will be concentrated in the container (1) shown in Figure 3.4. The DC cable from the PV panels installed in the A&E building will be stored and laid in cable racks and conduits along the building walls and eaves roof (crossing the road of the connecting passage between the A&E building and the main building) to the emergency generator building installed near the blood bank building. The DC cable from the PV panels installed in the blood bank building will also approach the emergency generator building via the existing cable rack, and after joining with the cable from the A&E building, the cable will be laid to the

container (1) using the cable line with the underground conduit and concrete pole. As a result of discussions with the hospital, it was decided to utilize the available space of the doctor's dormitory for the location of the container (1). The power, converted to DC/AC by the PCS will follow the same route as the DC cable mentioned above with an AC cable and will be connected to the power receiving cable for the main distribution board for the existing blood bank building at the power distribution board newly installed in the emergency generator building to supply power to the blood bank building. The purple line in Figure 2.7 shows the planned cable route.

(ii) PV system for JICA building

The PV power from the panels installed in the JICA building will be transmitted to the container (2) in Figure 2.8 via multiple DC cables. The DC cable from the PV panels will be laid with cable racks and conduits newly installed on the outer wall of the JICA building and the main building and connected to the container (2). As a result of discussions with the hospital, it was decided to utilize the available space of the doctor's dormitory for the location of the container (1). The DC cable from the PV panels will be laid with cable racks and conduits newly installed on the outer wall of the JICA building and the main building and connected to the container (2). As a result of discussions with the hospital, it was decided to utilize the available space in courtyard of the maternity ward of the main building for the location of the container (1). The power converted to DC/AC by the PCS transmitted the same route as the DC cable mentioned above with an AC cable, and is connected to the existing main distribution board installed in the electric room on the first floor of the JICA building. Since there is no space on the existing main distribution board to install the circuit breaker (MCCB) required for connection, a new distribution box equipped with MCCB will be installed in the electrical room in this project, and will be connected to the existing main distribution board bus with a cable. The orange line in Figure 2.7 shows the planned cable route.

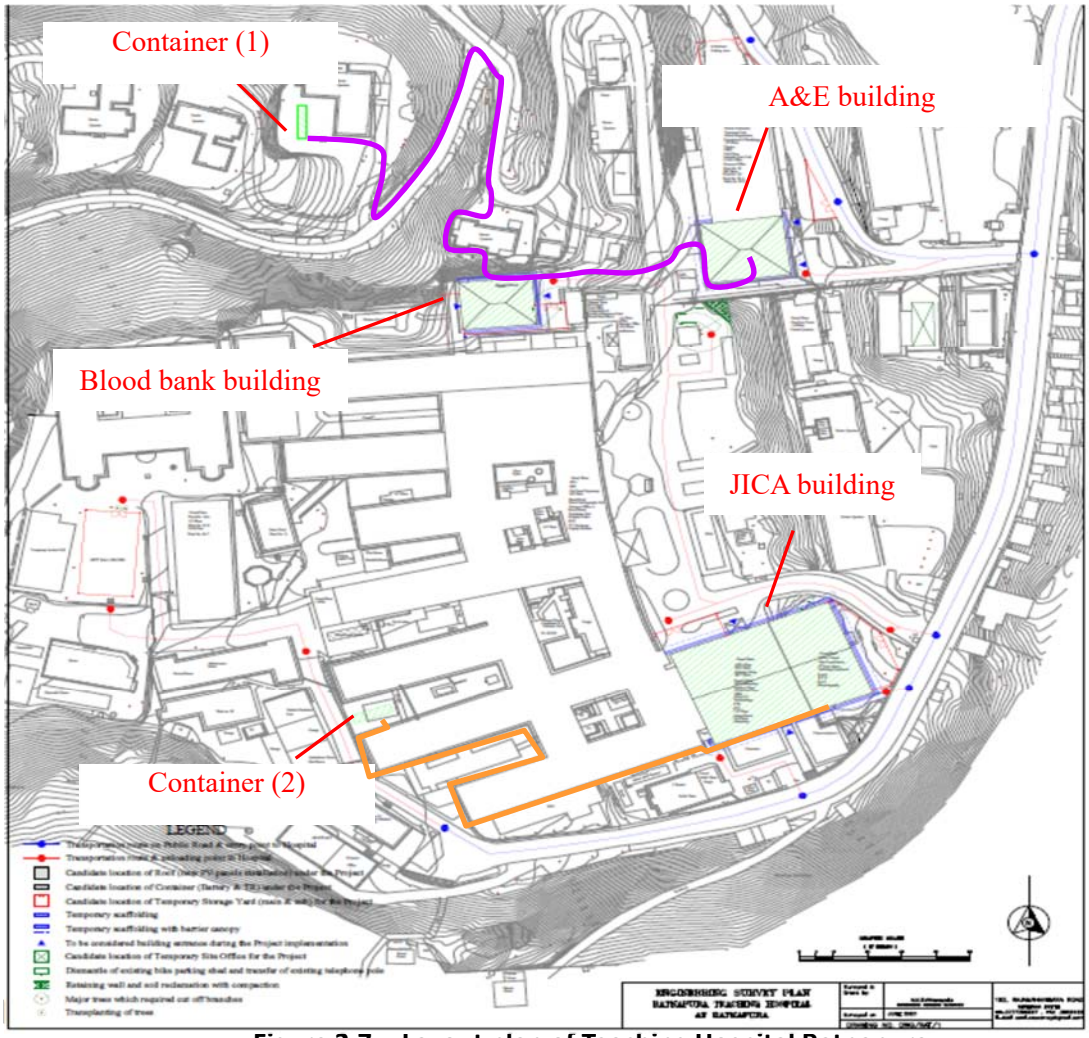
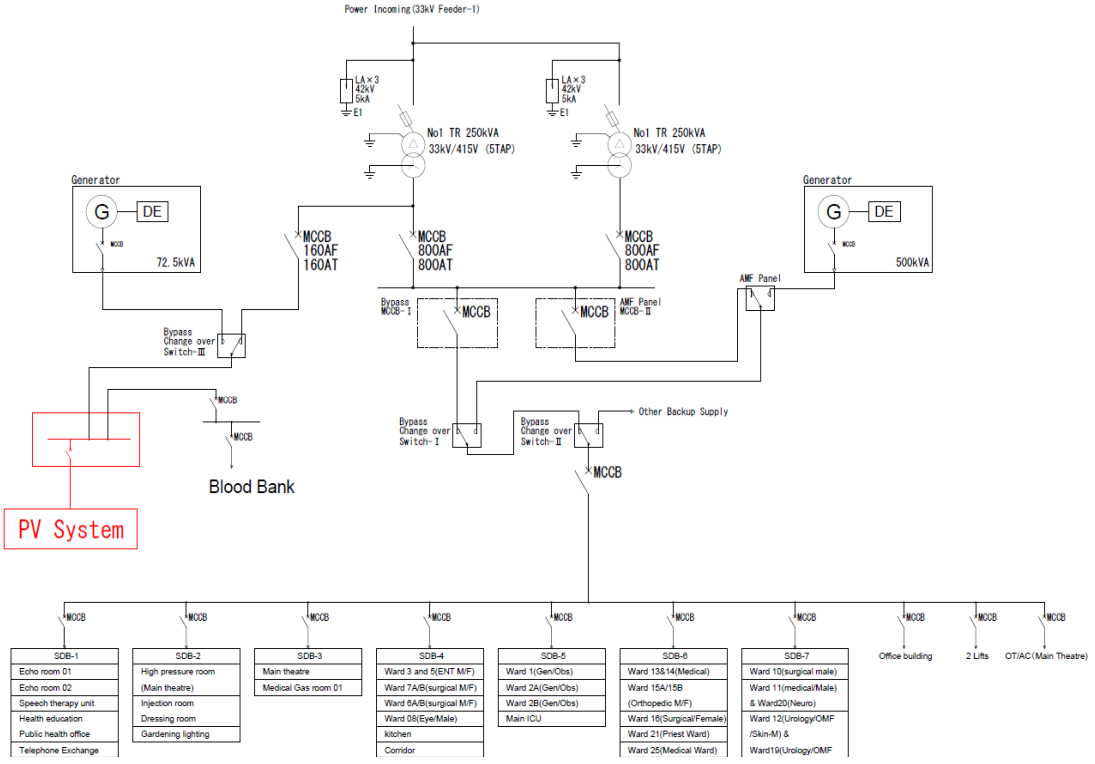


Figure 2.7 Layout plan of Teaching Hospital Ratnapura

(iii) Connection method of existing facilities

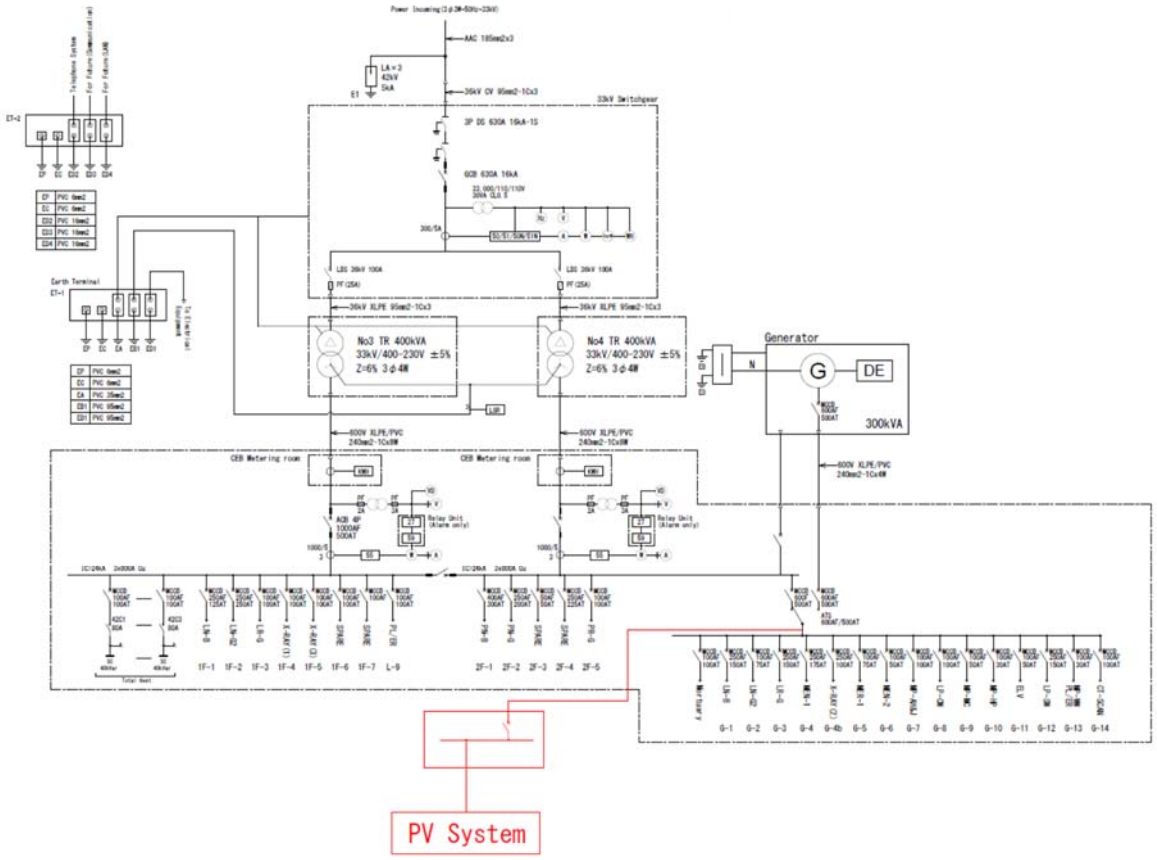
Figure 2.8 and Figure 2.9 show single line diagram for the connection between existing facilities and the PV system. As shown in Figure 2.8, the current blood bank building receives power from the secondary side of the transformer used by the main building system to receive power from the CEB grid, and is equipped with a dedicated emergency power generator. By installing a low-voltage distribution box downstream of the emergency generator and the Automatic changeover switch (ATS) and branching to the existing cable, it is possible to connect the System even during a relatively short power outage. The PV power generation installed in the A&E building and blood bank building will be supplied to the main building via the blood bank building and the low-voltage side terminal of the transformer.



[Source] JICA Survey Team

Figure 2.8 Single line diagram of Blood Bank Building

The current power receiving equipment of the JICA building consists of two power receiving transformers and a main distribution board with two 400 V general bus lines and one emergency bus line. There is no spare MCCB that can connect to the 200 kW class in the main distribution board, and there is no place to install an additional MCCB, therefore a new wall-mounted distribution box with built-in MCCB will be installed in the electric room of the JICA building, connected to the emergency bus which has large demand load with a new cable, and supply the power generated by the System. The In the event of a failure of this system, the faulty equipment will be disconnected from the grid and automatically stopped, so power supply from the solar power system will be reduced or stopped. However, the power distribution system maintained by CEB grid, and the emergency generator + UPS configuration are available for backup, so there is no decrease in the reliability of the power supply in both building.

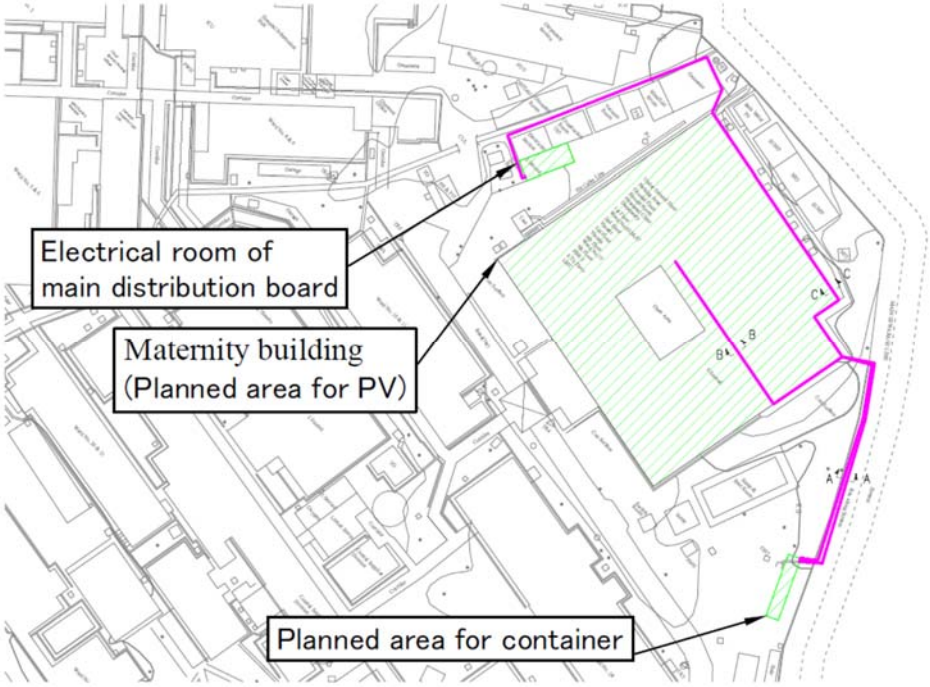


[Source] JICA Survey team

Figure 2.9 Single line diagram of JICA Building

3) Teaching hospital Kurunegala

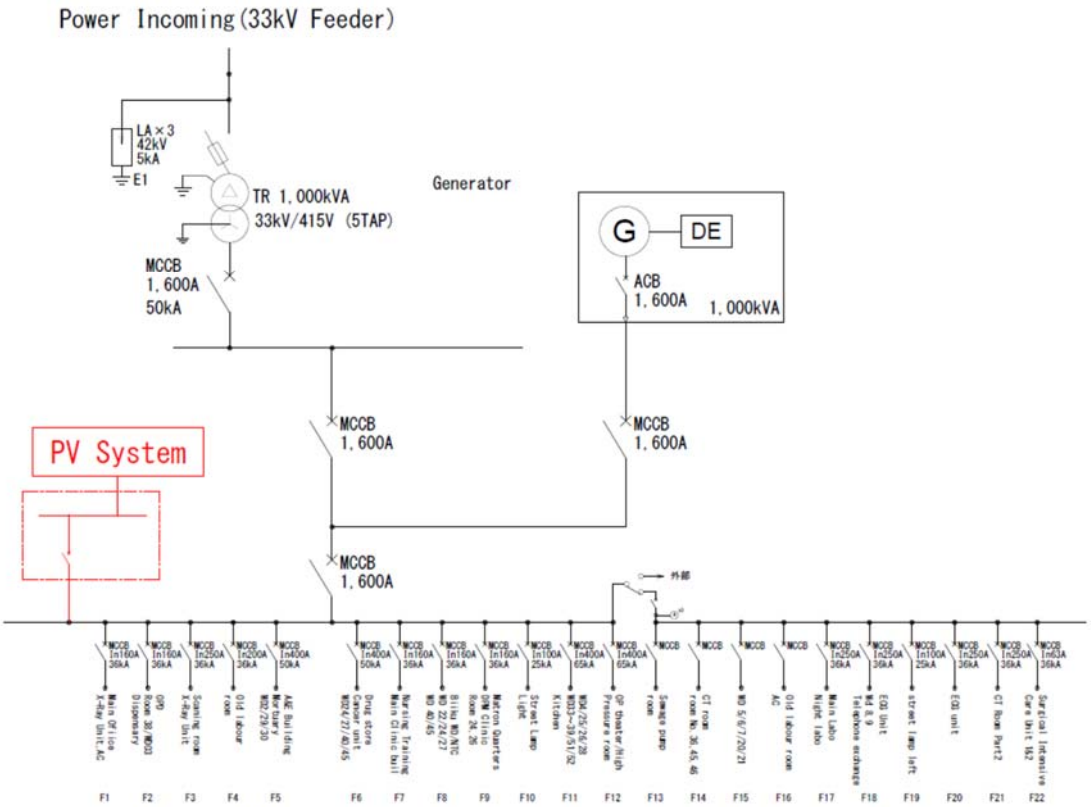
The overall layout of Kurunegala Teaching Hospital and the System layout plan are shown in Figure 2.10 for this hospital, PV panels plan to install on the roof of the maternity ward. There is currently an unused incinerator facility neighboring the maternity building. Therefore the old incinerator shall be demolished by the Sri Lanka side before the bid announcement and planning to install a container with built-in PCS in that location. The expected PV output is approximately 240 kW.



[Source] JICA Survey team

Figure 2.10 Layout plan of Teaching Hospital Kurunegala

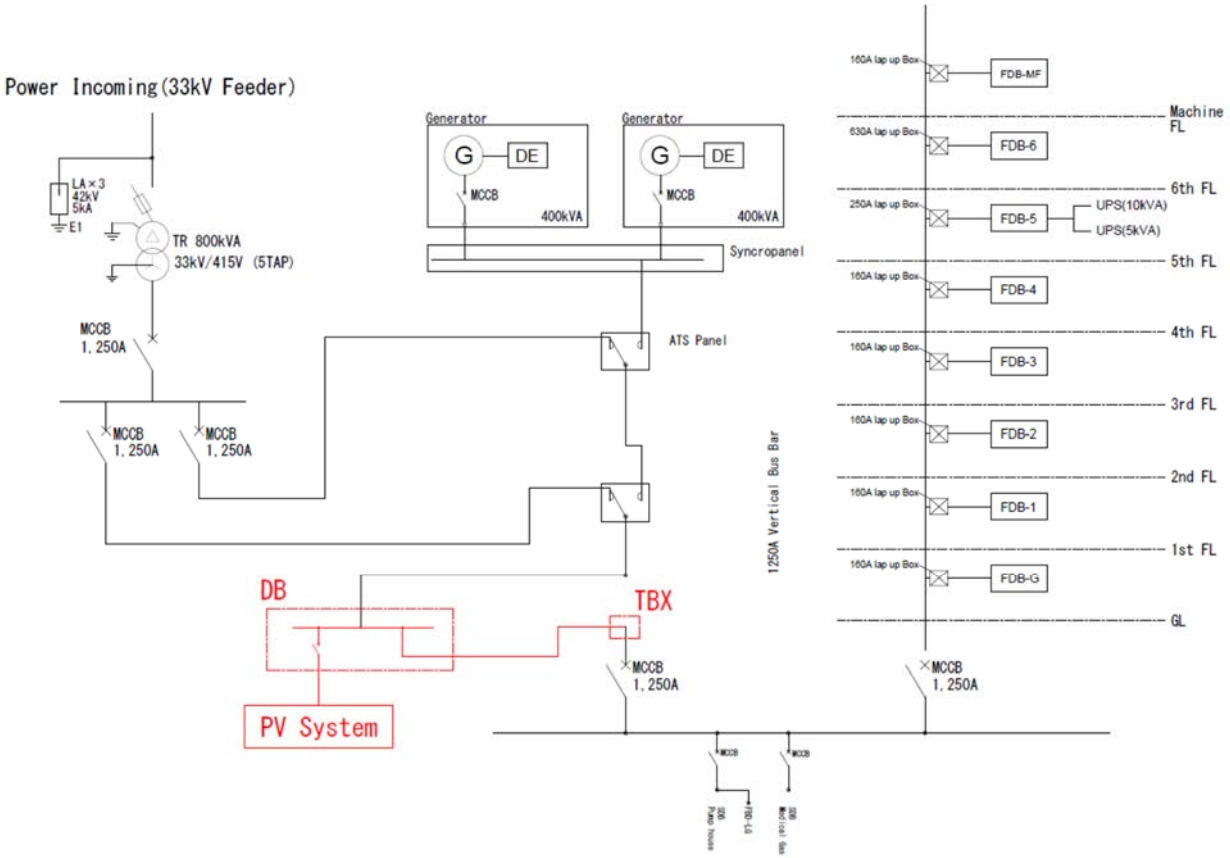
The DC cable from the PV panels installed on the roof of the maternity building will be pulled down to the basement parking area using the existing vertical duct inside the building, stored in cable trays and conduits, and laid to the container. In order to supply power to each of the two wards, prepare one PCS for the maternity building and two PCSs for the main system. The DC/AC-converted power transmitted via AC cable which is through the same route as the DC cable. The cable for the maternity building will be connected to the existing power receiving cable via a new terminal box installed in the basement parking lot. The cable for the main system is planned be to laid underground in the main system electrical room, after passing through the maternity building. But there is no suitable spare MCCB for the main distribution board, and it is difficult to secure the installation space. Therefore, a new wall-mounted distribution box with built-in MCCB will be installed in the electric room, connecting to the main distribution bus with a new cable. The figure 2-2-2-1.6 shows the planned cable route as pink line. The connection between the existing electrical equipment system and the System is shown in Figure 2.11 for the main system and Figure 2.12 shows the diagram for the maternity building.



[Source] JICA Survey team

Figure 2.11 Single line diagram of main system (TH Kurunegala)

The current main system consists of a 1,000kVA power receiving transformer connected to the CEB grid and a 1,000kVA backup emergency generator, which enables the continuation of power supply even in the event of a CEB grid blackout. The main distribution board has 22 feeders. The 400 V main bus is exposed on the main distribution board with an open back, making it easy to install new connections, but sufficient attention must be paid to safety. A new wall-mounted low-voltage distribution board plan to be installed in the electrical room and the power generated by the System will be connected to the high-demand bus of the main system via the new MCCB in the distribution board. Even at Kurunegala Hospital, in the event of a PV system failure, electricity power can be supplied from the existing system, including an emergency generator, and power supply reliability will be maintained.



[Source] JICA Survey Team

Figure 2.12 Single line diagram of Maternity Building

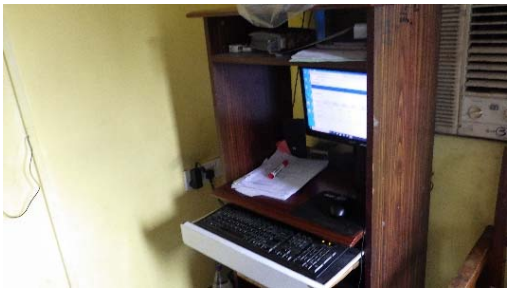
The maternity building is powered by a transformer connected to the CEB system and two synchronous emergency generators. The supplied power is connected to the power and distribution board installed on the first floor of the building, and power is supplied to each floor through vertical bus ducts. As a noted during the field survey, there is a spare MCCB on the distribution board on the first floor, hence by connecting the cable from the PV system to this, it is possible to easily supply PV power without power outages in the building. However, if this plan is implemented, it will be necessary to connect a PCS with a capacity of 50 kW or less, which cannot be used if the planned 100 kW PCS is adopted for this project. Therefore, the cable from the PV system is planned to branch and connect via terminal box with a built-in MCCB to the power receiving cable in front of the main distribution board.

4) Miscellaneous equipment

(i) Remote monitoring system

Ratnapura and Kurunegala teaching hospitals have already installed solar power facilities, and existing facilities are able to monitor the power generation status with a remote monitoring system.The system overview is shown in Table 2.5.

Table 2.5 Overview of remote monitoring system

Ratnapura	Kurunegala
A small inverter for PV is installed on the wall of the main building, and it is possible to monitor the power generation status by reading 2D barcode.	A dedicated PC is installed in the electrical engineer room, and power generation status can be monitored via a web browser.
	

[Source] JICA Survey team

For the new PV system, the remote monitoring system is planned to be introduced in this project for the purpose of managing the solar power generation and system status. Considering conditions such as locations where maintenance personnel are stationed to enable continuous monitoring, and locations where monitoring devices can be installed, as a result of surveys and interviews at each hospital, the locations shown in Table 2.6 were identified for installing remote monitoring devices.

Table 2.6 Planned location for remote monitoring system

Hospital	Location
Sri Jayewardenepura General Hospital	B-Block building 1st floor Electricity workshop
Ratnapura teaching hospital	JICA building B1 Electrical engineer room
Kurunegala teaching hospital	Main distribution room 2nd floor Electrical engineer room

[Source] JICA Survey Team

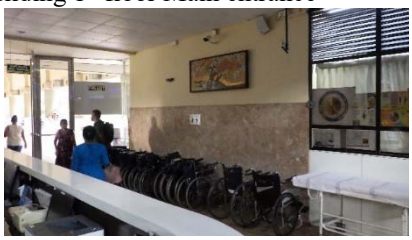
The monitoring data from the PCS to the remote monitoring PC, via fiber optic cable newly installed in the hospital.

(ii) PV system public monitor

A public monitor will be installed to inform hospital patients of the operating status of the PV system introduced in this project. The monitor is expected to display updated information on solar power generation, CO2 emission, and other data, refreshed every few tens of seconds.

As a result of discussions with hospital directors, etc., it is planned to install large monitors at the locations shown in Table 2.7.

Table 2.7 Location of monitor installation

Hospital	Location
Sri Jayewardenepura General Hospital	A Block building 1st floor Main entrance 
Ratnapura teaching hospital	JICA building 1st floor Outpatient entrance 
Kurunegala teaching hospital	Maternity building 1st floor hall 

[Source] JICA Survey Team

(iii) Fire detection system

Container facilities with built-in PCS are basically operated unmanned, and it is expected that if a fire accident occurs, it will be discovered late. Therefore, the fire (smoke) detector is planned to be installed in the container, enabling the remote monitoring system to immediately detect the fire alarm.

(4) Basic condition

1) Natural condition

Table 2.8 shows the natural condition for design of PV system and equipment foundation.

Table 2.8 Natural condition

Items		Data		
		Colombo	Kurunegala	Ratnapura
Altitude		7m	116m	86m
Ambient temperature (℃)	Maximum	33.3	36.7	35.4
	Minimum	23.7	22.1	22.0
	Average	31.2	32.2	32.2
Relative humidity (%)		95	95	95
Maximum wind speed (m/s)		2.1	1.3	2.0
Annual rainfall (mm)		2,443	2,209	4,078

[Source] JICA Survey Team

2) Design conditions of electricity system

- Operation Voltage (A/C): 400/230V (3 phase 4 wire)
- Frequency: 50Hz
- Consideration for voltage operating range
- Since the newly installed PV system is planned to be operated in synchronization with the existing power network so that the PV system voltage shall be suitable voltage range
  - ✓ Tap voltage of insulated transformer are,
    Line to line: 415 V, Phase: 240 V (Match the tap voltage of the CEB transformer, approximately 4% higher than the operating voltage)
  - ✓ To select a cable size that can meet the operating voltage value when the 400V bus voltage at the interconnection point (Consideration for voltage drop)
  - ✓ DC cables between PV modules and PCS will be selected with a target voltage drop of 3% or less based on the "Guidelines on Rooftop Solar PV Installation for Solar Service Providers (September 2022) Public Utilities Commission of Sri Lanka"
- Seismic design: 1.0G (Horizontal) and 0.5G (Vertical)

3) Applicable regulation and code

Table 2.9 shows the applicable standards and regulations for the deign of the System and equipment foundations.

Table 2.9 Applicable standards and regulations

Items	Application
Japanese Industrial standards(JIS)	Applicable to all industrial products
Japanese Electrotechnical Standards(JEC)	Applicable to electrical products in general
Standards of the Japanese Electrical Manufacturer's Association(JEM)	Ditto
Japanese Cable Maker's Association Standard(JCS)	Applicable to electric wires and cables
Japanese Technical standards for electrical equipment	Applicable to general electrical work
International Electrotechnical Commission(IEC)	Applicable to electrical products in general
International Organization for Standardization (ISO)	Applicable to all electrical and mechanical products
Relevant standards and specifications for Sri lanka	Mainly applicable to construction and its related matters

Tables 2.10 to 2.34 show the basic specifications of the equipment to be procured in this project.

Table 2.10 Specification of Supporting structure and fitting material for PV module

No	Items	Specifications
(1)	Applicable Code	IEC、JIS、JEC、JEM or equivalent
(2)	Type	Mono-crystalline, multi-crystalline silicon or equivalent
(3)	Degree of protection	IP65 or more
(4)	Module efficiency	20.0% or higher
(5)	Standard Test Condition	Solar irradiation:1000W/m sq, Module temperature: 25℃ Air mass 1.5 spectrum
(6)	Bypass diode	To be equipped
(7)	Maximum Output	410W with a tolerance of +10%, -0%
(8)	Capacity	440 kWp or higher（SJGH） 250kW or higher（TH Ratnapura） 240kW or higher（TH Kurunegala）

Table 2.11 Specification of PV module

No	Items	Specifications
(1)	Type	PV module mounting rail type
(2)	Material	Aluminum alloy or equivalent (Service life 20 years or more)
(3)	Fitting Materials	To be procured
(4)	Design wind speed	40m/s or higher

Table 2.12 Specification of Junction Box

No	Items	Specifications
(1)	Enclosure type	Outdoor use, proof from vermin and insect
(2)	Material of case	SPHC（JIS G 3131）or stronger
(3)	Coating of case	Powder coating or equivalent
(4)	Degree of protection	IP45 or higher
(5)	Enclosed function of input circuit	
	・Number of input circuit	To be specified
	・Type	Disconnecting switch
(6)	Enclosed function of output circuit	
	・Type	Circuit breaker
(7)	Blocking diode for reverse protection	To be provided

Table 2.13 Specification of Collecting Box

No	Items	Specifications
(1)	Enclosure type	Outdoor use, proof from vermin and insect
(2)	Material of case	SPHC（JIS G 3131）or stronger
(3)	Coating of case	Powder coating or equivalent
(4)	Degree of protection	IP45 or higher
(5)	Enclosed function of input circuit	
	・Number of input circuit	To be specified
	・Ampere frame (AF)	Total short circuit of connected strings or higher
(6)	Enclosed function of output circuit	
	・Ampere frame (AF)	Total short circuit of connected strings or higher
(7)	Others	Name plate, door handle wit key, ODA sticker shall be procured

Table 2.14 Specification of Power Conditioner

No	Items	Specifications
(1)	Rated Power Output	100kW
(2)	Integrated Power Output	100kW x 4（SJGH） 100kW x 3（TH Ratnapura） 100kW x 3（TH Kurunegala）
(3)	Input Voltage Range (DC)	600 V
(4)	Number of Phase of AC Output	Three-phase, Three-wire
(5)	Output Voltage Range (DC)	Manufacturer's standard
(6)	Rated Frequency	50 Hz
(7)	Efficiency	95% or higher（for 1 panel）
(8)	Protection function	Over/Low Voltage, Over/under frequency
(9)	stand-alone operation detection function	To be equipped
(10)	Operating number control	To be equipped (In case of two or more PCS System) Not considered (In case of single PCS system)
(11)	Color	5Y7/1 or Manufacturer's standard
(12)	Man Machine Interface	Display in English
(13)	Accessories	Channel base, Name Plate, fitting bolt nuts, etc

Table 2.15 Specification of DC Connecting Panel

No	Items	Specifications
(1)	Number of Panels	2 Panel（SJGH） 1 Panel（TH Ratnapura） 1 Panel（TH Kurunegala）
(2)	Type	Indoor use, self-standing metal enclosed type
(3)	Details of input/output circuit	Input :DC 100kW x 2circuit Output: each PCS
(4)	Color	5Y7/1 or Manufacturer's standard (shall be same as a PCS color)
(5)	Accessories	Channel base, Name Plate, bolt nuts, etc

Table 2.16 Specification of Cable Connecting Panel

No	Items	Specifications
(1)	Number of Panels	1 Panel（TH Ratnapura） 1 Panel（TH Kurunegala）
(2)	Type	Indoor use, self-standing metal enclosed type or wall mounted type
(3)	Details of input/output circuit	Input :DC 100kW Output: each PCS

Note： Procure as needed. Not used at SJGH

Table 2.17 Specification of Insulation Transformer

No	Items	Specifications
(1)	Rated capacity and quantity	200kVA x 2（SJGH） 200kVA x 1　100kVA x 1（TH Ratnapura） 200kVA x 1　100kVA x 1（TH Kurunegala）
(2)	Type	Dry (insulation class H)
(3)	Number of phase	Three phase
(4)	Rated voltage	Primary（Grid side）240/415 V、+2.5%、-2.5% Secondary(PCS side) PCS output voltage
(5)	Vector group	YNd1
(6)	% impedance	Manufacturer's standard
(7)	Cooling	ANAN

No	Items	Specifications
(8)	Connection	Primary 3 phase 4wire Secondary 3 phase 3 wire
(9)	Frequency	50 Hz
(10)	Accessories	Channel base, Name Plate, bolt nuts, etc

Table 2.18 Specification of weather data collection system

No	Items	Specifications
(1)	Temperature sensor	1 set（with cable shield）（SJGH、TH Kurunegala） 2 set（with cable shield）（TH Ratnapura）
(2)	Pyranometer	1 set（SJGH、TH Kurunegala） 2 set（TH Ratnapura）
(3)	Signal Transmitter	Manufacturer's standard
(4)	Accessories	Necessary fitting materials

Table 2.19 Specification of Control and monitoring system

No	Items	Specifications
(1)	Data acquisition	
	・Data sampling Cycle	Less than 30 sec (Manufacturer's standard)
	・Collected data	Solar radiation intensity, temperature, Watt-hour
(2)	Hardware specification	Serial signal converter (RS485 to RS232C) UPS: To prevent stoppage of control and monitoring system due to short-term power outage (approximately backup time shall be 10minitue) Data server (Data storage period shall be about one year) Rack for control and monitoring system
(3)	Software specification	Monitoring of operation data, trend graph and reporting Alarm and recording of Plant and PCS own fault Protection setting function of PCS External memory save function(e.g. CSV file)
(4)	Monitor system	LCD monitor x1 , desk, chair

Table 2.20 Specification of Remote monitoring system

No	Items	Specifications
(1)	Remote monitoring system	
	➢ PC for remote monitoring	1 set (with LCD monitor, key board, mouse etc.) The system should be equipped with same monitoring function equivalent to the control and monitoring system in the container
	➢ Data transmission device	A set of the data transmission device including media converter for optical fiber cable connection with the control and monitoring system in the container
	➢ Rack	A set of rack which is able to store remote monitoring devices and other auxiliaries
(2)	Public Monitor	Wall mounted type of LCD monitor (42inch or larger) with mounting stand Auxiliary PC for video display Media converter for public monitor side Media converter for control and monitoring system side

Table 2.21 Specification of container

No	Items	Specifications
(1)	Size	40ft x 1 set or 20ft x 2 set or equivalent（SJGH） 31ft x 1 set and 20ft x 1set（TH Ratnapura） 40ft x 1 set（TH Kurunegala）
(2)	Structural specification	1. The material shall be the Manufacturer's standard 2. The structure should be less affected by temperature rise inside the container by sunlight 3. A sufficient size should be secured for the door of container considering the loading of the panel 4. If maintenance from the back of the panel is required, the necessary space shall be considered. 5. The container shall have the structural strength to withstand the weight of the panels to be stored 6. For the floor of container, the necessary cable hole, and fitting materials shall be secured for panel installation.
(3)	Storage conditions	The insulation transformer and PCS shall be separated from each other by partition walls etc. Or store in a separate container
(4)	Specification	1. The room for the insulation transformer shall be equipped with an exhaust ventilation fan. Regarding the ventilation fan, insect proofing shall be considered 2. To keep the room temperature for PCS and other control equipment below 30℃ 3. To install lighting on the ceiling. The illuminance shall be 300 Lx or more for the PCS room and 70 Lx or more for the transformer room 4. The distribution board for miscellaneous load in the container shall be installed 5. 3 or more power outlet for 1 container shall be installed 6. The space for fire detection panel shall be considered
(5)	Color	5Y7/1 or Manufacturer's standard. Designed to withstand hot and humid tropical climates
(6)	Accessories	Base, Name Plate, fitting bolt nuts, etc

Table 2.22 Specification of Low voltage distribution board

No	Items	Specifications
(1)	Applicable Code	IEC、JIS、JEC、JEM or equivalent
(2)	Type	【SJGH】 Indoor use, self-standing metal enclosed type with base plate 【TH kurunegala】 Outdoor use, self-standing metal enclosed type with base plate *Front door with key handle shall be procured
(3)	Degree of protection	IP21 or more (SJGH) IP42 or more (TH kurunegala)
(4)	Number of Panels	2 set (SJGH) 1 set (TH kurunegala)
(5)	Color	5Y7/1
(6)	Rated voltage	400/230 V (3 phase 4 wires)
(7)	Rated Frequency	50Hz
(8)	Rated withstand current	16 kA (1sec) or more

No	Items	Specifications
(9)	Equipment	
	➢ MCCB	3 phase 4 wires with alarm contact 400 AT 1set (SJGH) 250 AT 1set (TH kurunegala)
	➢ Bus	1250 A or more (TH kurunegala) 4 bus configuration for 3 phase 4 wires (cable or conductor)
	➢ Terminal	The terminal block shall be installed at suitable position which are able to connect following sizing cable 【SJGH】 ➢ PCS side: 240mm^2(4C) ➢ Existing main distribution board side: 150mm^2(4C) 【TH kurunegala】 ➢ PCS side: 120mm^2(4C) ➢ Existing main distribution board side: 150mm^2(4C) ➢ ATS side: 240mm^2(4C) ➢ Main distribution board side: 240mm^2(4C) Terminal block for auxiliary contact
	➢ Internal Wire	Necessary electric internal wires for connecting equipment inside the panel (conductors can also be used)
	➢ Earth terminal	Terminal for earthing
	➢ Other necessary equipment	Fitting materials for equipment, cable duct, insulation board, name plate, etc
(10)	Cable connection	Bottom of the panel (SJGH) Side or back of panel（TH Kurunegala）
(11)	Accessories	Channel Base, Name Plate, fitting bolt nuts, etc

Table 2.23 Specification of Low voltage distribution Box (TH Ratnapura)

No	Items	Specifications
(1)	Applicable Code	IEC、JIS、JEC、JEM or equivalent
(2)	Type	【Box-1】 Outdoor use, wall mounted metal enclosed type 【Box-2】 Indoor use, wall mounted metal enclosed type *Front door with key handle shall be procured
(3)	Degree of protection	IP44 or more (Box-1) IP21 or more (Box-2)
(4)	Size	800W x 350D x 700H or less (Box-1) 1,000W x 350D x 1,000H or less (Box-2)
(5)	Number of Panels	Each 1 set
(6)	Color	5Y7/1
(7)	Rated voltage	400/230 V (3 phase 4 wires)
(8)	Rated Frequency	50Hz
(9)	Rated withstand current	16 kA (1sec) or more
(10)	Equipment	
	➢ MCCB	3 phase 4 wires with alarm contact 250 AT 1set (Box-1) 400 AT 1set (Box-2)
	➢ Bus (Box-1)	250 A or more 4 bus configuration for 3 phase 4 wires (cable or conductor)
	➢ Terminal	The terminal block shall be installed at suitable position which are able to connect following sizing cable

No	Items	Specifications
		【Box-1】 ➢ PCS side: 150mm^2(4C) ➢ Existing main distribution board side: 50～70mm^2(4C) 【Box-2】 ➢ PCS side: 185mm^2(4C) ➢ Existing main distribution board side: 185mm^2(4C)
	➢ Internal Wire	Necessary electric internal wires for connecting equipment inside the panel (conductors can also be used)
	➢ Earth terminal	Terminal for earthing
	➢ Other necessary equipment	Fitting materials for equipment, cable duct, insulation board, name plate, etc
(10)	Cable connection	Bottom of the panel (Box-1) Top of panel（Box-2）
(11)	Accessories	Channel Base, Name Plate, fitting bolt nuts, etc

Table 2.24 Specification of Low voltage distribution Box (TH Kurunegala)

No	Items	Specifications
(1)	Applicable Code	IEC、JIS、JEC、JEM or equivalent
(2)	Type	Indoor use, wall mounted metal enclosed type *Front door with key handle shall be procured
(3)	Degree of protection	IP21 or more
(4)	Size	400W x 350D x 1,000H or less
(5)	Number of Panels	1 set
(6)	Color	5Y7/1
(7)	Rated voltage	400/230 V (3 phase 4 wires)
(8)	Rated Frequency	50Hz
(9)	Rated withstand current	16 kA (1sec) or more
(10)	Equipment	
	➢ MCCB	3 phase 4 wires with alarm contact 400 AT 1set
	➢ Terminal	The terminal block shall be installed at suitable position which are able to connect following sizing cable ➢ PCS side: 240mm^2(4C) ➢ Existing main distribution board side: 150mm^2(4C)
	➢ Internal Wire	Necessary electric internal wires for connecting equipment inside the panel (conductors can also be used)
	➢ Earth terminal	Terminal for earthing
	➢ Other necessary equipment	Fitting materials for equipment, cable duct, insulation board, name plate, etc
(10)	Cable connection	Bottom or top of the panel
(11)	Accessories	Channel Base, Name Plate, fitting bolt nuts, etc

Table 2.25 Specification of cable terminal box (TH Ratnapura)

No	Items	Specifications
(1)	Applicable Code	IEC、JIS、JEC、JEM or equivalent
(2)	Type	Outdoor use, self-standing metal enclosed type with base plate *Front door with key handle shall be procured
(3)	Degree of protection	IP44 or more
(4)	Size	600W x 350D x 600H or less
(5)	Number of Panels	1 set

No	Items	Specifications
(6)	Color	5Y7/1
(7)	Rated voltage	400/230 V (3 phase 4 wires)
(8)	Rated Frequency	50Hz
(9)	Rated withstand current	16 kA (1sec) or more
(10)	Equipment	
	➢ Terminal or connection conductor	The terminal block shall be installed at suitable position which are able to connect following sizing cable ➢ Box-1 side: 50mm^2(4C) ➢ Blood bank distribution board side: 50～70mm^2(4C)
	➢ Earth terminal	Terminal for earthing
	➢ Other necessary equipment	Fitting materials for equipment, cable duct, insulation board, name plate, etc
(10)	Cable connection	Bottom of the panel (Countermeasure for entry of objects and small animals should be considered)

Table 2.26 Specification of cable terminal box (TH Kurunegala)

No	Items	Specifications
(1)	Applicable Code	IEC、JIS、JEC、JEM or equivalent
(2)	Type	Outdoor use, self-standing metal enclosed type with base plate *Front door with key handle shall be procured
(3)	Degree of protection	IP42 or more
(4)	Size	1,600W x 600D x 1,700H (with base) or less
(5)	Number of Panels	1 set
(6)	Color	5Y7/1
(7)	Rated voltage	400/230 V (3 phase 4 wires)
(8)	Rated Frequency	50Hz
(9)	Rated withstand current	16 kA (1sec) or more
(10)	Equipment	
	➢ Terminal or connection conductor	For 3 phase 4 wires 1 feeder The terminal block shall be installed at suitable position which are able to connect following sizing cable ➢ Low voltage distribution board side: 240mm^2(4C) ➢ Maternity distribution board side: 240mm^2(4C)
	➢ Earth terminal	Terminal for earthing
	➢ Other necessary equipment	Fitting materials for equipment, cable duct, insulation board, name plate, etc
(10)	Cable connection	Bottom of the panel (Countermeasure for entry of objects and small animals should be considered)

Table 2.27 Specification of power, control cable and others (SJGH)

DC cable and others

No	Items	Specifications
(1)	Applicable Code	IEC or equivalent
(2)	Type	XLPE insulated, PVC sheathed cable
(3)	Applicable	DC cable for PV module
(4)	Conductor	Concentric round stranded or compact round stranded
(5)	Number of conductors	Single core
(6)	Cable size and length *	*PV module～Junction Box: The cable size shall match the connector size on the PV module 1,500m x 2 (total 3,000m)

No	Items	Specifications
	$25mm^2$ or more	Junction Box x 8 ～Collecting Box x 2 125m x 2(total 250m)
	$95mm^2$ or more	Collecting Box x 2 ～PCS 230m x 2 x 2 (total 920m)
(7)	Others	All other necessary materials for cable connection

AC cable and others

No	Items	Specifications
(1)	Applicable Code	IEC,JIS or equivalent
(2)	Type	XLPE insulated, PVC sheathed cable
(3)	Conductor	Concentric round stranded or compact round stranded
(4)	Number of conductor	Four core
(5)	Cable size and length	
	$150mm^2$ or more	Low voltage distribution board～existing main distribution board 2set (total 40m)
	$240mm^2$ or more	Low voltage distribution board～PCS 2set (total 120m)
(6)	Others	All other necessary materials for cable connection

Control cable and others

No	Items	Specifications
(1)	Applicable Code	IEC,JIS or equivalent
(2)	Type of control cable	CVV-S with shield or equivalent
(3)	Type of Optical Fiber cable	Multi-mode type with tension member Core dia 50μm、Clad dia 125μm、core number 4 or more Optical fiber cable is utilized for data transmission between the Control and monitoring system and remote monitoring system, public monitor
(4)	Others	Cable terminal, optical fiber connector (SC or LC), network switch etc

Table 2.28 Specification of cabling materials (SJGH)

No	Items	Specifications
(1)	Electrical Conduit	Steel conduits(G,C), PVC pipes (VP) plastic corrugated pipes for underground cable installation or equivalent
(2)	Cable ladders or racks	Steel made ladder type racks with hot dipped galvanized or equivalent
(3)	Flexible pipe (FEP)	Plastic corrugated pipes for underground cable installation or equivalent
(4)	Materials for connection of existing main distribution board	Connect the cables from the new low-voltage distribution board to the busbars of the Emergency Power Control Board 1 and Emergency Power Control Board 2 boards that are part of the existing main distribution board (manufactured in the early 1980s by Toshiba). Concretely, the copper bus conductor is connected using the bolt-nut, connecting the part with the electric wire in the board. Prepare branch conductors (copper) for easy connection of cable end terminals
(5)	Others	Pull box, connection materials for conduit and ladder, support, sealed, cable lashing materials, sticker etc

Table 2.29 Specification of power, control cable and others (TH Ratnapura)

DC cable and others

No	Items	Specifications
(1)	Applicable Code	IEC or equivalent
(2)	Type	XLPE insulated, PVC sheathed cable
(3)	Applicable	DC cable for PV module
(4)	Conductor	Concentric round stranded or compact round stranded
(5)	Number of conductors	Single core
(6)	Cable size and length	
	*	*PV module～Junction Box: The cable size shall match the connector size on the PV module A&E building: 140m x 2 (total 280m) Blood bank: 150m x2 (total 300m) JICA building: 820m x 2 (total 1,640m)
	35mm^2 or more	【JICA building】 Junction Box x 6 ～Collecting Box x 2 95m x 2(total 190m)
	50mm^2 or more	【Blood bank】 Junction Box x 1 ～PCS 300m x 2(total 600m)
	70mm^2 or more	【A&E building】 Junction Box x 1 ～PCS 400m x 2(total 800m) 【JICA building】 Collecting Box x 2 ～ PCS 600m x 2(total 1200m)
(7)	Others	All other necessary materials for cable connection

AC cable and others

No	Items	Specifications
(1)	Applicable Code	IEC,JIS or equivalent
(2)	Type	XLPE insulated, PVC sheathed cable
(3)	Conductor	Concentric round stranded or compact round stranded
(4)	Number of conductor	Four core
(5)	Cable size and length	
	50mm^2 or more	Box-1～terminal box 10m
	150mm^2 or more	PCS(A&E, Blood bank)～Box-1 280m
	185mm^2 or more	PCS(JICA)～Box-2 2set total 700m
(6)	Others	All other necessary materials for cable connection

Control cable and others

No	Items	Specifications
(1)	Applicable Code	IEC,JIS or equivalent
(2)	Type of control cable	CVV-S with shield or equivalent
(3)	Type of Optical Fiber cable	Multi-mode type with tension member Core dia 50μm、Clad dia 125μm、core number 4 or more Optical fiber cable is utilized for data transmission between the Control and monitoring system and remote monitoring system, public monitor
(4)	Others	Cable terminal, optical fiber connector (SC or LC), network switch etc

Table 2.30 Specification of cabling materials (TH Ratnapura)

No	Items	Specifications
(1)	Electrical Conduit	Steel conduits(G,C), PVC pipes (VP) plastic corrugated pipes for underground cable installation or equivalent

No	Items	Specifications
(2)	Cable ladders or racks	Steel made ladder type racks with hot dipped galvanized or equivalent
(3)	Flexible pipe (FEP)	Plastic corrugated pipes for underground cable installation or equivalent
(4)	Distribution pole	Concrete pole length 12m PCS～existing diesel generator room
(5)	Others	Messenger wire (overhead line), supporting wire for pole, pull box, connection materials for conduit and ladder, support, sealed, cable lashing materials, sticker etc

Table 2.31 Specification of power, control cable and others (TH Kurunegala)

DC cable and others

No	Items	Specifications
(1)	Applicable Code	IEC or equivalent
(2)	Type	XLPE insulated, PVC sheathed cable
(3)	Applicable	DC cable for PV module
(4)	Conductor	Concentric round stranded or compact round stranded
(5)	Number of conductors	Single core
(6)	Cable size and length	
	*	*PV module～Junction Box: The cable size shall match the connector size on the PV module 1,600m x 2 (3,200m)
	70mm^2 or more	Junction box x 1～PCS(100kW) 240m x 2 (480m) Junction box x 3～PCS(200kW) 610m x 2 (1,220m)
(7)	Others	All other necessary materials for cable connection

AC cable and others

No	Items	Specifications
(1)	Applicable Code	IEC,JIS or equivalent
(2)	Type	XLPE insulated, PVC sheathed cable
(3)	Conductor	Concentric round stranded or compact round stranded *Armored cable shall be applied for direct buried cable
(4)	Number of conductor	Four core
(5)	Cable size and length	
	120mm^2 or more	PCS～Low voltage distribution board at maternity building BF 160m
	150mm^2 or more	Low voltage distribution box ～Main system existing distribution board 20m
	240mm^2 or more	PCS～Low voltage distribution box 220m Low voltage distribution board ～terminal box 50m
(6)	Others	All other necessary materials for cable connection

Control cable and others

No	Items	Specifications
(1)	Applicable Code	IEC,JIS or equivalent
(2)	Type of control cable	CVV-S with shield or equivalent
(3)	Type of Optical Fiber cable	Multi-mode type with tension member Core dia 50μm、Clad dia 125μm、core number 4 or more Optical fiber cable is utilized for data transmission between the Control and monitoring system and remote monitoring system, public monitor

No	Items	Specifications
(4)	Others	Cable terminal, optical fiber connector (SC or LC), network switch etc

Table 2.32 Specification of cabling materials (TH Kurunegala)

No	Items	Specifications
(1)	Electrical Conduit	Steel conduits(G,C), PVC pipes (VP) plastic corrugated pipes for underground cable installation or equivalent
(2)	Cable ladders or racks	Steel made ladder type racks with hot dipped galvanized or equivalent *For Maternity building BF, bottoms of PCS container
(3)	Flexible pipe (FEP)	Plastic corrugated pipes for underground cable installation or equivalent *For outdoor crossing part and buried route
(4)	Others	Messenger wire (overhead line), supporting wire for pole, pull box, connection materials for conduit and ladder, support, sealed, cable lashing materials, sticker etc

Table 2.33 Specification of Earthing materials

No	Items	Specifications
(1)	Earthing method	The earthing for container consisting of mesh and ground rod
(2)	Earth resistance	10 Ω or less (Interconnection with existing ground system shall be considered)
(3)	Materials	
	Earthing conductor and wires	Stranded bare copper wire for underground
	Earthing cable with sheath	PVC insulated wires
	Earthing rod	Coupling type copper clad steel rods
	Earthing materials	Compressed connectors or bolt connectors or equivalent
	Mast for lightning rod	Lightning rod and its fixing materials, lighting fixtures and their wiring materials and other necessary materials *Along with the installation of solar panels, lightning rods will be installed to prevent deviation from the existing lightning protection range.
	Earthing conductor	Earthing conductor, wire, wiring materials and connector
(4)	Others	Terminals and other necessary materials

Note) Lightning rod and earthing conductor shall be procured for TH Ratnapura and Kulunegala

Table 2.34 Specification of Fire detection system

No	Items	Specifications
(1)	Fire detector	
	Applicable code	IEC,JIS or equivalent
	Type	Smoke detected type
	Number of detector	4 set (TH Ratnapura) 2 set (SJGH, TH Kurunegala)
	Accessories	Necessary fitting materials
(2)	Fire alarm panel	
	Applicable code	IEC,JIS or equivalent
	Type	The panel receives fire signal from the container, alarm fire fault, and outputs the signal to remote monitoring system
	Number of panel	2 set (TH Ratnapura) 1 set (SJGH, TH Kurunegala)

No	Items	Specifications
	Accessories	Necessary fitting materials

2-2-2-2 Basic Plan (Facility plan)

(1) Site survey and target roof selection process

For the three candidate buildings of the three hospitals initially targeted, a survey flow was prepared based on the viewpoints shown in Table 2.35 and the target buildings were selected after the survey.

Table 2.35 Viewpoints of Investigation and Decision Items in Target Building Selection

Survey parts and Viewpoints	Evaluation Item
Exterior view of the building	Check for unusual cracks in the building frame (exterior walls, beams, floors), check for building settlement, and check for cracks in the surrounding retaining walls.
Building Roof	Degree of damage and deterioration
Inside of the building	Checking attic conditions, whether there are any leaks, and whether the lower floor is affected during the construction of solar panels.
Obtain existing drawings	Buildings for which drawings are not available at all shall be excluded. However, if some are not available, a decision will be made based on the condition of the existing building.

[Source] JICA Survey Team

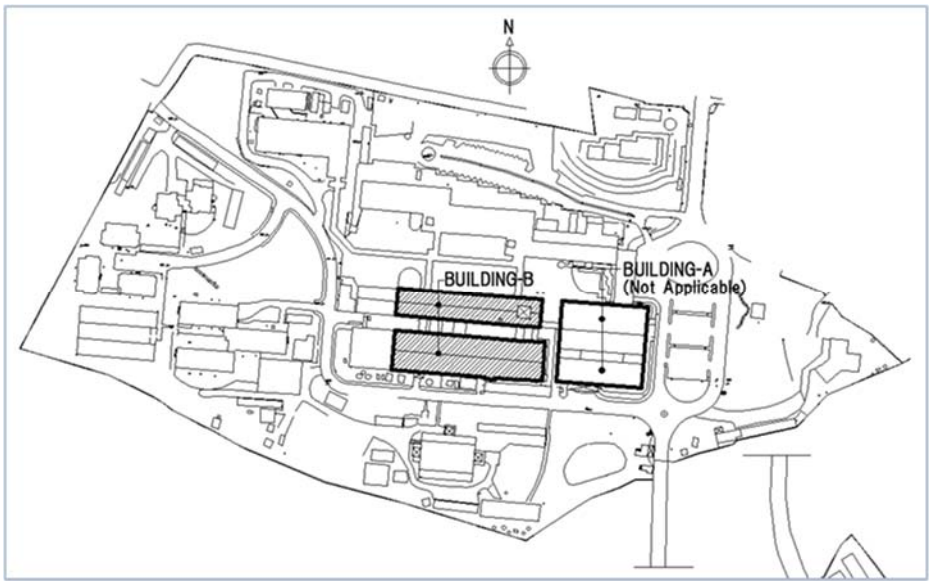
1) Sri Jayawardenapura General Hospital

Solar panels will be installed on the roof of Building B of the main building, which was constructed about 40 years ago with Japan's grant aid. The roof of the main building has a tile roof over a slate roof, but because it is difficult to fix the solar panels on the tiles, and many roof tiles are broken, the roof tiles will be removed, a new metal folded-plate roofing system will be installed, and the solar panels will be installed on top of the roof. Since the roof tiles will be removed, there will be no increase in the load on the roof with the metal-folded roofing and solar panels.

According to the plans at the time of construction, the slate roof contained asbestos, so no work was done to the slate roof, and the existing holes were used to secure the bolts for mounting the metal folded-plate roof and solar panels to the main roof of the building. In addition, a very small portion of the Building B slate was cracked and some evidence of leakage was observed, but the lower concrete slab did not affect the lower floor at all. A new metal folded-plate roof covering over the top of the slate roof will be used to prevent leaks.

The roof of Building A was also investigated as a candidate for the installation of solar panels. The roof of Building A was excluded from the solar panel installation because it has a different structure, with a suspended ceiling (no concrete ceiling), which makes it difficult to use the rooms on the floor below during construction, and because it is currently leaking, making it difficult to determine the original condition of the roof repair after the work is completed.

The container (approx. 12 m x 3 m) for storing the power conditioner to be placed on the site where the container is used as a temporary material storage area has been removed.



[Source] JICA Survey Team

Figure 2.13 Hospital site plan (SJGH)

Table 2.36 Solar Power System Generation Output of SJGH

Priority	Building	Capacity
A	Building B	443kW
—	Building A	-

[Source] JICA Surevey Team

Since the Sri Jayawardenapura General Hospital will have a metal folded-plate roof after the removal of roof tiles, we investigated the compressive strength of concrete using a Schmidt hammer to determine the degree of structural deterioration and the need for reinforcement of the concrete columns at the rear of the shed in Building B. In addition, as a preliminary investigation, we also measured the bundle columns for the machine foundation on the roof of Building B and the beams at the rear of the shed in Building A. We measured the compressive strength of the concrete columns at three locations. In addition, as a preliminary investigation, measurements were also taken at three locations on the roof of Building B, on the bundle columns for the machine foundation, and on the beams at the rear of Building A. The results are shown in Table 2.37 (see end of this report for detailed data). As mentioned earlier, Building A was not included in the study because of its difficulty in construction, but its concrete strength was also inferior to that of Building B. The expected strength of Building B was confirmed, and it was confirmed that Building B was suitable for selection.

Table 2.37 Results of concrete compressive strength test of SJGH

Test Building Name	Building B	Building B	Building A
Survey Parts	Rooftop bundle post	Bundle post of attic	Beam of attic
Estimated Compression Strength (Architectural Institute of Japan Type)	30.0 N/mm^2	27.5 N/mm^2	23.1N/mm^2

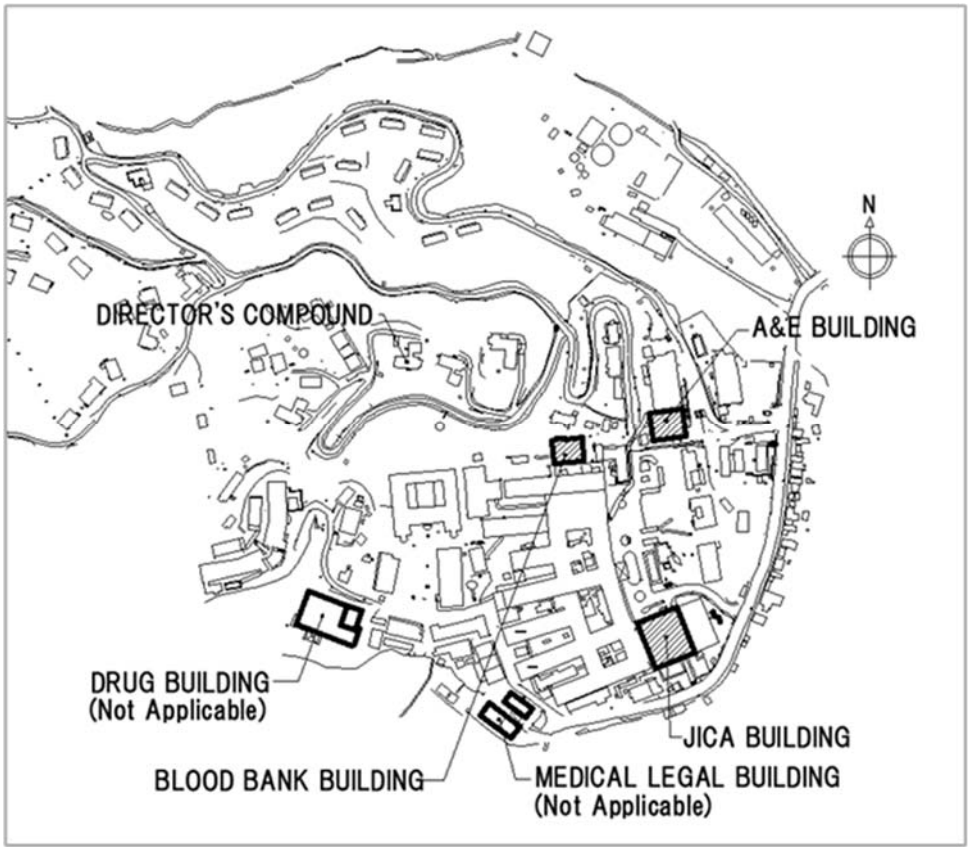
[Source] JICA Surevey Team

2) TH Ratnapura

Solar panels will be installed on the roofs of the main building (commonly known as the JICA building), the Accident and Emergency Medical Services Building, and the Blood Bank Building, which were constructed approximately 20 years ago with Japanese grant assistance. The Medical and Legal Building, which was considered at the time of the survey, was not included because the trusses in the attic were made of wood and their strength could not be confirmed. The drug storage building was not included because structural drawings were not available and because the long distance from the JICA building causes significant voltage drop and power distribution loss.

The container (approx. 12 m x 3 m) that stores the power conditioners will be installed in two separate locations

because the distance between the JICA building and the blood bank and Accident and Emergency Rescue building is too far apart to be suitable for condensation in terms of line loss and voltage drop.



[Source] JICA Survey Team

Figure 2.14 Site plan of the hospital (TH Ratnapura)

Table 2.38 Photovoltaic System Generation Output of TH Ratnapura

Priority	Bulding	Capacity
A	JICA Building	184kW
A	A&E Building	37kW
B	Blood Bank Building	30kW
—	Leagal Building	—
—	Drug Storage Building	—

[Source] JICA Survey Team

The roof of the JICA building, the subject building, has an asphalt shingle roofing with a ventilation layer directly below the asphalt shingle roofing and a concrete roof slab below this. Although the asphalt shingle roofing was not visually deteriorated or damaged, there was a high possibility that the screws used to install the solar panels would induce cracks or penetrate the ventilation layer. Therefore, the plan was to avoid mounting the solar panels directly on the existing roof by constructing a beam assembly to carry the solar panels on the top along the slope of the roof.

The existing metal folded-plate roofs of the A&E Building and Blood Bank Building will be painted and solar panels will be installed due to the deterioration of the painted surfaces.

The Schmidt hammer test was not conducted due to the lack of a safe place to conduct the test. Concrete strength was investigated based on existing drawings and documents only, taking into consideration that the JICA building will have a new beam assembly as described above, and that A&E Building and Blood Bank Buildings will have a steel frame purlin assembly.

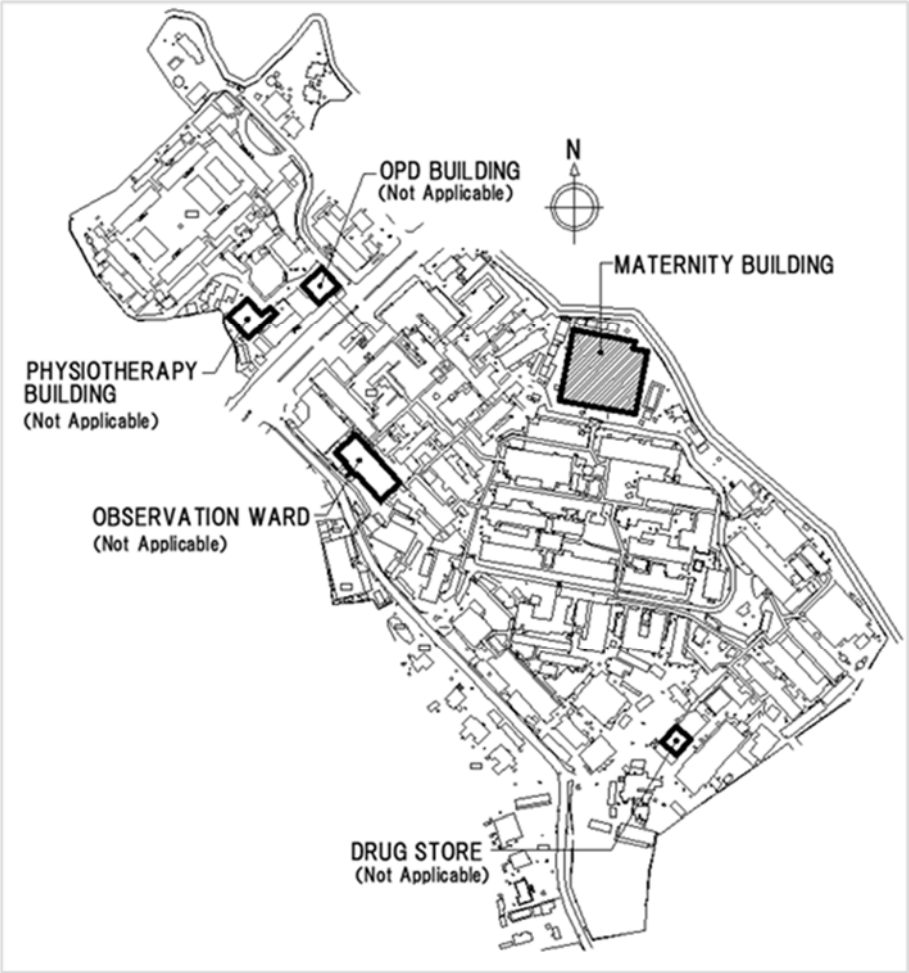
3) TH Kurunegala

The solar panels will be installed on the roof of Maternity Ward, which was completed in 2019. The roof is metal-

folded, so there are no obstacles to fixing the solar panels. Since this is a new building, structural drawings and other plans are available and can be evaluated structurally.

The hospital has requested the installation of solar panels on the roof of the Observation Ward, which is currently under construction. This building was to be an addition to the third through fifth floors of an existing two-story building. However, since no structural drawings of the existing building were submitted, the hospital was unable to confirm the structure of the building and decided to exclude the building from the project.

The hospital has agreed with the company that the container (approx. 12 m x 3 m) that will store the power conditioner will be placed on the site where the incinerator, which is currently not in use, was removed.



[Source] JICA Survey Team

Figure 2.15 Hospital Site Plan (TH Kurunegala)

Table 2.39 Photovoltaic System Generation Output of TH Kurunegala

Priority	Building	Capacity
A	Maternity Ward	240kW
-	Observation Ward	-
-	Outpatient Ward	-
-	Physical Therapy Building	-
-	Drug Storage Building	-

[Source] JICA Survey Team

On the roof of Maternity Ward, the compressive strength of the concrete was measured using a Schmidt hammer to determine the degree of structural deterioration and the need for reinforcement. In addition, a preliminary investigation was conducted at two other locations, including a large beam on the second floor of Observation Ward. The results

are shown in Table 2.40 (see Appendix for detailed data). As mentioned above, the Observation Ward was constructed as a two-story building with a planned addition above it, and was not included in the scope of this study because its frame was not designed for a five-story building, but its concrete strength was also inferior to that of the Observation Ward. The obstetrics ward was confirmed to have the expected strength and was suitable for the selection.

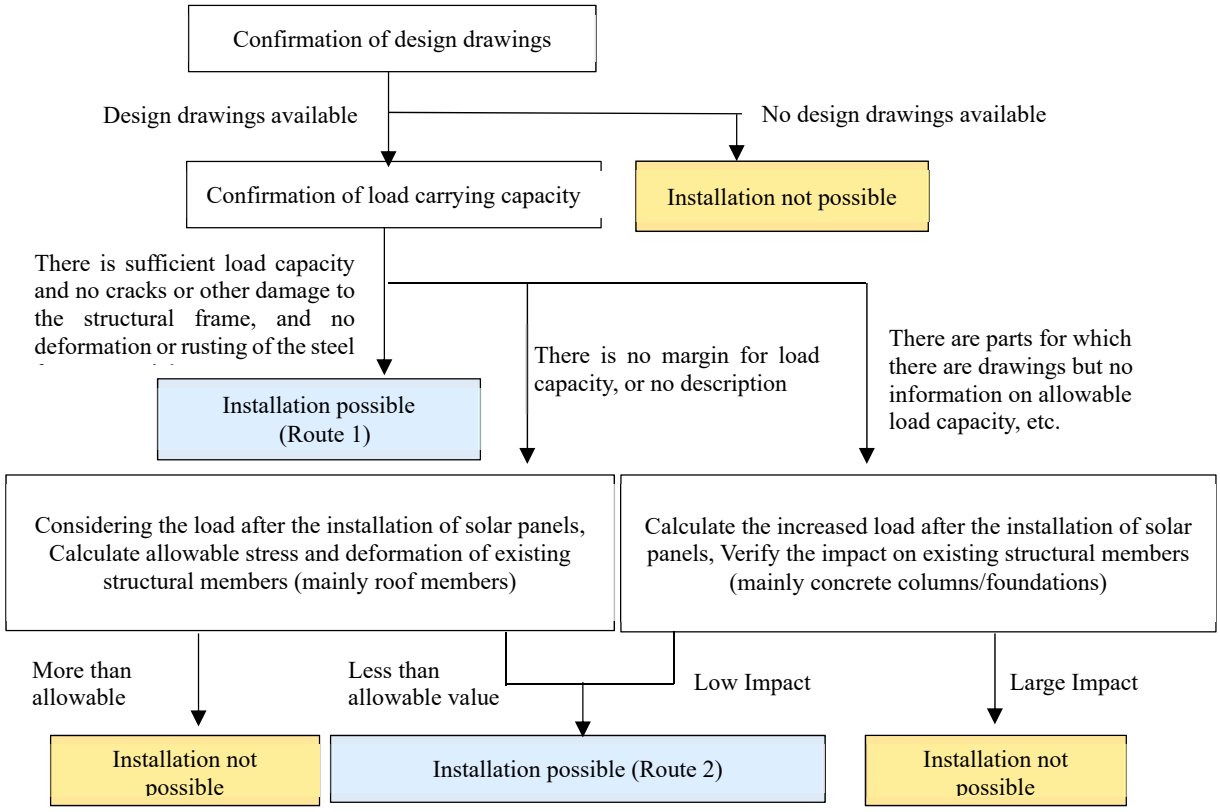
Table 2.40 Results of concrete compressive strength measurements for TH Kurunegala

Test Building Name	Maternity Ward	Observation Ward
Survey Parts	Rooftop Bundle Post	Beam
Estimated Compression Strength (Architectural Institute of Japan Type)	26.7 N/mm^2	23.2 N/mm^2

(2) Confirmation of building structural strength

1) Verification method

This verification is to check the strength of existing structures where solar panels are planned to be installed, based on the design documents, structural calculation documents and field survey results. Since many of the buildings are old and the structural design documents at the time of design are not sufficient, the verification will be conducted using the flowchart shown below.

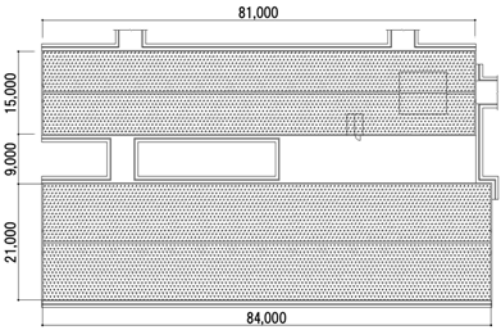


[Source] JICA Survey Team

Figure 2.16 Structural Strength Verification Flow

2) Structural evaluation of Sri Jayawardenapura General Hospital / Building B

(i) Outline of existing buildings



Roof Plan

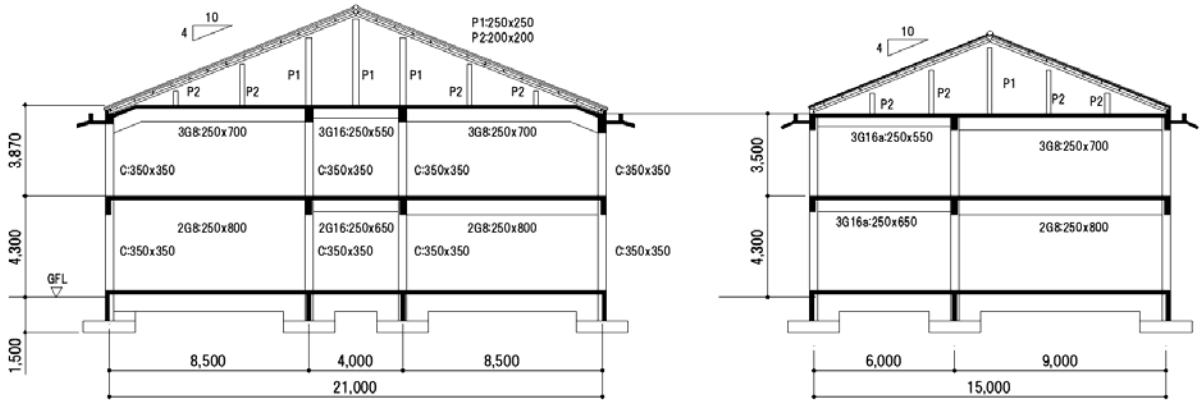


Exterior view of roof



Inside of the roof

Figure 2.17 Existing roof plan of solar panel and photographs



[Source] JICA Survey Team

Figure 2.18 Cross-section of building (Block B)

This building is a general hospital building constructed with Japanese grant aid and completed in 1983 (about 40 years ago). It is a two-story reinforced concrete structure. The first and second floors are hospital-related rooms, but the attic of the second floor is separated by a concrete slab and serves as a storage area for air conditioning units and ducts. The roof is made of steel beams and steel purlin with corrugated slates and roof tiles on top.

(ii) Structural design conditions obtained from existing design drawings.

Table 2.41 Structural Design Conditions Obtained from Existing Design Drawings (Block-B)

Structure / Number of floors	Reinforced concrete, 1 story above ground	
Concrete strength	Fc28=25N/mm^2	
Rebar strength	SD345	
Steel frame	SSC400	
Foundation design strength	20t/m^2	
Accumulated Load	Room Name	Accumulated Load
	Roof	76.5kg/m^2
	Waiting room	408kg/m^2
	Hospital room	204kg/m^2
	Office	255kg/m^2
	Corridors and stairwells	305kg/m^2
Wind load	Basic wind speed: 33.5 m/sec Wind pressure: 63.4 kg/m^2	
Seismic load	None	

Although no structural calculations were kept for this facility, drawings of the existing building were kept in relatively good condition, which allowed us to confirm the structural properties of the existing structure from the drawings.

(iii) Structural strength verification results

The roof of the facility is composed of corrugated slate overlaid with roof tiles. Since the roof tiles have been cracked and peeled off over a wide area after about 40 years of construction, it would be difficult to repair the roof tiles due to future deterioration if solar panels are installed on the existing roof. In addition, due to the difficulty of the solar panel installation work, the plan was to leave the corrugated slate, remove the roof tiles, and install a new steel folded-plate roof. In terms of weight, the weight of the new folded-plate roof and solar panels is approximately 25.0 kg/m^2 compared to the weight of the removed roof tiles (approximately 23.0 kg/m^2). Although this is a slight increase, it was determined that it would not affect the existing steel beams supporting the roof or the structural strength. Therefore,

A) There is sufficient margin for the loading capacity.

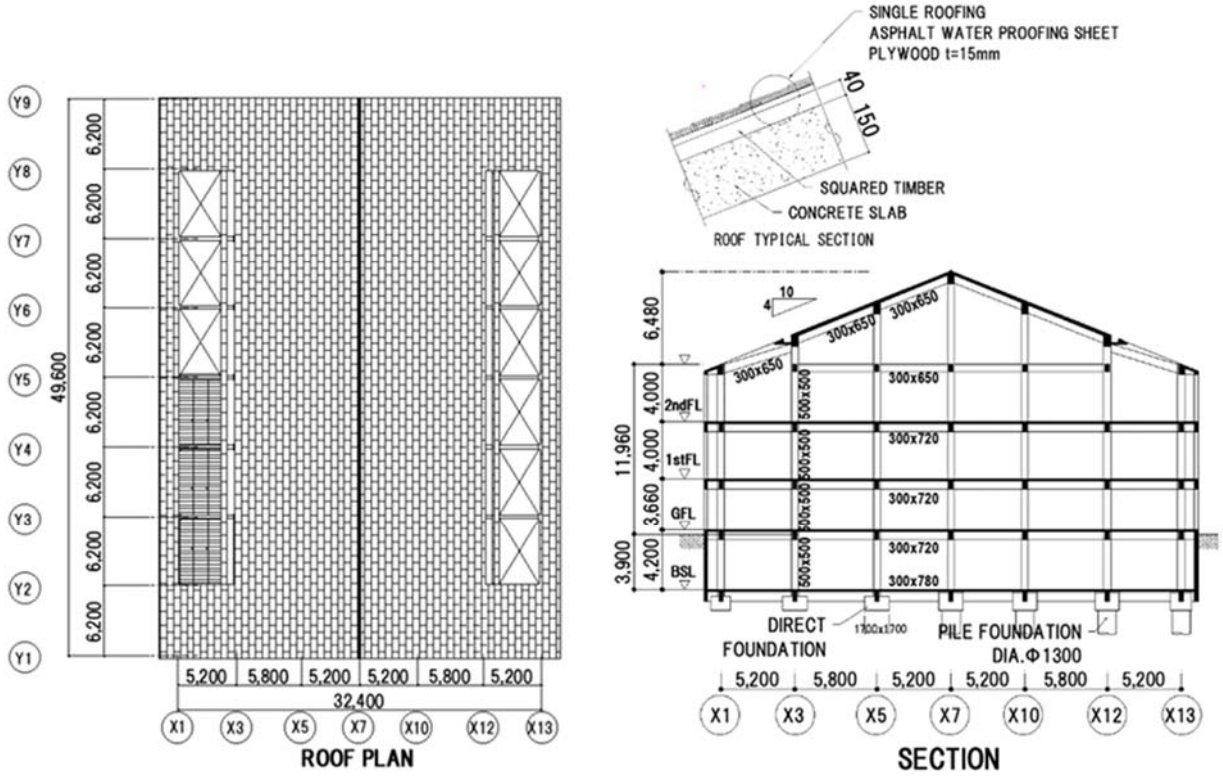
B) Concrete strength confirmed using schmidt hammer test is above the design strength, and there are no cracks or other damage to the structural frame.

C) There is no deformation or rusting of the roof steel frame material, and there are no problems with the condition of bolted joints.

Based on the above reasons, it was judged that "solar panels can be installed" using the verification method in route 1.

3) Structural Evaluation for JICA Building of TH Ratnapura

(i) Outline of Existing Building



[Source] JICA Survey Team

Figure 2.19 Roof plan and building cross section (Ratnapura JICA Building)

This building was constructed with Japanese grant aid and built in 2003 (about 20 years ago). The foundation is a combination of direct foundations and pile foundations. Since the building wasconstructed on a sloping site, it is assumed that pile foundations were used for the areas that would be filled during land development, and direct foundations were used for the areas that would be cut into the ground. The hospital is always in operation and there is no open space around the building, and the topographical constraints make it difficult to use heavy construction equipment such as cranes. As for the building design documents, some of the design drawings were missing, and the structural calculations were not stored, but the structural drawings were stored in relatively good condition.

(ii) Structural design conditions obtained from the existing design drawings and the original basic design survey report at that time.

Table 2.42 Structural Design Conditions Obtained from The Existing Design Drawings and The Original Basic Design Survey Report at the Time (Ratnapura JICA Building)

Structure / Number of floors	Reinforced concrete, 1 basement floor, 3 above-ground floors	
Concrete strength	Foundation: Fc28=24 N/mm^2 Above-ground part: Fc28=21 N/mm^2	
Rebar strength	JIS SD345/ SD295 equivalent	
Foundation type	On-site concrete pile foundation (3 types of pile diameter: 900/1100/1350mm) and direct foundation	
Pile bearing capacity	Diameter 900mm	125 ton（1225 kN）
	Diameter 1100mm	195 ton（1920 kN）
	Diameter 1350mm	282 ton（2763 kN）
Design capacity of direct foundation	100 ton/m2 (980 kPa)	
Roof specification	Over concrete slab, 4.0 cm square timber + 15 mm structural plywood + asphalt waterproofing layer + single roofing	
Live load	Room name	Live load
	Operating rooms, examination rooms, consultation rooms	300 kg/m^2
	X-ray examination room	400 kg/m^2
	Book storage warehouse	500 kg/m^2
	Corridor	180 kg/m^2
Wind load	Standard wind speed -33.5 m/sec (From the outline design study report)	
Wind load	None	

(iii) Structural strength verification results

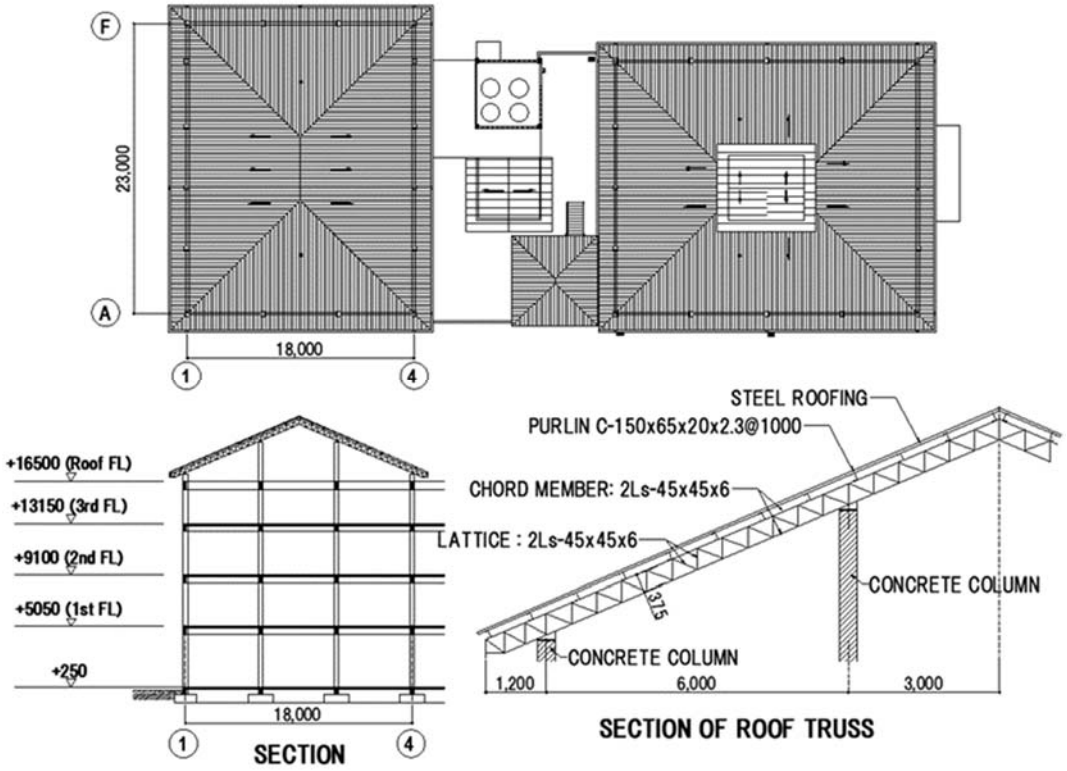
Since the value of the roof live load was unclear, structural calculations were performed to verify safety when solar panels were loaded. The results are shown in Table 2.43. Since it was confirmed that there were no problems with the bearing capacity of the concrete roof frame and foundation, it was judged that the solar panels could be installed.

Table 2.43 Results of structural strength verification of TH Ratnapura/JICA Building

Existing Structural Specification		Margin of the existing structural capacity when solar panels are loaded		Judgment
Roof slab	Concreate strength: 21 N/mm^2	Amount of rebar	209%	Within tolerance, OK
	Slab thickness: 150 mm			
	Rebar: D10・D12@200			
Beam of roof concreate	Concreate strength: 21 N/mm^2	Amount of rebar	128%	Within tolerance, OK
	Cross sectional dimensions: 30 x 55cm Main rebar: 3 - D22			
	Stirrup: D10@200	Shear strength	161%	Within tolerance, OK
Foundation	Concreate strength: 24 N/mm^2	Ground pressure	113%	Within tolerance, OK
	Design bearing capacity: 100 t/m^2			

4) A&E Building of TH Ratnapura

(i) Outline of Existing Building



[Source] JICA Survey Team

Figure 2.20 Roof plan and building cross section (Ratnapura A&E Building)

The building is relatively new, constructed in 2012 (about 10 years ago). The building has two roofs, and solar panels will be installed on the south roof, which has no roof shed. The steel trusses on the four-story reinforced concrete structure support the steel folded plate of the roof. General design drawings of the existing building and some structural drawings were kept, but no structural calculations were kept.

(ii) Structural design conditions obtained from existing design drawings

Table 2.44 Structural Design Conditions Obtained from Existing Design Drawings（Ratnapura A&E Building）

Structure / Number of floors	Reinforced concrete, 4 stories
Concrete strength	Fc28=25 N/mm^2 (GRADE25)
Rebar strength	Deformed rebar 460N/mm^2 / Round steel bar 250N/mm^2
Steel frame	GRADE 43/ Yeild Strength 275N/mm^2
Foundation type	Direct foundation (allowable endurance: unknown)
Roof specification	Insulation + folded plates over steel truss structure
Live load	Unknown

(iii) Structural strength verification results

Since the value of the load capacity of the roof was unknown, structural calculations were performed for the steel trusses to verify safety when loaded with solar panels. The allowable bearing capacity of the foundation was unknown, but the size and type of the foundation were specified in the drawings, so the impact of the weight of the solar panels on the strength was calculated and safety was verified. The results are shown in Table 2.45. Since it was confirmed that there were no problems with the

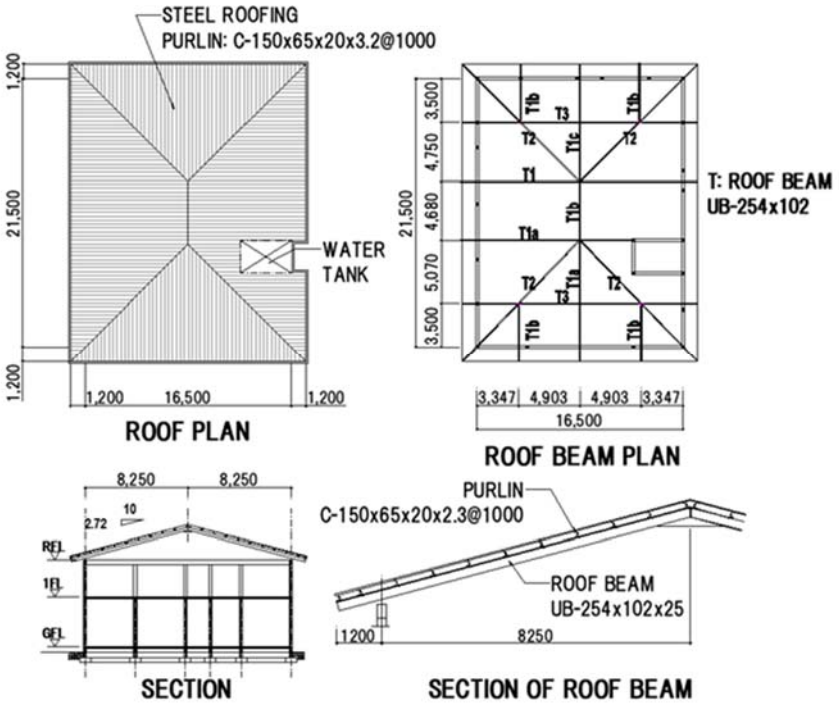
bearing capacity of the roof trusses, the concrete frame, and the foundation, it was judged that the solar panels could be installed.

Table 2.45 Results of structural strength verification for A&E Building of TH Ratnapura

Existing Structural Specification		Margin of the existing structural capacity when solar panels are loaded			Judgment
Roof steel frame	Truss string 2Ls-45x45x6	Structural Strength	Usual	460 %	OK
			Short term (during construction)	360 %	OK
		Amount of deformation	Usual	0.3 cm (L/2000)	OK
			Short term (during construction)	0.5 cm (L/1200)	OK
	Truss lattice 2L-45x45x6	Structural Strength	Usual	1200 %	OK
			Short term (during construction)	900 %	OK
	Purlin C-150x65x20x2.3	Structural Strength	Usual	240 %	OK
			Short term (during construction)	160 %	OK
		Amount of deformation	Usual	3.4 mm (L/1400)	OK
			Short term (during construction)	4.0 mm (L/1200)	OK
Column concreate	Column size: 35 x 35 cm / Concrete strength: 25 N/mm2 / Main rebar: 8-D20 / upper 8-D16				OK
	The roof trusses are supported by columns and have no effect on the beams. When solar panels are installed, the maximum increase per column is 7.0 kN, but this is a slight increase of 0.2% in compressive stress and does not affect the structural strength of the columns at all.				
Foundation	Since the design ground bearing capacity is unknown, it is determined from the percentage increase in ground pressure when solar panels are installed. The maximum increase per foundation would be 7.0 kN, but since the size of the foundation is 2.0 m x 2.0 m, the ground pressure would increase by 3.2 kN/m2. Since the ground bearing capacity of the Blood Bank Building on the same site is 100 kN/m2, we conclude that this is not a problem.				OK

5) Blood Bank Building of TH Ratnapura

(i) Outline of Existing Building



[Source] JICA Survey Team

Figure 2.21 Roof Plan and Building Cross Section (Ratnapura Blood Bank Building)

This building was constructed around 2005 (about 18 years ago), and although some of the design and structural drawings were kept, the structural calculations were not. The building is a two-story reinforced concrete structure with a purlin roof over steel trusses, insulation and steel folded plates. The reinforced concrete is not a rigid-frame structure as the columns are not aligned. The foundation is a direct foundation with gravel under the ground beams.

(ii) Structural design conditions obtained from existing design drawings

Table 2.46 Structural Design Conditions Obtained from The Existing Design Drawings (Ratnapura Blood Bank Building)

Structure / Number of floors	Reinforced concrete, 2 stories
Concrete strength	Assumed Fc28 = 21 N/mm^2 due to unknown
Rebar strength	Assumed deformed steel bar 460 N/mm^2 / Round steel bar 250 N/mm^2 due to unknown
Steel frame	UB-254x102x25 GRADE 43/ Yeild Strength 275N/mm^2
Foundation type	Direct foundation (allowable capacity: 100 kN/m^2)
Roof specification	Above steel beam, insulation + folded plates
Roof live load	Unknown

(iii) Structural strength verification results

For this facility, only a portion of the drawings of the existing building were kept. Concrete strength, reinforcing bars, loading capacity, and other details are unknown. Since the drawings and materials used for the steel frame material of the roof were clearly indicated, strength calculations were performed to confirm safety, taking into account the weight of the solar panels. Since the materials used for the reinforced concrete sections were unknown, verification was conducted assuming Fc28=21N/mm^2, which is the strength of concrete normally adopted. Moreover, given the materials

used for the reinforcing bars were also unknown, the verification was conducted based on the assumption that the deformed bars were 460 N/mm^2, using other buildings as a reference. Finally, since the size and allowable ground bearing capacity of the foundation were specified, we calculated the impact of the weight of the solar panels on the strength of the foundation and verified its safety. The results are shown in Table 2.47. Since it was confirmed that there were no problems with the bearing capacity of the roof trusses, the concrete frame, and the foundation, it was judged that the solar panels could be installed.

Table 2.47 Results of structural strength verification for Blood Bank Building of TH Ratnapura

<table>
<tr><th colspan="2">Existing Structural Specification</th><th colspan="3">Margin of the existing structural capacity when solar panels are loaded</th><th>Judgment</th></tr>
<tr><td rowspan="6">Roof steel frame</td><td rowspan="3">Main materials
UB-254x102</td><td rowspan="2">Structural Strength</td><td>Usual</td><td>200 %</td><td>OK</td></tr>
<tr><td>Short term (during construction)</td><td>180 %</td><td>OK</td></tr>
<tr><td rowspan="2">Amount of deformation</td><td>Usual</td><td>1.2 cm (L/1400)</td><td>OK</td></tr>
<tr><td>Short term (during construction)</td><td>2.4 cm (L/700)</td><td>OK</td></tr>
<tr><td rowspan="4">Purlin
C-150x65x20x3.2</td><td rowspan="2">Structural Strength</td><td>Usual</td><td>240 %</td><td>OK</td></tr>
<tr><td>Short term (during construction)</td><td>160 %</td><td>OK</td></tr>
<tr><td rowspan="2">Amount of deformation</td><td>Usual</td><td>3.4 mm (L/1400)</td><td>OK</td></tr>
<tr><td>Short term (during construction)</td><td>4.0 mm (L/1200)</td><td>OK</td></tr>
<tr><td rowspan="2">Column concreat</td><td colspan="4">Column size: 22.5 x 22.5 cm / Concreat strength: 21 N/mm^2</td><td rowspan="2">OK</td></tr>
<tr><td colspan="4">The roof truss is supported by 20 posts in the perimeter. When solar panels are installed, the maximum increase per column is 1.0 kN, but the compressive stress is a slight increase of approximately 0.3%, which does not affect the structural strength of the columns at all, and is therefore considered to be within the allowable range.</td></tr>
<tr><td>Foundation</td><td colspan="4">Since the design ground bearing capacity is unknown, it is determined from the rate of increase in ground pressure when solar panels are installed. The maximum increase would be 1.0 kN per foundation. Since the size of the foundation is 0.9mx0.9m, the ground pressure will increase by about 1.2kN/m^2. However, since the allowable ground bearing capacity is 100KN/m^2, an increase of about 1.2% is considered within the allowable range.</td><td>OK</td></tr>
</table>

6) Maternity ward of TH Kurunegala

(i) Outline of Existing Building

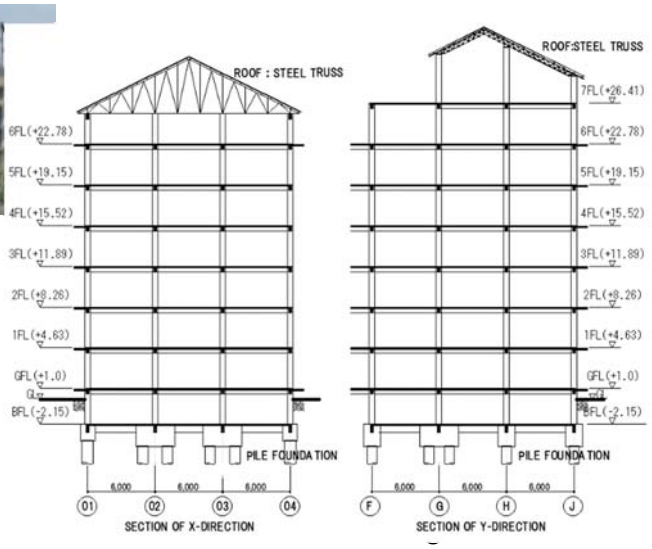


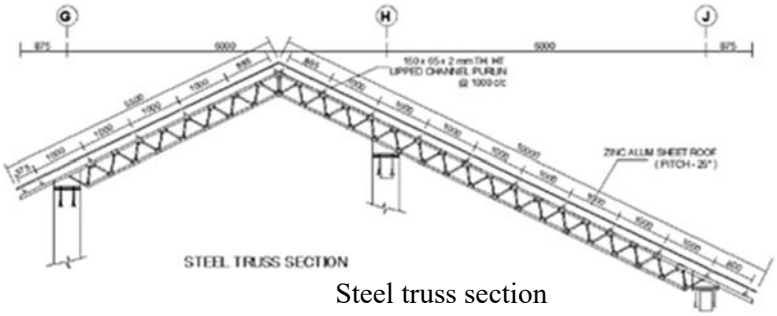


Roof Steel Folded



Steel truss and roof





Steel truss section

[Source] JICA Survey Team

Figure 2.22 Exterior and Interior Photographs, Building Cross Section and Truss Section (Kurunegala Maternity Building)

This building is a new building constructed in 2019. It is a reinforced concrete structure with one basement floor and seven above-ground floors (partially eight floors), the foundation is cast-in-place piles, and the roof is finished with insulation + steel folded plates over steel trusses. Only a part of the design drawings and a part of the structural drawings were kept, and no structural calculation sheet was kept. No cracks or other defects were found in the concrete, and a proof stress test was conducted using a Schmidt hammer, which confirmed that the concrete was above the design strength. The reinforcement drawings show that the building is of good quality with sufficient reinforcement.

(ii) Structural design conditions obtained from existing design drawings

Table 2.48 Structural Design Conditions Obtained from The Existing Design Drawings (Kurunegala Maternity Building)

Structure / Number of floors	Reinforced concrete structure, 7 floors above ground and 1 basement floor (partially 8 floors)
Concrete strength	Fc28 = 30 N/mm^2
Rebar strength	GRADE 460（BS4449 or BS4481）
Foundation type	On-site cast-in-place concrete pile foundation (pile diameter: 750/900/1000 mm, pile length: 10.0 m to 15.0 m); pile bearing capacity is unknown
Roof specification	Lightweight steel purlin on steel truss beams, finished with insulation + folded plates
Roof live load	Unknown

(iii) Structural strength verification results

Although some drawings of the existing building were kept for this facility, the structural calculations were not kept. Since the load carrying capacity of the roof was unknown, strength calculations wereperformed for the roof steel trusses to account for the weight of the solar panels, and it was confirmed that both member strength and deflection were within the allowable values. Since the roof trusses areall supported by concrete columns, we calculated the increased load due to the solar panels and confirmed that it would not affect the strength of the columns. In addition, the foundations are pile foundations, and although the pile capacities were not listed, it was confirmed that the increased load due to the solar panels did not affect the pile capacities. The results are shown in Table 2.49. Since it was confirmed that there were no problems with the bearing capacity of the roof trusses, concrete frame, and foundation, the building was judged to be "ready for solar panel installation.

Table 2.49 Structural Strength Verification Results for Maternity Building of TH Kurunegala

<table>
<tr><th colspan="2">Existing Structural Specification</th><th colspan="3">Margin of the existing structural capacity when solar panels are loaded</th><th>Judgment</th></tr>
<tr><td rowspan="8">Roof steel frame
Column concreat</td><td rowspan="4">Roof trusses
chord member</td><td rowspan="2">Structural Strength</td><td>Usual</td><td>300 %</td><td>OK</td></tr>
<tr><td>Short term (during construction)</td><td>200 %</td><td>OK</td></tr>
<tr><td rowspan="2">Amount of deformation</td><td>Usual</td><td>0.2 cm (L/4000)</td><td>OK</td></tr>
<tr><td>Short term (during construction)</td><td>0.4 cm (L/2000)</td><td>OK</td></tr>
<tr><td rowspan="2">Roof trusses
Lattice membar</td><td rowspan="2">Structural Strength</td><td>Usual</td><td>210 %</td><td>OK</td></tr>
<tr><td>Short term (during construction)</td><td>157 %</td><td>OK</td></tr>
<tr><td rowspan="4">Purlin
C-150x65x20x32.</td><td rowspan="2">Amount of deformation</td><td>Usual</td><td>158 %</td><td>OK</td></tr>
<tr><td>Short term (during construction)</td><td>120 %</td><td>OK</td></tr>
<tr><td rowspan="2">Amount of deformation</td><td>Usual</td><td>0.8 cm (L/350)</td><td>OK</td></tr>
<tr><td>Short term (during construction)</td><td>1.0 cm (L/320)</td><td>OK</td></tr>
<tr><td rowspan="2">Roof steel frame</td><td colspan="4">Column size: 50 x 50 cm / Concreat strength: 30 N/mm^2</td><td rowspan="2">OK</td></tr>
<tr><td colspan="4">The roof trusses are supported by columns and have no effect on the beams. When solar panels are installed, the maximum increase per column is 9.0 kN, but the compressive stress is a slight increase of 0.4% and does not affect the structural strength of the columns, so this is not considered a problem.</td></tr>
</table>

Existing Structural Specification		Margin of the existing structural capacity when solar panels are loaded	Judgment
Foundation	The foundation of this building is made of cast-in-place concrete piles and the concrete used is Fc28=30N/mm^2. Since the bearing capacity of the piles is unknown, it is determined from the rate of increase in load when solar panels are installed. There are three types of piles with a minimum diameter of 750 mm. The maximum increase in load per foundation is 9.0 kN when solar panels are loaded, but since this is only 0.2% of the allowable compressive strength of the piles, it is determined that the foundations will not be affected.		OK

2-2-3 Outline Design Drawing

(1) Equipment Drawings

Sri Jayewardenepura General Hospital
- SE-1_ Layout Plan of PV Panel
- SE-2_Overall Layout Plan
- SE-3_Single Line Diagram
- SE-4_System Configuration
- SE-5_Layout Plan of Container
- SE-6_Cable Route Plan

Teaching Hospital Ratnapura
- RE-1_ Layout Plan of PV Panel
- RE-2_Overall Layout Plan
- RE-3_Single Line Diagram
- RE-4_System Configuration
- RE-5_Layout Plan of Container
- RE-6_Cable Route Plan

Teaching Hospital Kurunegala
- KE-1_ Layout Plan of PV Panel
- KE-2_Overall Layout Plan
- KE-3_Single Line Diagram
- KE-4_System Configuration
- KE-5_Layout Plan of Container
- KE-6_Cable Route Plan
- KE-7_Layout Plan of Main distribution board room

(2) Facility Drawings

Sri Jayawardenepura General Hospital
- SF-1_Site Plan
- SF-2_Building-B・Existing Roofing Plan
- SF-3_Building-B・Additional Roofing Plan and Details
- SF-4_ Building-B・Roof Purlin Plan for Additional Roofing
- SF-5_ Building-B・Detail of Tie bar
- SF-6_ Building-B・Detail of the Flashing Plate
- SF-7_Container Foundation
- SF-8_ Temporary facilities plan

TH Ratnapura
- RF-1_Site Plan
- RF-2_ JICA Building・Existing Roofing Plan

- RF-3_JICA Building・Steel Roofing Plan for Additional Roofing
- RF-4_JICA Building・Additional Roofing Plan
- RF-5_JICA Building・Detail of the Steel Roofing
- RF-6_JICA Building・Detail of the Flashing Plate
- RF-7_A&E Building・Existing Roofing Plan
- RF-8_A&E Building・Steel Roof Plan and Section
- RF-9_Blood Bank Building・Existing Roofing Plan
- RF-10_ Container Foundation
- RF-11_ Temporary facilities plan

TH Kurunegala

- KF-1_Site Plan
- KF-2_Maternity Building・Existing Roofing Plan and Section
- KF-3_Maternity Building・Existing Roofing Plan
- KF-4_ Container Foundation
- KF-5_ Temporary facilities plan

2-2-4 Implementation Plan

2-2-4-1 Implementation Policy

It is judged that this project will be performed in accordance with the framework of Japan's grant aid to ensure an appropriate construction period, construction accuracy, and quality. The Installation Work will commence following the signature of the Exchange of Notes (E/N) and Grant Agreement (G/A). Basic policy and special considerations needed if the project is implemented are given below.

(1) Basic Policy for Cosntruction / Procurement

Safety and process management will be prioritized, and quality control will be ensured. In order to ensure quality and process control, local contractors with many local construction experiences and familiarity with the procurement of materials and equipment and labor management capabilities will be efficiently utilized. In particular, since the construction work for this project will be performed inside hospitals that are in operation, it will be taken into consideration the separation of lines of flow between hospital personnel and users and construction workers, and thorough measures will be taken to prevent accidents to the third-party. In addition, care should be taken to prevent falls during work at high elevations and to prevent construction materials from falling.

(2) Project Implementing Body on Sri Lanka Side

The MOH as the implementing agency will be responsible for signing and executing the E/N and G/A as well as contracting for the implementation of this project, and will coordinate with each hospital during the implementation period.

(3) Consultant

In order to ensure the smooth implementation of this project, Japanese consultants will enter a design and supervision agreement with MOH to procure and install equipment for the project, produce detailed design and supervise the work related to this project. Along with drafting bidding documents, consultants will handle bidding on behalf of MOH, the project implementing body.

In addition to procurement supervision, the Consultant shall assign a resident supervisor of equipment engineers to the site from the start of the installation work to its completion, since the work includes installation work during the operation of the hospital. In addition, a construction engineer supervisor will be dispatched on a short-term basis to provide comprehensive procurement supervision, including quality control and process management.

(4) Contractor

In accordance with Japan grant aid framework, independent Japanese contractors selected by Sri Lanka side through open bidding will procure and install equipment for the project.

The Contractor for the installation work is required to have a track record of construction, especially for past projects similar to this project, the ability and track record to work safely and reliably at the project site, and an appropriate plan for carrying in and out materials and equipment. Furthermore, the Contractor is required to take sufficient safety measures for hospital users and nearby residents during the construction period.

The Contractor for equipment procurement is required to have the ability to manage the construction period appropriately, to handle transportation procedures, and to have close discussion with related persons of the procurement and installation of equipment and materials.

(5) Need for Dispatching Engineers

This project includes roof repair work at the building where the solar panels are to be installed, along with procurement, transportation, and delivery of materials and equipment, and on-site construction work. Therefore, it is required to manage this project in consideration of the renovation work process at each hospital, and it is deemed necessary to assign a Japanese contractor's engineer permanently who can consistently lead and manage the entire construction work.

Since the procurement and management of equipment involves detailed discussions with the installation team, on-site coordination with manufacturers, and work after the commissioning of the equipment, it is necessary to provide detailed explanations not only to the MOH but also to the equipment maintenance managers and hospital directors at each hospital who actually handle the equipment. Therefore, it is planned for Japanese engineers with expertise in maintenance and management of the equipment to be dispatched to the each site.

(6) Overall Relationships concerning Project Implementation

Role correlations for this project, including those during construction supervision, are as shown in Figure 2.23.

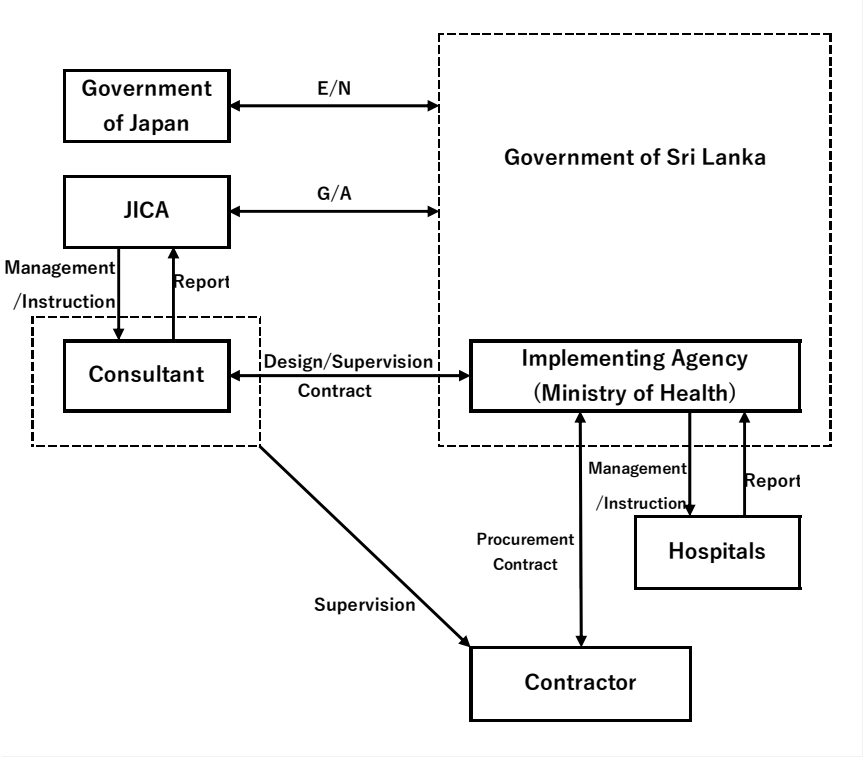


Figure 2.23 Project Relation Diagram

2-2-4-2 Implementation Conditions

(1) Installation Location

In the suburbs of the capital city, it is necessary to pay attention to traffic congestion, especially during morning and evening commuting hours. The project site is about 1 hour from the capital city to SJGH, about 3 hours to TH

Kurunegala, and about 3 hours to TH Ratnapura. The risk of construction delays related to inland transportation is low because materials and equipment can be temporarily stored in the material storage yards at the each hospital after being transported to each site. On the other hand, since the existing hospitals are still in operation, it is necessary to take measures such as assigning traffic guides along the route from the material storage yards to the subject buildings, in order to avoid accidents involving hospital staff or patients. In addition, the following points should be taken into consideration when developing the construction and procurement plans.

1) Transportation of Construction Materials and Timing of Delivery

In Sri Lanka, rainfall tends to increase from February to May, decrease from June to July, and increase again from August to November. In particular, rainfall peaks in May and November. It is important to formulate a plan in advance for bringing in materials and equipment in anticipation of the rainy season, and to keep temporary storage of materials during the rainy season to a minimum.

2) Storage of Materials and Equipment

Since this project is to be constructed within an existing hospital, there are limited locations that can be used as the "main materials storage area" (temporary storage after inland transportation). The subject buildings are located far from the "main storage area," each hospital will provide a "secondary storage area" for temporary storage of materials and equipment near the subject buildings for roof repair and equipment installation. A plan for transporting materials and equipment within the hospital will be developed, taking into account the distance between the "main material storage area" and the "secondary material storage area" at each hospital.

(2) Procurement of Materials

All major construction materials and equipment to be used for the roof repair work can be procured within Sri Lanka (including imported materials available in the local market), and there are no particular problems with procurement.

(3) Safety Measurements

Construction plans should be formulated and described in detail as per following to establish a safety management structure in theis project.

- In accordance with "The Guidance for the Management of Safety for Construction Works in Japanse ODA Projects", a safety measurement plan and a safety construction plan should be prepared by the Contractor and should be reviewed, and all activities related to safety management should be accomplished properly.
- Site engineers should carry a mobile telephone, and an emergency contact network should be prepared and distributed that covers all persons concerned with the project in Japan and Sri Lanka, and medical related staff.
- A morning meeting should be enforced before the commencement of activities of the day and the contents of activities and safety measurements should be confirmed in this meeting.
- Site patrols should be thoroughly and regularly undertaken, and the safety environment of scaffolding and timber guardrails should be confirmed.
- There should be inspections at access points, and these should be kept in good conditions to avoid dropping or falling in bad weather.

(4) Considerations of Equipment Procurement

The Japanese government has been emphasizing the importance of respect for human rights in the international community, for example, by announcing the "Guidelines for Respect for Human Rights in Responsible Supply Chains, etc." in September 2022. In some cases, PV modules, the main component of this project, were manufactured under human rights violations including forced labor. In order to ensure appropriate procurement of equipment, the following policy for equipment procurement has been established, taking into account the status of efforts to respect human rights in the supply chain by domestic and overseas organizations.

- Preparatory Survey Period

  Quotations for related equipment will be obtained only from companies that are members of the JPEA, which has issued a Declaration of Commitment to Human Rights Issues in the Photovoltaic Industry (October 15, 2022). After confirming the status of efforts to comply with the guidance developed by the JPEA and major suppliers, their quotations will be eliminated if deemed inappropriate. In this way, the cost

estimation is carried out under conditions that ensure respect for human rights in the supply chain.

- Detailed Design Period

The following procurement policies apply:

- ✓ Reflect in the bidding documents the submission of a certificate/statement that there is no forced labor or child labor in the supply chain.
- ✓ With reference to the Asian Development Bank's standard bidding documents and the "IPF SOLAR PROCUREMENT BIDDER DECLARATION- FORCED LABOR" prepared by the World Bank, bidders are required to submit "eligibility criteria that clearly indicate that no contract defaults have occurred in the past five years due to noncompliance with forced labor or child labor obligations."
- ✓ Since activities to respect human rights require a company-wide effort, it must be demonstrated that efforts are being implemented with the involvement of management team. For this reason, the person who is at the management level must sign the relevant documents.

2-2-4-3 Scope of Work

Both sides agreed on the outline of the Project and major undertakings to be borne by the Sri Lankan side by M/D. The Sri Lankan side also agreed to secure the budget and conduct the major undertakings at an appropriate time. Demarkation of undertakings by both sides (procurement works, installation works, etc.) are shown in Table 3.52.

2-2-4-4 Consultant Supervision

According to Japan's grant aid system, consultants are to form a project team consistent with the final design and construction supervision based on the spirit of the basic design and smoothly completes the work. During procurement supervision, the Consultant shall be fully aware of the various circumstances in Sri Lanka and the subject buildings in which the project equipment is to be installed. Furthermore, the Consultant shall plan to maintain consistency in process control, quality control, workmanship control, and safety control.

(1) Basic Policy for Procurement Management

As basic policy, the Consultant supervises that the progress of procurement work, installation work, commissioning, OJT are completed within the given period. Along with ensuring equipment is delivered on time and up to the quality and finished forms given in the agreement, the Consultant is to supervise and advise the Contractor so that the Contractor can perform the work safely at the site.

1) Schedule Management

In order to ensure that the work is completed within the period indicated in the contract documents, the Consultant shall check each week and each month the status of the work and the actual progress of the work as planned by the Contractor at the time of the start of the contract. If delays are anticipated, the Consultant will alert the Contractor, request that the Contractor submit and implement a countermeasure plan, and instruct the Contractor to complete the work within the contracted period.
Comparison of the planned process and the progress of the project is mainly based on the following items.

a) Confirmation of construction completion (status of procurement of construction materials and equipment and construction progress)

b) Confirmation of delivery of materials and equipment (construction materials and equipment)

c) Confirmation of the status of temporary construction and preparation of construction equipment

d) Confirmation of the number of engineers, technicians, and construction workers

2) Safetey Management

As described in "2-2-4-2 Implementation Conditions (3) Safety Measurements", in consultation and cooperation with the safety manager of the Contractor, safety management should ensure that occupational accidents on site during the installation work period are prevented, as well as injuries and accidents to third parties (hospital staff, patients, etc.). Points to be considered for safety management on site are as follows.

a) Establish safety management regulations and appoint a manager.

b) Prevent accidents by conducting periodic inspections of construction machinery

c) Establishment of operation routes for construction vehicles and transport equipment, etc., and

thorough implementation of safe driving

d) Installation and periodic inspection of safety facilities

e) Establishment of a welfare system for workers and encouragement of them to take holidays

(2) Procurement Management System

SJGH is located in the suburbs of the capital city, and TH Kurunegala and TH Ratnapura are about 3 hours by car from the capital city, so there are no obstacles to the short-term dispatch of Japanese engineers and the assignment of resident supervisors.

The construction work includes metal folded plate roofing of Building B at SJGH, installation of a steel frame base (for new metal folded plate roofing material) for the JICA building at TH Ratnapura, and high-pressure washing and repainting of the existing metal folded plate roof of the A&E Building and the Blood Bank Building at TH Ratnapura. Therefore, JICA Survey Team planed to dispatch an architectural engineer for a period during the relevant construction period, and establish an appropriate construction supervision system based on the detailed design.

The consultant's resident supervisor, the construction company's work manager, and the architectural engineer shall be able to inspect the site at any time.

(3) Procurement Management Policy

The main work for procurement supervision are as follows

1) Meetings with the Contractor and confirmation of equipment manufacturing drawings (in Japan)

Confirm the procurement and manufacturing plans, and verify the validity of related documents such as production drawings and manufacturing schedules.

2) Factory inspection (in Japan)

Confirm shipping preparations and coordinate schedules for pre-shipment inspections conducted by third-party inspection agencies.

3) Pre-shipment inspection (in Japan or third countries)

After the product is packed in the warehouse at the factory after checking it against the product inspection certificate, checking its components and accessories, and inspecting its external appearance, the implementation details of the pre-shipment inspection are confirmed with the "Product Inspection Report".

4) Procurement supervision (on-site)

The resident supervisor supervises the overall installation of procured equipment and materials, verifies the time of delivery of equipment and materials, determines temporary storage and unpacking locations for equipment and materials, hands over keys to equipment storage locations, and verifies the method of curing facilities and equipment. In addition, the company shall verify the acceptance test and delivery documents (in English) required after the installation of procured equipment and materials.

5) Pre-warranty inspection (on-site)

During the pre-warranty inspection of the equipment for this project, the Consultant will interview the director, staff, and maintenance department staff of each hospital to ascertain the operational status of the equipment, whether or not there are any malfunctions, and what to do in case of malfunction, and to consider appropriate measures.

2-2-4-5 Quality Control Plan

(1) Basic Policy

The Consultant shall inspect and confirm whether or not the roof renovation and the installed equipment meet the required quality and workmanship, in accordance with the Contract Documents. As a result of the verification/confirmation, if the Consultant determines that the quality or workmanship is unsatisfactory, the Consultant shall immediately request the Contractor to make corrections, changes, or modifications.

Concrete for the container foundations is assumed to be cast on-site for small quantities. The laboratory for public

compressive strength testing is located in Colombo. Each hospital is within a day's travel from the laboratory, so there will be no problem in conducting the concrete casting tests.

The testing equipment calibration status of the laboratory selected by the Contractor at the start of construction work will be checked.

(2) Quality Control Plan

The Consultant shall ensure the following verification, supervision, and confirmation as quality control items. In addition, the main quality control plan is shown in Table 2.50.

1) Verification of construction drawings and specifications of materials to be used

Prior to the construction work, the Contractor is required to submit construction drawings for various types of work, and the contents are verified. In addition, the Contractor is required to submit specifications and purchase certificates for materials to be delivered to ensure quality assurance.

2) Verification of production drawings and specifications for metal folded-plate roofs and steel-frame sheathing

Prior to the manufacture and on-site work of metal folded-plate roofs and steel-frame claddings, the Contractor shall be required to submit fabrication drawings and confirm their contents. In addition, when the metal folded-plate roof and steel-frame underlayment are delivered, they shall be checked against the specifications and fabrication drawings.

3) Attendance at the manufacturing/production site of the metal folded-plate roof and steel-frame underlayment, or verification of the inspection results

If necessary, the Consultant shall attend and inspect the production/manufacturing plant or fabrication/assembly plant of the metal folded-plate roofing and steel-frame underlayment to confirm the quality of the materials and raw materials and to verify the product inspection certificates, etc.

4) Supervision and confirmation of workmanship

On-site technical guidance and on-site inspections are conducted at each stage of construction. Any defective parts are thoroughly reworked, and the Contractor takes corrective measures. In addition, the workmanship inspection shall check the workmanship against the construction drawings.

5) Quality Confirmation for Equipment Procurement

The Consultant shall supervise and verify whether the quality of materials and equipment procured for this project, as well as the quality and workmanship of their construction/installation, are in accordance with the Contract Documents (technical specifications, execution design drawings, etc.), based on the items listed below. When quality and workmanship are not assured, the contractor is asked to make corrections, changes, or modifications.

a) Verification of production drawings and specifications of materials and equipment

b) Attendance at factory inspections, or verification of factory inspection results

c) Verification of packing, transportation, and on-site temporary storage method

d) Verification of construction drawings and installation manuals for materials and equipment

Table 2.50 Main Quality Control Items

Work items	Management items	Test (inspection) method	Test frequency
Earthwork	Soil bearing capacity	Flat plate loading test or simple support measurement	Once for each container
	Degree of compaction	Visual inspection (confirmation every 30 cm using rammer compaction)	All points around the foundation
	Excavation slope angle Accuracy for flooring	Measurements (slope ratio of 1: 0.8 or more) Mesurements	
Formwork	Check dimension	Dimension inspections / photos	All parts
	Material inspection	Plate thickness / materials / deformation	All parts
	Assembly inspection	Visual inspections (clearance, reinforcement materials, spacer)	All parts

Work items	Management items	Test (inspection) method	Test frequency
Reinforcement work	Tensile strength	Tensile strength test (JIS, ASTM, etc. standard or higher)	Once for each size / steel type
	Quality in general	Mill sheet (original) * In case copy, check the tag.	Once for each size / steel type
	Reinforcement inspection	Number, diameter, rebar spacing, joint length, fixing length, cover thickness	Before concrete placement, all locations
Concrete Work	Aggregate density	Sieve analysis tests	Once
	Trial Mixing	Formulation, water-cement ratio, compressive strength, slump, salinity tests	Once (for each design strength)
	Compressive strength	Compressive strength test (design standard strength + correction value + extra)	Once for each casting part
	Slump	Slump tests	Every time it is placed
	Amount of Chloride	Cantab tests	Once for each casting part
	Concrete temperature	Concrete temperature at the time of casting (35°C or less)	Every time it is placed
	Check dimension (After dismantling the formwork)	Measurements	All parts
Folded-plate Roofing Work	Fabrication Plant	Certificate of Fabrication Plant	Before Fabrication
	Folded-plate roofing materials	Visual measurements	At the time of delivery
	Installation accuracy	Visual inspections and measurement	During installation
Steel Fabrication Work	Fabrication Plant	Certificate of Fabrication Plant	Before Fabrication
	Steel Fabrication	shop certificate, mill shee	At delivery
	Installation accuracy	Visual inspections and measurement	During installation
Painting Work	Materials	Standard	At the time of delivery
	Middle and top coats	Visually inspections	Appropriate

2-2-4-6 Procurement Plan

(1) Procurement Plan for Construction Work

The main materials and equipment to be used in the rehabilitation of the roofs can generally be procured in Sri Lanka (including imported materials and equipment available in the local market). Of the construction materials and equipment, cement, aggregate, rebar, wood, paint, and other items are either domestically produced in Sri Lanka (cement, aggregate, rebar) or imported from neighboring countries (India and Pakistan for steel frame, and Malaysia for wood, Paint is imported from third countries including Japanese manufacturers), and is readily available in the market. Construction machinery, heavy equipment, and transport vehicles can be procured (leased) from construction companies in Sri Lanka. A list of major materials and equipment and their procurement sources are shown in Table 2.51.

Table 2.51 Material and Equipment Procurement Sources

Materials and equipment	Procurement	Production		Reference
	Local	Local	Imported	
Foundation Work for Container				
Portland cement	○	○	-	Available domestically (materials are imported)
Aggregate	○	○	-	Available domestically
Timber	○	○	○	Available domestically
Formwork	○	-	○	Available domestically (imported from Malasya)
Reinforcement bar	○	○	○	Available domestically
Roof Repair Work				
Common temporary construction materials (temporary fencing)	○	-	○	Available domestically
Direct temporary construction materials (scaffolding)	○	-	○	Available domestically

Materials and equipment	Procurement	Production		Reference
	Local	Local	Imported	
Steel frame	○	-	○	Available domestically (materials imported from India and Pakistan, processing and assembly in Sri Lanka)
Metal Folded Plate Roof	○	-	○	Available domestically (materials imported from Australia, processing and assembly in Sri Lanka)
Painting materials	○	-	○	Available domestically (imported from Japanese manufacture / third countries)
Construction Machinery				
Dump trucks	○	-	-	Available domestically
Backhoe	○	-	-	Available domestically
Truck cranes	○	-	-	Available domestically
Concrete mixer	○	-	-	Available domestically

(2) Procurement Plan for Equipment

With regard to the procurement of PV modules for this project, it is necessary to consider issues and stipulate procurement requirements so that products and companies involved in forced labor can be eliminated. As the JPEA has issued a "Declaration of Commitment to Human Rights Issues in the Photovoltaic Industry," companies belonging to the association shall be the main suppliers.

The following countries (countries of origin) shall be considered as major suppliers of equipment.

1) Equipment procured in Japan or locally

Supporting structures for PV module and fitting material, junction boxes, collecting boxes, power conditioners, DC collecting panels, insulation transformers, wether data collecting devices, containers, wiring materials, earthing materials and fire detectors, etc.

2) Materials and equipment procured from Japan or third countries (DAC or ASEAN)

DC cables, AC cables, control cables and terminal materials, etc.

3) Materials and equipment procured from Japan or third countries (DAC, ASEAN or APEC)

PV modules

2-2-4-7 Operational Guidance Plan

Guidance on initial equipment operation and maintenance will be provided by the Supplier as OJT (on the job training).

(1) Initial operation guidance plan

1) Inspections, checks and measurement guidance before the start of operation

The inspection, check and measurement items to be implemented before operation are described in detail in Section 2-5-2 (Routine inspection and periodical inspection items). The results of inspections, checks and measurements will be recorded. Installation engineers of the Supplier will conduct technology transfer of the following items to inspectors.

2) PV module inspections

In the construction stage, thoroughly check for any damage or breakage that may have occurred during transportation. Check for cracking, fractures and discoloration of the surface glass will be conducted as well.

3) Confirmation of connecting terminals

Screws of power conditioners. sometimes become loose during transportation. Temporary wiring is sometimes left unfinished, while cases that have been loosened for testing, etc. are sometimes left as they are. Check for any loose screws on terminal sections before operation. Also, make sure there are no terminals with mistaken polarity (positive polarity is P or +, and negative polarity is N or -) or mistaken wiring between DC and AC circuits.

4) Inspection of other peripheral instruments

Checking of other peripheral instruments will be conducted by visual inspection.

(2) Measurement guidance and safety measures guidance

Inspectors will check that the installed PV modules are operating correctly and are maintaining performance levels before the start of operation. Inspectors and work assistants will receive guidance regarding safety measures on the handling of PV modules from the installation engineers before the start of actual work.

1) Safety measures

Before the start of work, it is important to observe the following points regarding safety measures (clothing and electrical shock countermeasures):

(i) Clothing
- Wear helmets and safety gears.

(ii) Shock prevention
- Detach one end of PV strings before the start of work
- Wear low voltage insulated gloves
- Use insulated tools
- Do not work when it rains.

2) PV array inspection: Confirmation of voltage and polarity and measurement of short circuit currents

(i) Confirmation of the performance (voltage) of PV modules
Make sure that the output voltage is as detailed in the specifications. Also, make sure that positive and negative polarities are not confused by checking each string with a voltmeter.

(ii) Measurement of short circuit current
Measure the PV modules by ammeter to make sure that short circuit current flows as specified in the specifications.

3) Insulation resistance measurement

Insulation resistance testing will be implemented in order to confirm that it is acceptable to turn on power to the PV system. Insulation resistance will be measured after the construction (before the start of operation), during periodic inspections and when identifying and repairing malfunctioning areas during accidents. Measured resistance values will be recorded. When the used voltage is higher than 300 V, insulation resistance should be at least 0.4 MΩ.

4) Ground resistance measurement

Grounding of electrical devices is important in order to protect human lives and property from accidents and fires caused by ground faults. Grounding works are divided into four types, i.e. A, B, C or D. Types A, C and D grounding works are implemented on uncharged areas such as the metal armor of electrical devices and cables. High voltage metal external boxes and low voltage exterior boxes exceeding 300 V are reduced to 10 Ω or less (Type C), however, 500 Ω or less is acceptable in cases where a device is installed for breaking current within 0.5 seconds when ground faults occur. Voltages of the PV system to be installed by the Project is higher than 300V, the grounding resistance will be 10 Ω or less.

(3) Operation guidance plan

Once the grid-connected PV system goes into operation, unlike emergency diesel generators, there is no need to conduct system controls. The grid-connected PV system automatically operates every day. However, the system stops operation through the function of islanding detection when the power outage of the grid occurs. When the power supply from the grid is restored, the PV system will be automatically connected.

At the initial stage of the system operation, since problems are apt to occur in the semiconductors and PV modules, it will be necessary to conduct inspections every day. Inspectors and installation engineers will patrol power conditioner containers and installed data acquisition system to learn the inspection methods.

1) Preparation for routine inspection records

Routine inspection items are described in detail in Section 2-5-2 (Routine inspection and Periodic

Inspection Items). The operation manager will record routine inspection results in notebooks and archive them. Keeping records will make it possible to detect changes in the instruments.

2) Solar irradiation and generated electrical energy checks

Inspectors will check the amount of solar irradiation and generated electrical energy through the reporting function of power conditioners. Through this check, inspectors detect any abnormal status immediately.

2-2-4-8 Soft Copmponent (Technical Assistance) Plan

TH Ratnapura and TH Kurunegala have existing PV power generation systems, and maintenance of the equipment is done by electrical engineers. Although Sri Jayawardenepura General Hospital does not currently have a photovoltaic power generation system in operation, it properly manages power receiving equipment from the grid and has equipment operation and maintenance management technology. A photovoltaic system is a system that does not normally require operation like an emergency generator.

Considering the current state of maintenance at each hospital and the characteristics of the solar power generation system, the manufacturer's engineers will provide initial operation guidance and operation guidance based on the characteristics and specifications of each equipment. Through this activity, it is judged that operation and maintenance after handing over of the equipment is possible. Since the maintenance system is well established, including the current outsourcing system to an external organization, the soft component related to operation and maintenance will not be included in this project.

2-2-4-9 Implementation Schedule

It will take about 5 months from the execution of E/N and G/A to the signing of a contract agreement with the Contractor, 19 months for installation, and 24 months from the execution of E/N to handover to the Client (MOH). The draft implementation schedule is described on the Figure 2.24.

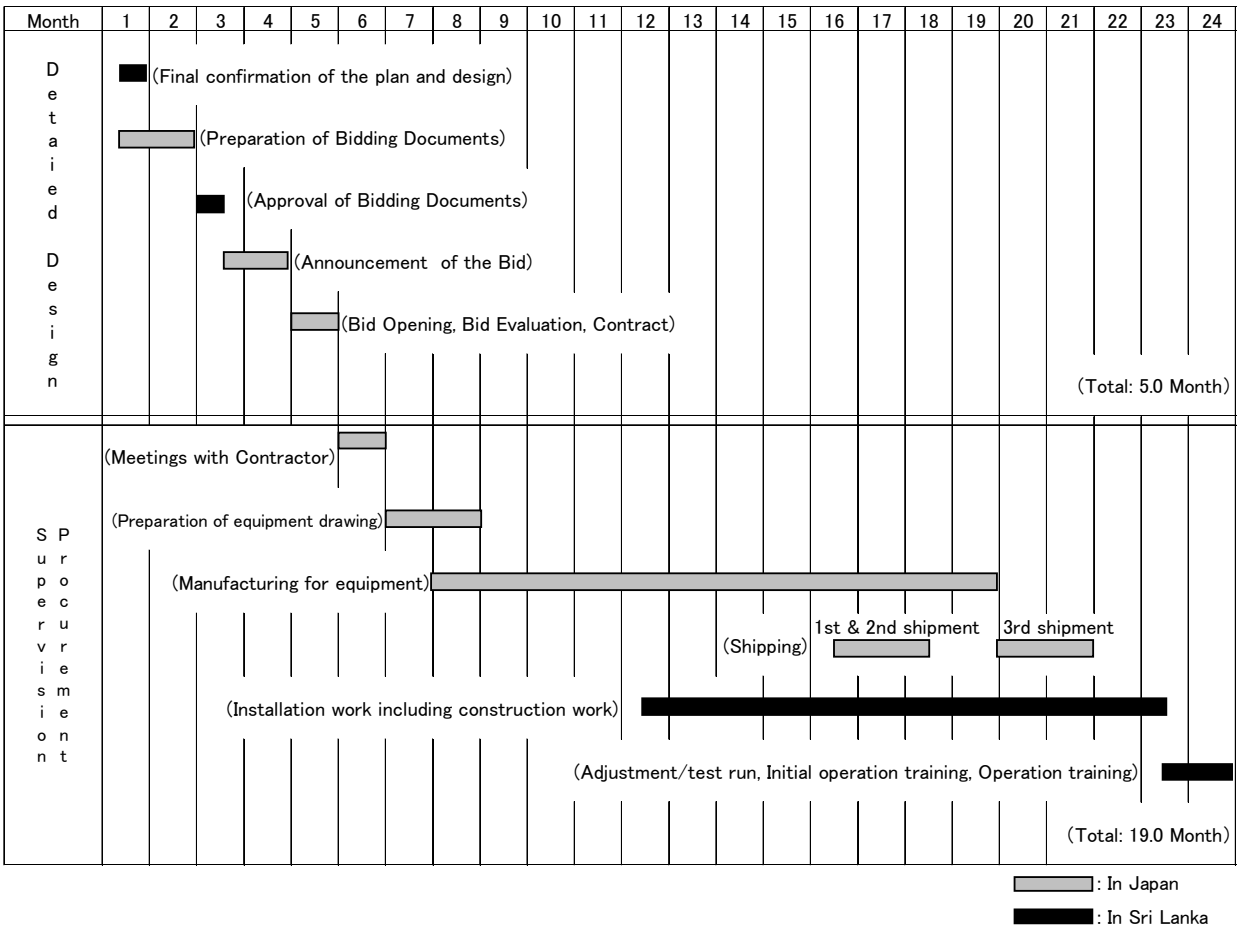


Figure 2.24 Implementation Schedule (Draft)

2-3 Security Plan

Since March 2022, there have been frequent protests against the government due to soaring prices and fuel shortages caused by economic deterioration. These have tended to subside. However, since there is a possibility of recurrence, it is necessary to pay attention to the latest security information and take appropriate safety measures such as collecting safety information from the JICA Sri Lanka office, the Embassy of Japan in Sri Lanka, and the MOH when implementing this project.

2-4 Obligations of Recipient Country

2-4-1 Works to be borne by the Recipient Country

Following the conclusion of E/N, MOH will conduct the necessary work listed in Table 2.52 with relevant authorities.

Table 2.52 Major undertakings

Items	Deadline	Japan		Sri Lanka		In charge	Remarks
		Proc.	Inst.	Proc.	Inst.		
A. Before notice of the bidding							
(1) To sign the banking arrangement (B/A) with a bank in Japan (the Agent Bank) to open bank account for the Grant	within 1 month after the signing of the G/A	-	-	●		MOH	Central Bank of Sri Lanka
(2) To issue the authorization to pay (A/P) to the Agent Bank for the payment to the Consultant	within 1 month after the signing of the contract	-	-	●		MOH	MOF
(3) To bear the following commissions to the Agent Bank for the banking services based upon B/A							
1) Advising commission of A/P	within 1 month after the signing of the contract(s)	-	-	●		MOH	MOF
2) Payment commission for A/P	every payment	-	-	●		MOH	MOF
(4) To ensure that customs duties, internal taxes, and other fiscal levies which may be imposed in the country of the Recipient with respect to the purchase of the products and/or the services be exempted by its designated authority without using the Grant	within 1 month after the signing of the G/A	-	-	●		MOH	Relevant authorities
(5) To ensure the tax exemption procedures and apply for it.	Before notice of the bidding	-	-	●		MOH	If necessary
(6) To secure and clear the lands for container of PV system.	Before notice of the bidding	-	-	●		MOH (*)	(*)SJGH TH Ratnapura TH Kurunegala
(7) To obtain the planning, zoning, building permit from the Urban Development Authority (UDA)	Before notice of the bidding	-	-	●		MOH (*)	(*)SJGH TH Ratnapura TH Kurunegala
(8) To obtain tree cutting /transplanting permit from relevant authority if necessary.	before notice of the bidding	-	-	●		MOH (*)	(*)SJGH TH Ratnapura TH Kurunegala If necessary
(9) To submit Project Monitoring Report (with the result of Detailed Design)	Before preparation of the bidding documents	-	-	●		MOH	
B. During the Project Implementation							
(1) To issue A/P to the Agent Bank for the payment to the supplier and the contractor	within 1 month after the signing of the contract	-	-	●		MOF	
(2) To bear the following commissions to the Agent Bank for the banking services based upon the B/A		-	-	●			
1) Advising commission of A/P	within 1 month after the signing of the contract	-	-	●		MOF	

2) Payment commission for A/P	every payment	-	-	●	MOF	
(3) To provide Main temporary store yard (where transported materials to each site is stored) and sub temporary store space (besides each buildings).	within 1 month after the signing of the contract	-	-	●	MOH (*)	(*)SJGH TH Ratnapura TH Kurunegala
(4) To provide plots/vacant room for site offices of the Consultant and the Supplier.	within 1 month after the signing of the contract	-	-	●	MOH (*)	(*)SJGH TH Ratnapura TH Kurunegala
(5) Procurement, Installation and Commissioning of the Equipment	During the work	●	●	-		SJGH TH Ratnapura TH Kurunegala
(6) Procurement of Spare parts, Consumables and Tools	During the work	●	-	-		SJGH TH Ratnapura TH Kurunegala
(7) Operation Training Work	During the work	-	-	-		SJGH TH Ratnapura TH Kurunegala
(8) To conduct power outage of the existing equipment when the PV system will be interconnected to the low voltage facilities.	During the work	-	-	●	MOH (*)	(*)SJGH TH Ratnapura TH Kurunegala
(9) To obtain the interconnection license from the Ceylon Electricity Board (CEB)	Before completion of the work	-	-	●	MOH (*)	(*)SJGH TH Ratnapura TH Kurunegala
(10) To conduct necessary test which is necessary for obtaining the grid-connection permit from the Ceylon Electricity Board (CEB)	Before completion of the work	-	-	-	-	SJGH TH Ratnapura TH Kurunegala
(11) To procure and install two-way watt-hour meter	Before completion of the work	-	-	●	MOH (*)	(*)SJGH TH Ratnapura TH Kurunegala
(12) Relocation/Removal of existing container where the container of the Project will be installed.	Before the work	-	-	●	MOH SJGH	
(13) Removal of existing facilities at and around the place where the container of the Project will be installed.	Before the work	-	-	●	MOH SJGH	Overhead line, poles, etc.
(14) Secure the store space where the existing tiles of Block-B will be transferred.	Before the work	-	-	●	MOH SJGH	
(15) Removal of existing tiles and transfer to the designated space in the hospital.	During the work	-	●	-		SJGH
(16) Installation of steel roofing on the existing corrugated cement sheet of Block B	During the work	-	●	-		SJGH
(17) Removal of trees and branches along the low voltage overhead cable routes and at the access point of main store yard.	During the work	-	-	●	MOH TH Ratnapura	
(18) Installation of steel roofing on the existing roof of JICA Building	During the work	-	●	-		TH Ratnapura
(19) High-pressure washing and re-painting the existing roofs of A&E building and blood bank building	During the work	-	●	-		TH Ratnapura
(20) To remove unused incinerator by the maternity building to vacate a space for the container of PV system.	During the work	-	-	●		TH Kurunegala
(21) Removal of possible obstacles (including trees, braches) which are found to be necessary to remove.	During the work	-	-	●	MOH (*)	(*)SJGH TH Ratnapura TH Kurunegala
(22) To ensure prompt unloading and customs clearance at ports of disembarkation in the country of the Recipient and to assist the Supplier(s) with internal transportation	During the work	-	-	●	MOH	

	therein					
(23)	To accord Japanese physical persons and/or physical persons of third countries whose services may be required in connection with the supply of the products and the services such facilities as may be necessary for their entry into the country of the Recipient and stay therein for the performance of their work	During the work	-	-	●	MOH	
(24)	To conduct necessary work so that customs duties, internal taxes, and other fiscal levies which may be imposed in the country of the Recipient with respect to the purchase of the products and/or the services be exempted by its designated authority without using the Grant	During the work	-	-	●	MOH	
(25)	To provide facilities for electricity, water supply and other facilities necessary for the implementation of the work at site	During the work	-	-	●	MOH (*)	(*)SJGH TH Ratnapura TH Kurunegala
(26)	To bear all the expenses, other than those covered by the Grant, necessary for the implementation of the Project	During the work	-	-	●	MOH	
(27)	To submit Project Monitoring Report after each work under the contract(s) such as shipping, hand over, installation and operational training	within 1 month after completion of each work	-	-	●	MOH	
(28)	To submit Project Monitoring Report (final) (including as-built drawings, equipment list, photographs, etc.)	within 1 month after issuance of Certificate of Completion for the works under the contract(s)	-	-	●	MOH	
(29)	To submit a notice concerning completion of the Project	within 6 months after completion of the Project	-	-	●	MOH	
(30)	To ensure the safety of persons engaged in the implementation of the Project	During the work	-	-	●	MOH	
(31)	To take necessary measures for security and safety of the Project site	During the work	-	-	●	MOH (*)	(*)SJGH TH Ratnapura TH Kurunegala
C.	**After the Project**						
(1)	To maintain and use properly and effectively the facilities constructed and equipment provided under the Grant Aid 1) Allocation of maintenance cost 2) Operation and maintenance structure 3) Routine check/Periodic inspection	After completion of the construction	-	-	●		

[Source] JICA Survey Team

2-4-2 Tax and tax exemption

Sri Lanka will provide tax exemptions to Japanese consultants and contractors for equipment and services to be procured for the implementation of this project. The taxation system and procedures related to this project are shown below.

The taxation system in Sri Lanka is frequently changed, so it is necessary to check the taxation system at the time of project implementation.

(1) Taxation

1) Corporate Tax

(i) Coporate Income Tax

The corporate income tax rate was 14% during 2022, except for certain companies. It was revised to 30% on January 1, 2023. The tax rate is based on the Inland Revenue (Amendment) Act, No. 45 of 2022.

(ii) Withholding Tax

The withholding tax of 14% is applied to Sri Lankan non-residents on Sri Lankan-sourced service fees. The tax rate is based on the Inland Revenue (Amendment) Act, No. 45 of 2022.

2) Personal Income Tax

This is a tax on personal income and is levied at a rate of 0-36% depending on income. The tax rate is based on the Inland Revenue Act No. 10 of 2006 and the Advance Personla Income Tax Table (2023.01.01-2023.03.31).

3) Value Added Tax (VAT)

An indirect tax imposed on purchases of goods and services. The rate was 12% until August 31, 2022, but was revised to 15% after October 1, 2022. The tax rate is based on the Gazette Extraordinary No. 2295/08 dated August 31, 2022.

4) Ports and Airports Development Levy (PAL)

The Ports and Airports Development Levy (PAL) came into effect in January 2009. The tax is levied on all non-Sri Lankan imported cargo. The tax rates are determined by the HS code of the imported cargo. The tax rates are based on the Ports and Airports Development Levy Act, No. 18 of 2011 and the Gazette Notification No. 2312/67 dated December 31, 2022. It should be noted that the tax rates imposed on imported shipments are frequently revised.

5) Social Security Contribution Levy (SSCL)

The Social Security Contribution Levy (SSCL) came into effect in October 1, 2022. It imposes a quarterly tax rate of 2.5% on the following taxable persons. The tax rate is based on the SSCL Act No. 25 of 2022.

1) Importers of any goods
2) Manufacturers of any goods
3) Businesses providing any type of service
4) Wholesale or retail operators of goods, including the importation and sale of goods other than those sold by manufacturers subject to above 2)

(2) Tax Exemption Procedures

Since this project is implemented as a grant aid, it is tax exempt in principle. There are two main procedures for tax exemption in Sri Lanka.

The first is that "Strategic Development Projects" that meet certain requirements will be applied to this project. “Strategic Development Projects" are projects that are in the national interest of Sri Lanka and have the potential to bring the following economic and social benefits to the country:

1) Potential to benefit the economy as a whole
2) Potential inflow of foreign currency
3) Job creation and increased income opportunities
4) Technological development

If the above conditions are met in this project, the project becomes a "Strategic Development Project" and is eligible for tax exemptions and other preferential treatment for a specific period of time. However, this project does not meet the conditions.

The second is to obtain a tax exemption permit. This procedure was approved by the Sri Lankan Cabinet in July 2022, and this project will apply this procedure. The MOH, which is the implementing agency for this project, will request the Ministry of Finance and the Department of Trade and Investment Policies (DTIP) to issue the tax exemption permit, and DTIP will issue the permit. The Contractor receives a copy of the permit from the MOH and submits the permit and prescribed shipping documents to the customs office for customs clearance.

(3) Interview to Japanese Companies

Interviews regarding tax exemption procedures were conducted with Japanese companies that have experience implementing ODA projects in Sri Lanka. The results are summarized below. It should be noted that the project was implemented between 2012 and 2014, and the results relate to the tax exemption procedures at that time. In addition, the project was implemented as "Strategic Development Projects".

Table 2.53 Results of Interviews with Japanese Company

Items	Results
Summary of Project	2012-2014 Bridge Costruction Project
Corporate Income Tax	The company applied to the Inland Revenue Department (IRD) and obtains a temporary Tax Identification Number (TIN). The company then sent monthly tax returns to the IRD and notified the IRD that the project was tax exemption.
Personal Income Tax	Income earned by non-residents of Sri Lanka were exempt if they are engaged in ODA projects. (For stays longer than 183 days, application to the IRD was required.)
Value Added Tax	A letter was obtained from the Ministry of Finance (MOF) indicating the exemption from VAT, and the procurement of materials and equipment in Sri Lanka was exempted from taxation upon showing this letter.
Port and Airport Development Tax	The tax exemption was applied by the project implementing agency applying for tax exemption from the MOF.
Social Security Contribution Levy (SSCL)	Since the SSCL was effective in 2022, it had not been applicable at the time of implementation of the project.

2-5 Procject Operation Plan

2-5-1 Basic Plan

Project sites where the PV system will be installed, namely SJGH, TH Ratnapura and TH Kurunegala have technicians for maintaining electricity facilities. Each hospital operates and maintains not only distribution power and low voltage equipment but also emergency diesel generators, which has high temperature mechanical sliding parts, which requires higher operation and maintenance skills. Through the observation, each hospital is judged to have sufficient skill of operation and maintenance of PV system. The PV system to be installed by the Project will be maintained by the personnel who currently belong to the operation and maintenance team.

According to interviews with TH Ratnapura and TH Kurunegala, if faults on PV modules are identified, necessary replacement work will be outsourced. Ordinary operation and maintenance will be done by each hospital and repair work will be done by external companies.

2-5-2 Routine inspection and periodical inspection items

(1) Periodical inspection items

Routine maintenance and inspections will be essential in order to ensure the sustainable operation of the grid-connected PV system. Operation managers will basically implement the following two types of inspections:

- Routine inspections following the start of operation
- Periodic inspections after operation

1) Routine inspections

Unlike other generating facilities, the grid-connected PV system requires no special controls following the start of operation such as start up and turns off.

The grid-connected PV system automatically starts operating every day once the sun rises to a certain

point. If the grid-connected PV system stops for some reason, it is necessary to investigate the cause and restart it by manually pushing the start switch. In the initial stages of operation, since troubles sometimes occur in the semiconductors and PV modules, it is necessary to implement inspections of operational status on a daily basis.

The PV equipment can be automatically operated without any operating personnel. However, performing routine inspections makes it possible to quickly discover system abnormalities.

Routine inspections will be implemented as visual checks every day for the first month after the start of operation. After that, these inspections can be implemented around once per week. After a heavy rainstorm, routine inspection needs to be conducted. Table 3.54 shows the inspection items.

Table 2.54 Routine inspection items

Inspected equipment	Inspection items
Measurement equipment	・ Normal power generation, comparison of actual power generation and irradiation ・ Indicator
Junction box / Collecting box	・ External box corrosion, rust ・ External wiring damage
Power conditioner	・ External box corrosion, rust ・ External wiring damage ・ Noise, odor during operation ・ Blockage of the ventilation outlet filter ・ Installed environment (humidity, temperature, etc.)
Grounding	・ Wiring damage

[Source] JICA Survey Team

Inspectors shall observe the following two points when implementing routine inspections:

- Preparation and archiving of routine inspection records

The routine inspection items are indicated in Table3.54 above. After checking the items indicated in the table, inspectors will record the results and keep them. Leeping records in this waywill enable detection of changes in the equipment.

- Solar irradiation and generated electrical energy check

Inspectors shall constantly check the amount of solar irradiation and generated electrical energy. Through this practice, the operation manager will be able to detect any changes when troubles arise in the PV modules and power conditioners.

2) Periodic inspections

Table 2.55 shows the general periodic inspection items and measurement items. Periodic inspection entails stopping the system after a certain period in order to inspect the instruments and measure the items shown in the table. The first periodic inspection will be implemented five years after the start of operation.

Table 2.55 Periodic inspection items

Inspection Target	Inspection Item	Measurement/Test
PV module	・ Surface dirt, damage ・ External wiring damage ・ Mounting structure corrosion, rust ・ Grounding wire damage, ground wire looseness	・ Insulation resistance measurement ・ Open voltage measurement (when needed)
Junction box, collecting box	・ External box corrosion, rust ・ External wiring damage, connecting terminal looseness ・ Grounding wire damage, ground wire looseness	・ Insulation resistance measurement
Power conditioner	・ External box corrosion, rust ・ External wiring damage, connecting	・ Insulation resistance measurement ・ Surface operation check

Inspection Target	Inspection Item	Measurement/Test
	terminal looseness ・ Grounding wire damage, grounding wire looseness ・ Noise, odor during operation ・ Blockage of the ventilation outlet filter ・ Installed environment (humidity, temperature, etc.)	・ Protective function test
Grounding	・ Wiring damage	・ Grounding resistance measurement

[Source] Design and Installation of Photovoltaic Power Generating Systems

2-5-3 Spare Parts Procurement Plan

Since the PV system uses inverters, there is a possibility that failure will occur in the semiconductors. Since semiconductor faults appear during initial operation, it is expected that the system shall operate flawlessly if no initial troubles arise. Parts other than semiconductors possibly get failures caused by natural disasters or degradation due to long-term use. It is, therefore, necessary to keep needed spare parts.

(1) Equipment replacement intervals and inspection contents

Equipment wears down and eventually loses its functions over time. The state of degradation in PV modules can be judged to some degree through a measuring of output characteristics, however, it is difficult to discern degradation in many other instruments. According to the preventive maintenance philosophy for preserving system reliability, parts are changed before they break down. Table 2.56 shows the recommended replacement intervals and inspection contents of major instruments for reference. Depending on the system, there is concern that costs will increase, however, spare parts will be supplied in the Project.

Table 2.56 Replacement intervals and inspection contents of major equipment (Recommended cases)

Part Type	Recommended Replacement Interval	Inspection Contents
PV modules	20-30 years	External appearance and voltage measurement
Junction box	10-15 years	Malfunction
Collecting box	10-15 years	Malfunction
Power conditioner	10-15 years	Malfunction
Low voltage panels	10-15 years	Malfunction
Interconnection transformer	20 years	Temperature increase
Fuse	7 years or 50,000 hours	Meltdown
Air conditioner	5-10 years	Malfunction, reduced performance
Cooling fan	5 year	Malfunction

[Source] JICA Survey Team

(2) Spare parts storage

Breakages and failures of main items of equipment in PV systems frequently lead to suspension of system functions. When troubles occur, it is desirable to promptly conduct repairs or replace the problem equipment, and the system can be quickly restored if replacement equipment is kept on hand. However, since it is expensive to store of expensive parts or large quantities of parts, it is necessary to determine the types and quantities of spare parts upon considering the equipment characteristics, economy and time required for system recovery and other matters Table 2.57 shows the types and quantities of spare parts that are recommended for storage at each hospital.

Table 2.57 Spare parts to be procured

Equipment	Quantity
PV modules	3% of all the PV modules
Junction box	2
Collecting box	1
Cooling fan	1 lot (100%)
Electromagnetic contactor	Each 1 of all types
Display panel	1 lot
Fuse	1 lot (100%)
MCCB	Each 1 of all types
DC cable connector	3% of all types
Optic fiber cable connector	5 sets
Sensor (Fire detector)	1 set

[Source] JICA Survey Team

(3) Spare parts procurement plan

The recommended replacement intervals of the major items of equipment in the grid-connected PV system are as indicated in Table 2.58. Costs arise when major items of equipment are replaced, and it is necessary to budget for these every year. However, in the Project, spare parts will be procured for all the main instruments that comprise the photovoltaic system.

The service life of the air conditioner in the container is 5-10 years, and since no spare air conditioner will be procured in the Project, it will be necessary to budget for its replacement in the 5th year after the start of operation.

Table 2.58 Replacement intervals and costs of replacement parts

Part	Replacement Interval	Quantity	Cost
Air conditioner	5-10 years	2units (SJGH) 4units (TH Ratnapura) 2units (TH Kurunegala)	Rs.550,000/unit

[Source] JICA Survey Team

(4) Testing equipment and maintenance tools procurement plan

Necessary testing equipment and maintenance tools will be procured in this Project. The list is shown in Table 2.59.

Table 2.59 Test equipment and maintenance tools

Part	Quantity
Digital Multi Meter	1 lot
Insulation Resistance Tester	1 lot
Voltage Detector	1 lot
Clamp Meter	1 lot
Earth Resistance Tester	1 lot
Electrical Tool Set	1 lot
Combination Tool Set	1 lot

[Source] JICA Survey Team

2-6 Project Cost Estimation

2-6-1 Initial Cost Estimation

The rough project costs are estimated as *confidential*. The cost breakdown for Japan and Sri Lanka has been estimated and illustrated in the tables below. This amount is not limited to the granted E/N amount.

2-6-1-1 Cost Borne by Japan

The project cost is estimated at *confidential*.

2-6-1-2 Cost Borne by Recipient Country

Cost to be borne by the Sri Lankan side is approximately 192,685 US Dollars. The breakdown is shown in Table 2.60.

Table 2.60 Costs for works to be borne by Sri Lanka

Cost Approx. 25.9 million JPY

Items	Deadline	Implmenting agency	Cost to be borne by Sri Lanka [US$]	Remarks
A. Before notice of the bidding				
(1) To bear the following commissions to the Agent Bank for the banking services based upon B/A				
1) Advising commission of A/P	within 1 month after the signing of the contract(s)	MOH	*confidential*	MOF
2) Payment commission for A/P	every payment	MOH	*confidential*	MOF
(2) To ensure that customs duties, internal taxes, and other fiscal levies which may be imposed in the country of the Recipient with respect to the purchase of the products and/or the services be exempted by its designated authority without using the Grant	within 1 month after the signing of the G/A	MOH	153,600	Relevant authorities
B. During the Project Implementation				
(1) To bear the following commissions to the Agent Bank for the banking services based upon the B/A				
1) Advising commission of A/P	within 1 month after the signing of the contract	MOF	*confidential*	
2) Payment commission for A/P	every payment	MOF	*confidential*	
(2) To obtain the interconnection license from the Ceylon Electricity Board (CEB)	Before completion of the work	MOH (*)	*confidential*	(*)SJGH TH Ratnapura TH Kurunegala
(3) To procure and install two-way watt-hour meter	Before completion of the work	MOH (*)	*confidential*	(*)SJGH TH Ratnapura TH Kurunegala
(4) Relocation/Removal of existing container where the container of the Project will be installed.	Before the work	MOH SJGH	*confidential*	
(5) Removal of existing facilities at and around the place where the container of the Project will be installed.	Before the work	MOH SJGH	*confidential*	Overhead line, poles, etc.
(6) Removal of trees and branches along the low voltage overhead cable routes and at the access point of main store yard.	During the work	MOH TH Ratnapura	*confidential*	
(7) To remove unused incinerator by the maternity building to vacate a space for the container of PV system.	During the work		5,000	TH Kurunegala
(8) Removal of possible obstacles (including trees, braches) which are found to be necessary to remove.	During the work	MOH (*)	*confidential*	(*)SJGH TH Ratnapura TH Kurunegala
C. After the Project				
(1) To maintain and use properly and effectively the facilities constructed and equipment provided under the Grant Aid 1) Allocation of maintenance cost 2) Operation and maintenance structure 3) Routine check/Periodic inspection	After completion of the construction		*confidential*	(*)SJGH TH Ratnapura TH Kurunegala

[Source] JICA Survey Team

2-6-1-3 Condition of the Cost Estimation

(1) Time of cost estiomation: May 2023 (at end of field survey)
(2) Exchange rate: 1 US$ = 134.38JPY
1 SLR = 0.39703JPY
(3) Period of implementation and procurement: Refer to Implementation Schedule
(4) Others: Cost estimation is based on Japanese Grant Aid projects. This project includes a contingency. However, the Ministry of Foreign Affairs in Japan will determine the application of the contingency and the contingency rate.

2-6-2 Operation and Maintenance Cost

Since the operation and maintenance of the system can be managed by the current maintenance department staff at each hospital, it is not required to increase personnel costs. On the other hand, the operation and maintenance costs shown in Table 2.61 will be required.

Table 2.61 Annual O&M Costs

Site	Items	Cost (US$)	Remarks
SJGH	Outsourced maintenance costs	500	Cost of services by third company
	Accumulation costs of air conditioner replacement	320	1 unit
TH Kurunegara	Outsourced maintenance costs	500	
	Accumulation costs of air conditioner replacement	320	1 unit
TH Ratnapura	Outsourced maintenance costs	500	
	Accumulation costs of air conditioner replacement	640	2 unit

Chapter 3 Project Evaluation

Chapter 3 Project Evaluation

3-1 Preconditions

As a precondition of the implementation of this Project, the Sri Lankan side has to secure a budget and implement works to be borne by the Sri Lankan side. The outline of the works to be borne by the Sri Lanka side is shown below.

3-2 Necessary Inputs by Recipient Country

(1) Before public notice of bidding

1) Each hospital shall acquire permit and license which are necessary for conducting the work, if any.
2) Each hospital shall secure main temporary store yards and temporary store yards on site as necessary.
3) Each hospital shall secure available spaces for the Supplier's office and the Consultant's office on each site.
4) SJGH shall secure budget and carry out necessary prior arrangement work for removal of existing overhead line and power poles during the work period.
5) SJGH shall secure budget and carry out necessary prior arrangement work for removal of existing containers during the work period.
6) SJGH shall secure budget and carry out necessary prior arrangement work for obtaining space where removed roofing tiles on the Block-B shall be transferred by the Japanese side.
7) TH Ratnapura shall secure budget and carry out necessary prior arrangement work for removal of existing trees and branches at the entrance of main store yard and low voltage overhead cable route.
8) TH Kurunegala shall secure budget and carry out necessary prior arrangement work for decommissioning of existing incinerator and leveling work.
9) Each hospital shall maintain project affected areas on site as they were at the preparatory survey period.

(2) During construction

1) Each hospital shall conduct actual works stated in item (1) '4) – 8)' above before the works borne by Japanese side.
2) Each hospital shall conduct necessary power outage of the existing low voltage facilities when the PV system will be interconnected.
3) Each hospital shall apply the license for interconnection of PV system to the grid (through low voltage facilities) to CEB. Each hospital shall also conduct necessary arrangement for the Supplier to conduct tests required by CEB.

(3) After completion of construction and start of service provision

Each hospital shall maintain the PV system appropriately as described in section 2-5-2 (Routine inspection and periodical inspection items).

3-3 Important Assumptions

The external conditions that are prerequisites for the development and sustaining of the project's effects are as follows:

(1) Overall goals

- The renewable energy policy of Sri Lanka will not be changed.
- The politics and economy of Sri Lanka will remain stable.

(2) Project goals

- The budget required for the operation and maintenance will be secured.
- The operation and maintenance of the photovoltaic system will be continually conducted in a proper manner.

(3) Expected results

- Current climate pattern will remain.
- The PV system will be fully operated.

3-4 Project Evaluation

3-4-1 Relevance

As is indicated below, since the Project will contribute to the realization of Sri Lanka's development plans and energy policy as well as benefit the general population, it is deemed to have high relevance as a grant aid undertaking.

(1) Urgency

Reduction of payment for the power tariff contribute to the financial status of the Ministry of Health (MOH). MOH is responsible for health related policies in Sri Lanka. The benefit is conveyed to all the Sri Lankan people.

(2) Benefits

According to the Annual performance report (2020) of Ministry of Health, one of objectives of MOH is to develop new strategies to reduce out-of-pocket spending and reduce financial risk.

Priority areas (Mid-term target) of Japan's Country Assistance Policy to Sri Lanka (June, 2013) includes Mitigation of vulnerabilities. Under this item, the Country Assistance Policy states 'Japan will assist in the improvement of the social service system specifically by improving the facilities and capacity building in the health sector. Japan will also assist to improve the efficiency of disaster management system of the Government of Sri Lanka.'

The PV system to be procured and installed under this Project will contribute to the reduction of out-of-pocket spending by generation of energy. Also, this PV system will strengthen the power supply capacity of each hospital, which will lead to the improvement of social service systems by improving the facilities in the health sector. Therefore, this project matches the policies of both Sri Lanka and Japan.

3-4-2 Effectiveness

Based on the analysis on the effectiveness from quantitative and qualitative views in this section, sufficient effects on the reduction of greenhouse gases and the reduction of electrical expenses are anticipated. Since the personnel in charge of operation and maintenance at each hospital havethe necessary skill level, the Project has high relevancy and effectiveness.

(1) Quantitative effects

The anticipated quantitative effects are shown in Table 3.1.

Table 3.1 Quantitative effects of the Project

Indicator	Reference value (2023)	Target value (2028)
Net electric energy generated by the PV system	0	1,269.4MWh (8.6% of the present power consumption of hospitals)
GHG reduction	0	820t-CO_2 (11.1% reduction of CO_2 emission casued by power consumption)
Reduction of payment for the electricity	0	25.5 million SLR/year (8.7% reduction the present electricy bill of hospitals)

Note: Based on the result of questionnaire conducted in 2022, power tariffs of SLGH, TH Ratnapura and TH Kurunegala are assumed as 22.6 SLR/kWh, 18.0SLR/kWh and 17.6SLR/kWh respectively.

[Source] JICA Survey Team

1) Anticipated power generation

Power generated by the PV system is calculated as follow:

$$E_{PM} = K' \times K_{PT} \times P_{AS} \times H_{AM} / G_S$$

Whereas,

- E_{PM} Anticipated generation energy [kWh/month]

- K' Basic design coefficient
- K_{PT} Temperature correction factor
- P_{AS} Sum of total output of PV module [kW]
- H_{AM} Global Solar radiation on tilted surface [kWh/(m^2*month)]
- G_S Solar radiation intensity under STC (Standard Test Condition) [kW/m^2]

Basic design coefficient K' is determined by following formula by using DC correction factor K_d and efficiency of inverterη_{INO}.

$$K' = K_d \times \eta_{INO}$$

0.9 is applied to Kd, considering dirt on PV surface, loss of solar radiation by its changing.

0.95 is applied to ηINO.

KPT is the correction factor for changing the power generation efficiency caused by the temperature rise of PV module. K_{PT} is calculated by the following formula.

$$K_{PT} = 1 + \alpha (Tm - 25) / 100$$

-0.5(% / ºC) is applied to α (Maximum output temperature coefficient) assuming that the type of pV module is crystalline.

Tm (Module temperature: oC) = Tav + ΔT (Whereas, Tav: Average monthly temperature (oC) and ΔT is 21.5 oC considering the location of PV modules is rooftop.

PV output P_{AS} is the sum of assumed PV output based on the number of panels. H_{AM} is calculated by using solar radiation calculation software METEONORM Version 8.1 by applying the conditions shown in Table 3.2.

Table 3.2 Condition of calculation of power generation by PV system

Location	Building	PV output (kW)	Azimuth	Tilt	Remark (Azimuth of roof)
SJGH (Colombo)	Block B	210.74	+4°	21°	South
		232.47	-176°	21°	North
TH Ratnapura (Ratnapura)	JICA building	92.25	-21°	21°	South-South-East
		92.25	+159°	21°	North-North-West
	A&E	12.30	-7°	21°	South
		6.15	+83°	21°	West
		12.30	+173°	21°	North
		6.15	-97°	21°	East
	Blood bank	12.30	-5°	15°	South
		6.15	+85°	15°	West
		6.15	+175°	15°	North
		6.15	-95°	15°	East
TH Kurunegala (Kurunegala)	Maternity building	73.39	-34°	26°	South-East
		45.1	+56°	26°	South-West
		91.43	+146°	26°	North-West
		51.66	-124°	26°	Nort-East

1 is applied to Gs.

The result of anticipated power generation is shown in Table 3.3. The annual total power generation is 1,269.4MWh.

Table 3.3 Anticipated monthly power output

Sri Jayewardenepura General Hospital (SJGH)

Unit: MWh

	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Block-B	47.9	49.6	58.1	54.5	50.4	48.8	50.3	51.7	52.3	50.1	46.8	44.2	604.7

TH Ratnapura

Unit: MWh

	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
JICA building	20.7	21.1	24.6	22.8	21.0	20.3	20.8	21.4	21.6	21.2	19.9	18.9	254.2
Blood building	3.6	3.7	4.2	3.9	3.5	3.4	3.5	3.6	3.7	3.7	3.4	3.3	43.5
A&E building	4.1	4.2	4.9	4.6	4.2	4.1	4.2	4.3	4.3	4.2	4.0	3.8	50.9
Total	**28.4**	**29.0**	**33.7**	**31.3**	**28.7**	**27.8**	**28.5**	**29.3**	**29.6**	**29.1**	**27.3**	**26.0**	**348.6**

TH Kurunegala

Unit: MWh

	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Maternity complex	26.6	26.7	31.1	29.3	26.4	25.4	25.9	26.1	26.0	25.5	24.0	23.2	316.1

[Source] JICA Survey Team

2) Anticipated annual reduction of fossil fuels

According to the JICA Climate-FIT: Mitigation (Climate change countermeasures assisting tool), reduction of GHG (ERy) is calculated as below in case of installation of solar power generation system.

ERy = BEy – Pey

Whereas,

- ERy: Reduction of GHG as of year y (when the project will be implemented) (t-CO2e/y)
- BEy: Reduction of GHG as of year y (Baseline scenario) (t-CO2e/y)
- PEy: Reduction of GHG as of year y (Project scenario) (t-CO2e/y)

In addition, BEy is calculated as below:

$BE_y = EG_y – EF_{elec}$

Whereas,

- EGy: Total power generated by renewable energy sources (MWh/year)
- EFelec: CO2 emission factor

Considering the characteristics of intermittent power supply of solar PV system, EF_{elec} applies the value of Combined Margin Grid Emmission Factor (Intermittant Energy) of Attachment-3 of 'JICA Climate-FIT: Mitigation'. Accordingly, 0.646 is used. As a result, BEy is calculated as 1,269.4 x 0.646 = 820t-CO2.

In case of project for installation of solar power generation system, 0 is applied for PEy.

In conclusion, Reduction of GHG (ERy) is calculated as 820-0=820t-CO2.

3) Sustainability of the Project

Electricity tariff applied for hospitals is 17.2 SLR/kWh. After the installation of the PV system of the Project, the reverse power flow from each hospital to CEB grid is expected not to occur. In case that all the power generated by the PV system will be consumed within each hospital, the payment for the electricity will be reduced as indicated in Table 3.4, and thus the payment for electricity amounting to approx. 21.8 million SLR will be reduced. According to '2-6-2 Operation and Maintenance Cost', the expense for the operation and maintenance of the PV system is estimated to be approximately 2,780USD

(941 thousand SLR), which is 4% of anticipated reduction amount for power tariff. Thus, the sustainability of the PV system after handing over is secured.

The above stated electricity expenses to be reduced is calculated based on the data obtained by JICA Survey Team.

Table 3.4 Anticipated reduction amount of power tariff

Unit: Thousand SLR

	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
SJGH	824	853	999	937	867	839	865	889	900	862	805	760	10,401
TH Ratnapura	488	499	580	538	494	478	490	504	509	501	470	447	5,996
TH Kurunegala	458	459	535	504	454	437	445	449	447	439	413	399	5,437

[Source] JICA Survey Team

(2) Qualitative effects (project-wide)

Qualitative effects of the Project is indicated in Table 3.5.

Table 3.5 Qualitative effects

Current conditions and problems	Project countermeasures	Degree of Project effects and improvement
1. Renewable Energy Master Plan targets the 70% of energy generated by renewable sources by 2030.	Installation of 900kWp of grid-connected PV system to each hospital.	The total generation capacity of this Project is approximate mega solar class and contribute to the achievement of the goal.
2. MOH conduct health related policy with the limited budget.	Indirectly increase the budget for health related policy by reduction of payment for power tariff to CEB.	According to the Annual Performance Report (2020) of MOH, the budget for recurrent expenses is 127,606 million SLR. The reduction of payment for CEB is 21.8 million SLR. According to the interview held at the first field survey, the reduction of payment is anticipated to be used for the implementation of health policy in Sri Lanka.

Appendices

1. Member List of the Survey Team

First field survey

NAME	ASSIGNMENT	ORGANIZATION	REMARK
Katsuya KUGE	Team Leader	Japan International Cooperation Agency (JICA)	ONLINE
Kuri SHIBATA	Operation Officer	JICA	ONLINE
Kyoji FUJII	Chief Consultant / PV generation plan (1)	Yachiyo Engineering Co., Ltd. (YEC)	
Makoto ABE	PV generation plan (2)	YEC	ONLINE
Hidemi HASHIMOTO	Battery energy storage system	YEC	
Kazuaki KONDO	Deputy Chief Consultant / Equipment plan (1)	YEC	
Taro NAKAMURA	Equipment plan (2)	West Japan Engineering Consultants, Inc. (WJEC)	
Keiichiro OHASHI	Equipment plan (3)	WJEC	
Ichiro MASUDA	Facility plan (1)	YEC	
Hisayuki YAMAMOTO	Facility plan (2)	YEC	
Kosei ITO	Facility plan (3)	YEC	
Hironori KOMATSU	Procurement and installation plan & cost estimation (Facilities)	YEC	
Keiya FUJIWARA	Procurement and installation plan & cost estimation (Equipment)	YEC	

Second field survey

NAME	ASSIGNMENT	ORGANIZATION	REMARK
Katsuya KUGE	Team Leader	Japan International Cooperation Agency (JICA)	ONLINE
Eri KAMEI	Operation Officer	JICA	ONLINE
Kyoji FUJII	Chief Consultant / PV generation plan (1)	Yachiyo Engineering Co., Ltd. (YEC)	ONLINE
Makoto ABE	PV generation plan (2)	YEC	ONLINE
Kazuaki KONDO	Deputy Chief Consultant / Equipment plan (1)	YEC	ONLINE
Hisayuki YAMAMOTO	Facility plan (2)	YEC	ONLINE

2. Study Schedule

First field survey schedule

Date			JICA official	Chief consultant / PV generation plan (1)	Deputy chief consultant / Equipment plan (1)	Battery energy storage system	Equpment plan (2)	Equpment plan (3)	Procurement and installation plan & cost estimation (Equipment)	Facility plan (1)	Procurement and installation plan & cost estimation (Facilities)	Facility plan (2)	Facility plan (3)	Place to stay
				Kyoji FUJII YEC	Kazuaki KONDO YEC	Hidemi HASHIMOTO YEC	Taro NAKAMURA WJEC	Keiichiro OHASHI WJEC	Keiya FUJIWARA YEC	Ichiro MASUDA YEC	Hironori KOMATSU YEC	Hisayuki YAMAMOTO YEC	Kosei ITO YEC	
1	2023/4/15	Sat		Trip (Narita 11:35 -> Colombo 17:25)						Trip (Narita 11:35 -> Colombo 17:25)				Colombo
2	2023/4/16	Sun		Data analysis, internal meeting						Data analysis, internal meeting				Colombo
3	2023/4/17	Mon		8:30 @ Lobby Site survey (Sri Jayewardenepura Hospital) 16:30						8:30 @ Lobby Site survey (Sri Jayewardenepura Hospital) 16:30				Colombo
4	2023/4/18	Tue		8:30 @ Lobby Site survey (Sri Jayewardenepura Hospital) 16:30						8:30 @ Lobby Site survey (Sri Jayewardenepura Hospital) 16:30				Colombo
5	2023/4/19	Wed		7:00 @ Lobby Trip (Colombo -> Kurunegala) Site survey (Kurunegala Hospital)						7:00 @ Lobby Trip (Colombo -> Ratnapula) Site survey (Ratnapura Hospital)		Trip (Colombo -> Kurunegala) Site survey (Kurunegala Hospital)		Ratnapura, Kurunegala
6	2023/4/20	Thu		Site survey (Kurunegala Hospital)						Site survey (Ratnapura Hospital)		Site survey (Kurunegala Hospital)		Ratnapura, Kurunegala
7	2023/4/21	Fri		7:00 @ Lobby -> Trip (Kurunegala -> Ratnapura) Site survey (Ratnapura Hospital)						Site survey (Ratnapura Hospital)		Site survey (Ratnapura Hospital)		Ratnapura, Kurunegala
8	2023/4/22	Sat		Site survey (Ratnapura Hospital)						Site survey (Ratnapura Hospital)		Site survey (Ratnapura Hospital)		Ratnapura, Kurunegala
9	2023/4/23	Sun		AM or PM Trip (Ratnapura -> Colombo) Data analysis, internal meeting						Trip (Ratnapura -> Colombo) Data analysis, internal meeting		Trip (kurunegala) -> Colombo) Data analysis, internal meeting		Colombo
10	2023/4/24	Mon		09:00 Meeting (JICA office) 11:00 Courtesy visit (Ministry of Health (MOH)) 16:00 Technical discussion (Sri Lanka Sustainable energy Authority (SLSEA))		Site survey (Sri Jayewardenepura Hospital)				Market survey Site survey (Sri Jayewardenepura Hospital)				Colombo
11	2023/4/25	Tue		8:00 Site survey (Sri Jayewardenepura Hospital) 14:00 Visit (Sri Lanka Standards Institution)		Site survey (Sri Jayewardenepura Hospital)			Trip (Narita 11:35 -> Colombo 17:25)	Market survey Site survey (Sri Jayewardenepura Hospital)				Colombo
12	2023/4/26	Wed	Discussion on the MOD (ONLINE)	11:00 Technical discussion (Ministry of Power and Energy: MOPE) 12:00 Discussion on the MOD		Trip (Colombo -> Ratnapura) Site survey (Ratnapura Hospital)			Market survey	Market survey				Colombo, Ratnapura
13	2023/4/27	Thu	Discussion on the MOD (ONLINE)	Data analysis, internal meeting		Site survey (Ratnapura Hospital)			Market survey	Market survey Technical discussion (SLREA) Preparation for procurement plan				Colombo, Ratnapura
14	2023/4/28	Fri	Signing the MOD (ONLINE)	11:30 Report (Embassy of Japan) 13:30 Report (JICA) Trip (Colombo 19:15 -> Tokyo 7:35+1)		Site survey (Ratnapura Hospital)			Market survey	Market survey Technical discussion (Department of Meteorology) Trip (Colombo 19:15 -> Tokyo 7:35+1)				Colombo, Kurunegala
15	2023/4/29	Sat		Trip	Trip (Colombo -> Ratnapura) [Kondo & Fujiwara only] Site survey (Ratnapura Hospital)					Trip				Ratnapura
16	2023/4/30	Sun			Trip (Ratnapura -> Kurunegala) Data analysis, internal meeting									Colombo
17	2023/5/1	Mon			Site survey (Kurunegala Hospital) Preparation for field report									Kurunegala
18	2023/5/2	Tue			Site survey (Kurunegala Hospital) Preparation for field report									Kurunegala
19	2023/5/3	Wed			Site survey (Kurunegala Hospital) Submission of draft field report to hospitals									Kurunegala
20	2023/5/4	Thu			Trip (Kurunegala -> Colombo) Online discussion on draft field report									Colombo
21	2023/5/5	Fri			Holiday Data analysis, internal meeting									Colombo
22	2023/5/6	Sat			Holiday Data analysis, internal meeting									Colombo
23	2023/5/7	Sun			Data analysis, internal meeting									Colombo
24	2023/5/8	Mon			Signing the field report (MOH) Trip (Colombo 19:15 -> Tokyo 7:35+1)									on board
25	2023/5/9	Tue			Trip									—

[Remark] MOD: Minutes of Discussions, YEC: Yachiyo Engineering Co., Ltd. WJEC: West Japan Engineerign Consultants Inc.

FIELD SURVEY SCHEDULE (ONLINE)

Date			JICA official	Chief consultant / PV generation plan (1)	Deputy chief consultant / Equipment plan (1)	Facility plan (2)	Place to stay
				Kyoji FUJII YEC	Kazuaki KONDO YEC	Hisayuki YAMAMOTO YEC	
1	2023/4/24	Mon	Explanation of draft preparatory survey report and discussion on the MOD				Online
2	2023/4/25	Tue					
3	2023/4/26	Wed					
4	2023/4/27	Thu					
5	2023/4/28	Fri	Explanation of draft preparatory survey report and discussion on the MOD				Online

3. List of Parties Concerned in the Recipient Contry

Ministry of Health （MOH)

Dr. Sunil De Alwis	Consultant in Medical Administration Additional Secretary (Medical Services)
Dr. Avanthi Rupasinghe	Senior Registrar/Add. Secretary of Office
Eng. S.P. Senavirathna	Civil Engineer
Eng. A.S. Dharmabandu	Mechanical Engineer
Eng. K.S.C.M. De Silva	Electrical Engineer

Sri Jayewardenepura General Hospital

Dr. Rathnasiri A Hewage	Consultant in Medical Administration Director
T.W. Jayanath	Electrical Foreman
D.C. Wickramasena	Accountant
T.W. Malitha S. Perera	Management Assistant

Teaching Hospital Ratnapura

Dr. Anoja Rodrigo	Director
Dr. R.D.S. Ranasinghe	Deputy Director
Dr. K.D.U.C. Rathnayake	Medical Officer-GMU
I.B.Y. Kandewatta	Development Officer

Teaching Hospital Kurunegala

Dr. Chandana Kendangamuwa	Director
Dr. Sanjeewanie Rajakaruna	Deputy Director
Dr. H.B.I.L. Siriwimala	Medical Officer - Planning
A.L. K. Samarasinghe	Resident Engineer – CECB
S. Wickaramaarchchi	Hospital Secretary
Thushara Ilankoon	Hospital Secretary
Dr. R.A.W.N. Ranathunga	Medical Officer Quality Management Unit
H.M.P. Gunaratne	Development Officer
H.M.I.S. Herath	Development Officer
H.M.N.J. Bandara	Health Management Assistant Officer
E.D.M.K. Wijesinghe	Development Officer
H.M.J.P.B. Herath	Health Management Assistant Officer

Ministry of Power and Energy

Mr. Samitha Thennakoon	Deputy Director

Sri Lanka Sustainable Energy Authority

Eng. J. M. Athla	Director General

Department of Meteorology

Shiromani Jayawardene	Director

Central Engineering Consultancy Bureau (CECB), Ratnapura

Aruna Abeyrathne	Electrical Engineer
Praneeth Jayaweera	Electrical Superintendent

Ceylon Electricity Board (CEB), Ratnapura

Eng. Parakrama Ranasinghe	Civil Engineer
I.A.M. Senarath	Quantity Surveyor

Ceylon Electricity Board (CEB), Kurunegala

Eng. Palitha Rathnayake	Chief Engineer

Embassy of Japan in Sri Lanka

Ms. Sachi Tanaka	Second Secretary (Economic Section)

JICA Sri Lanka Office

Tetsuya Yamada	Chief Representative
Yuri Ide	Senior Representative
Tsuyoshi Mizuno	Representative
Takashi Kondo	Representative

4. Minutes of Discussions (M/D)

Minutes of Discussions
on
the Preparatory Survey for the Project
for
Strengthening Electricity Resilience in Hospitals Using Renewable Energy

Based on the several preliminary discussions between the Government of Sri Lanka (hereinafter referred to as "Sri Lanka") and Japan International Cooperation Agency, Japan International Cooperation Agency (hereinafter referred to as "JICA") dispatched the Preparatory Survey Team for the Outline Design (hereinafter referred to as "the Team") of the Project for Strengthening Electricity Resilience in Hospitals Using Renewable Energy (hereinafter referred to as "the Project") to Sri Lanka. The Team held a series of discussions with the officials of the Government of Sri Lanka and conducted a field survey. In the course of the discussions, both sides have confirmed the main items described in the attached sheets.

Colombo, 28 April, 2023

Dr. KUGE Katsuya
Leader, Preparatory Survey Team
Japan International Cooperation Agency
Japan

Mr. Janaka Sri Chhadraguptha
Secretary
Ministry of Health
Sri Lanka

ATTACHMENT

1. Objective of the Project
The objective of the Project is to provide a stable power supply to the hospitals by/through installing solar power generation and battery storage system, thereby contributing to provide improved medical services through decarbonization and reduction of cost of fuel and electricity.

2. Title of the Preparatory Survey
Both sides confirmed the title of the Preparatory Survey as "the Preparatory Survey for the Project for Strengthening Electricity Resilience in Hospitals Using Renewable Energy".

3. Project site
Both sides confirmed that the sites of the Project are Sri Jayawardhanapura General Hospital (SJGH) in Western Province, Teaching Hospital (TH) – Rathnapura in Sabaragamuwa Province, and Teaching Hospital (TH) - Kurunegala in North-Western Province,which is shown in Annex 1.

4. Responsible authority for the Project
Both sides confirmed the authorities responsible for the Project are as follows:

4-1. The Ministry of Health will be the executing agency for the Project (hereinafter referred to as "the Executing Agency"). The Executing Agency shall coordinate with all the relevant authorities to ensure smooth implementation of the Project and ensure that the undertakings for the Project shall be managed by relevant authorities properly and on time. The organization charts are shown in Annex 2.

5. Items requested by the Government of Sri Lanka

5-1. As a result of discussions, both sides confirmed that the items requested by the Government of Sri Lanka are as follows:
Roof mounted solar power generation and battery storage system with EMS (Energy Management System) for Sri Jayawardhanapura General Hospital, Teaching Hospital – Rathnapura and Teaching Hospital - Kurunegala

5-2. JICA will assess the feasibility of the above requested items through the survey and will report the findings to the Government of Japan. The final scope of the Project will be decided by the Government of Japan.

5-3. The Government of Sri Lanka shall submit an official request to the Government of Japan through a diplomatic channel before the appraisal of the Project, which is scheduled in August, 2023.

6. Procedures and Basic Principles of Japanese Grant

6-1. The Sri Lanka side agreed that the procedures and basic principles and basic principles of Japanese Grant (hereinafter referred to as "the Grant") as described in Annex 3 shall be applied to the Project.

As for the monitoring of the implementation of the Project, JICA requires Sri Lanka side to submit the Project Monitoring Report, the form of which is attached as Annex 4.

6-2. TheSri Lanka side agreed to take the necessary measures, as described in Annex 5, for smooth implementation of the Project. The contents of the Annex 5 will be elaborated and refined during the Preparatory Survey and be agreed in the mission dispatched for explanation of the Draft Preparatory Survey Report.

The contents of Annex 5 will be updated as the Preparatory Survey progresses, and eventually, will be used as an attachment to the Grant Agreement.

7. Schedule of the Survey

7-1. The Team will proceed with further survey in Sri Lanka until 8th of May 2023.

7-2. An official request to the Government of Japan will be submitted before August, 2023.

7-3. JICA will prepare a draft Preparatory Survey Report in English and to explain its contents around August 2023.

7-4. If the contents of the draft Preparatory Survey Report is accepted and the undertakings for the Project are fully agreed by the Sri Lanka side, JICA will finalize the Preparatory Survey Report and send it to Sri Lanka around April 2024.

7-5. The above schedule is tentative and subject to change.

8. Environmental and Social Considerations

8-1. The Sri Lanka side confirmed to give due environmental and social considerations during implementation, and after completion of the Project, in accordance with the JICA Guidelines for Environmental and Social Considerations (January, 2022).

8-2. The Project is categorized as "A/B/C/FI" from the following considerations:

The project is likely to have minimal adverse impact on the environment under the JICA guidelines for environmental and social considerations (January, 2022).

The EIA report is not required for the Project in the country's legal system.

9. Other Relevant Issues

9-1 Gender Mainstreaming

Both sides confirmed that following gender elements shall be duly reflected in the scope of Preparatory Survey.

(a) Percentage of female in health service beneficiaries and service providers.

(b) Percentage of female staff in departments responsible for equipment maintenance.

Annex 1 Project Site

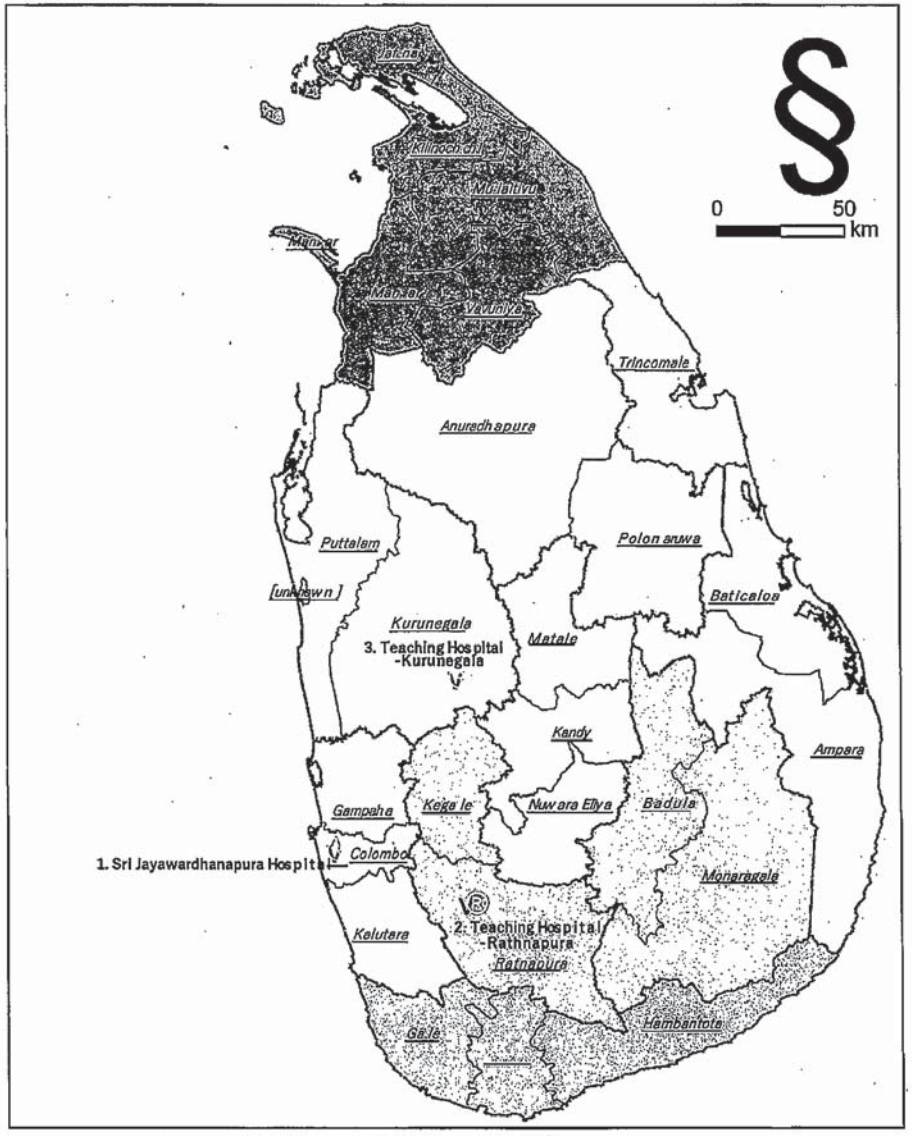
Annex 2 Organization Chart

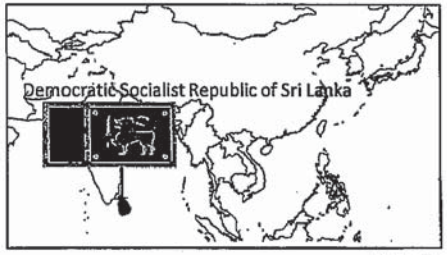
Annex 3 Japanese Grant

Annex 4 Project Monitoring Report (template)

Annex 5 Major Undertakings to be taken by the Government of Sri Lanka

Annex 1





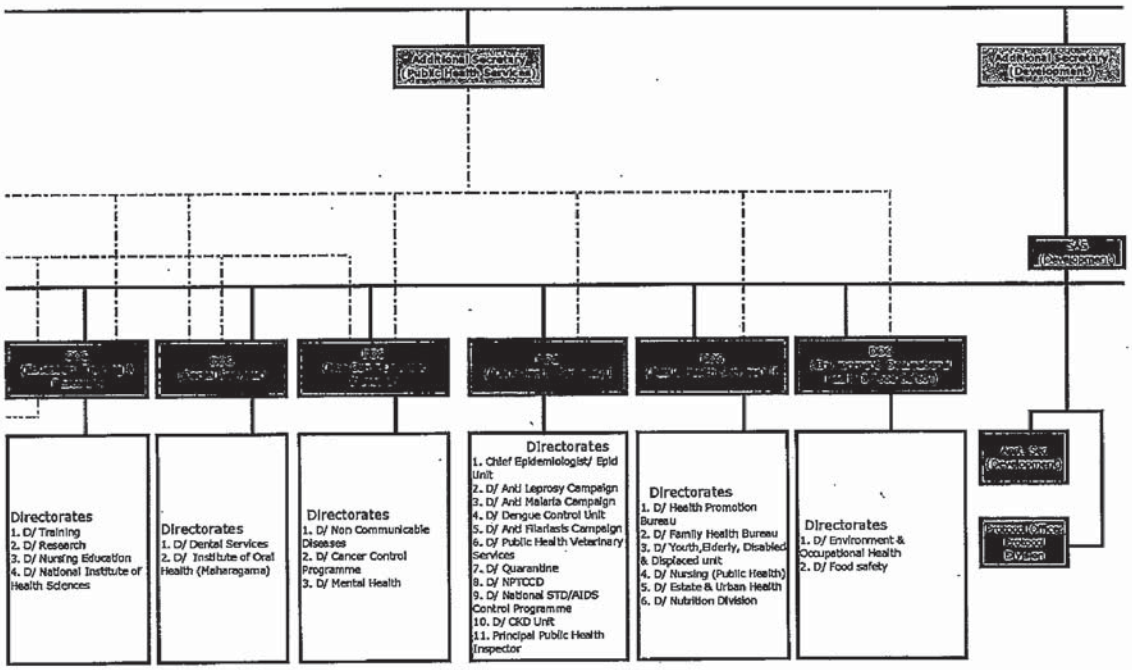
Legend

- Capital Sri Jayawardenepura Kotte
- Hospital
- Province border

Province

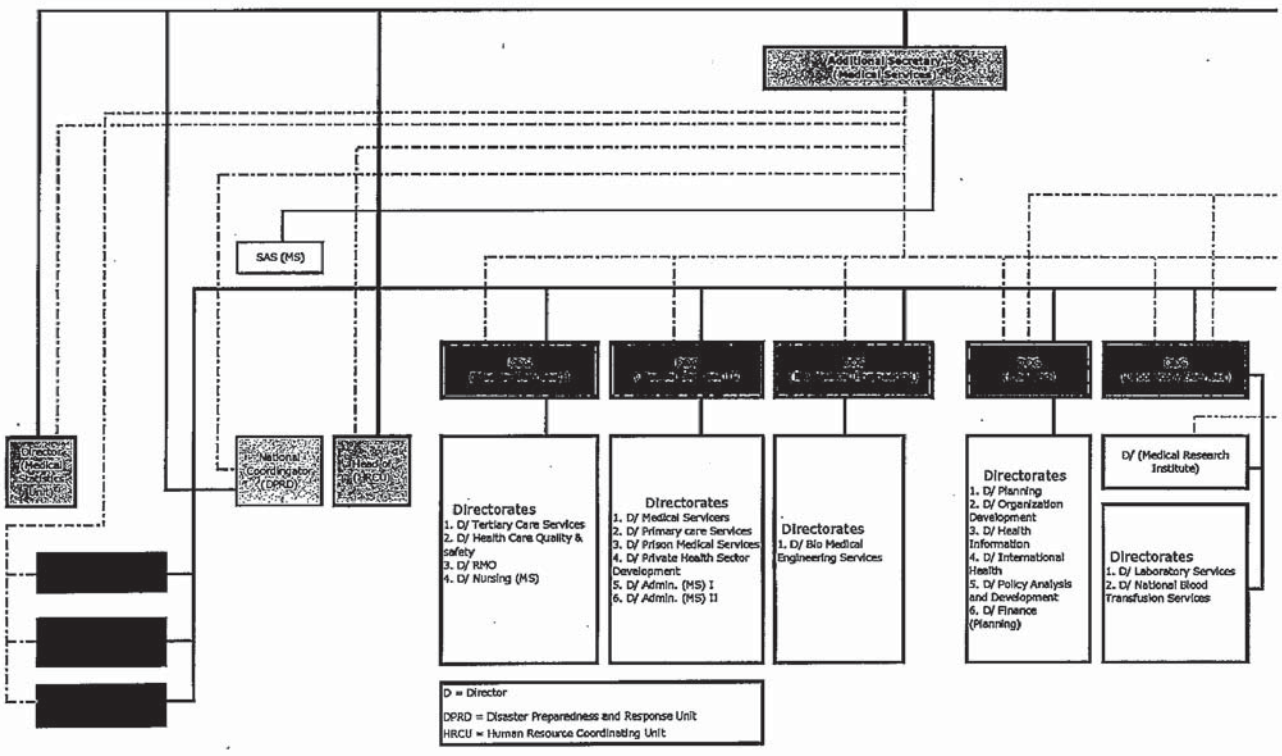
- Central
- Eastern
- North Central
- NorthWestern
- Northern
- Sabaragamuwa
- Southern
- Uva
- Western

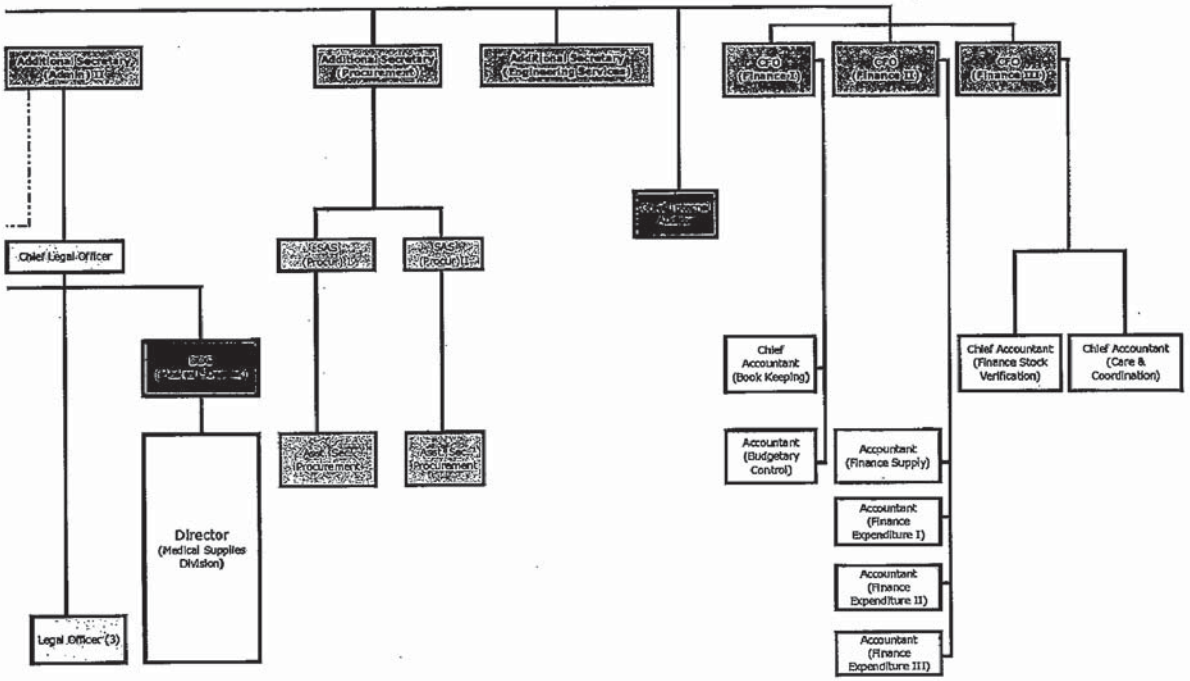
Project Site



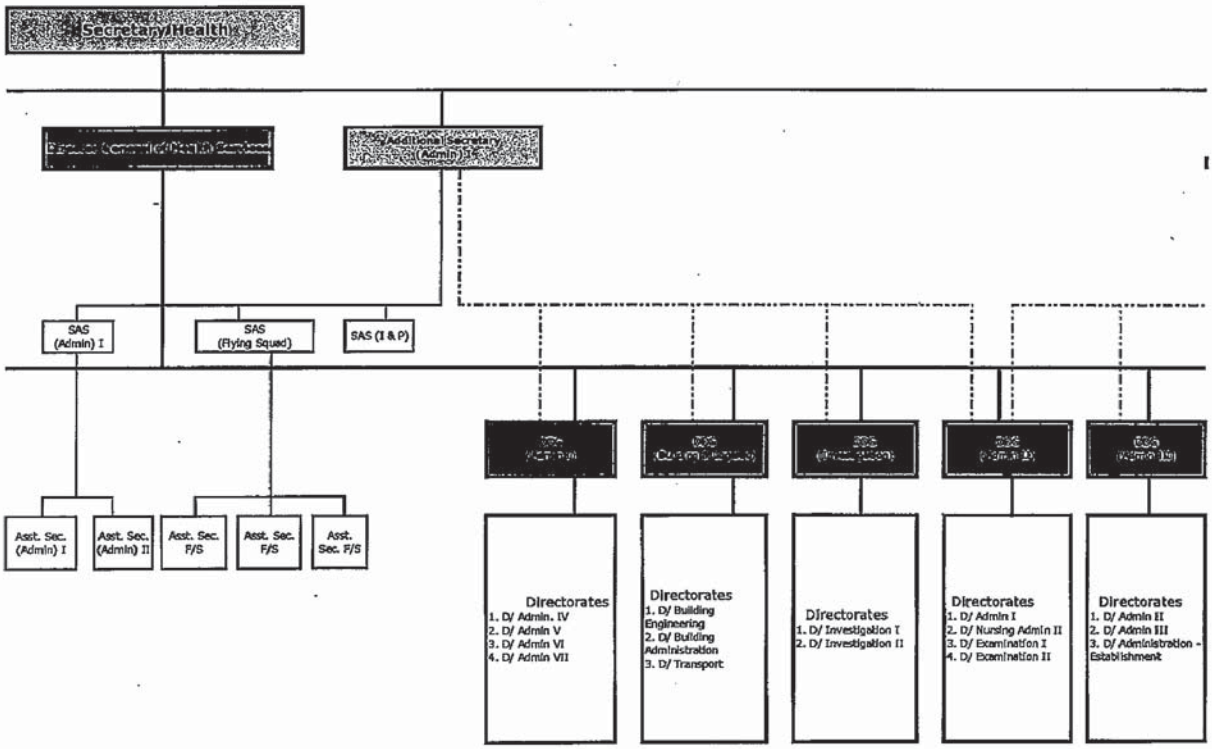
Annex 2

Draft Organization Structure for Ministry of Health - 24.03.2022





OD Unit – MDPU (24.03.2022)



OD Unit – MDPU (24.03.2022)

Annex 3

JAPANESE GRANT

The Japanese Grant is non-reimbursable fund provided to a recipient country (hereinafter referred to as "the Recipient") to purchase the products and/or services (engineering services and transportation of the products, etc.) for its economic and social development in accordance with the relevant laws and regulations of Japan. Followings are the basic features of the project grants operated by JICA (hereinafter referred to as "Project Grants").

1. Procedures of Project Grants

Project Grants are conducted through following procedures (See "PROCEDURES OF JAPANESE GRANT" for details):

(1) Preparation
- The Preparatory Survey (hereinafter referred to as "the Survey") conducted by JICA

(2) Appraisal
- Appraisal by the government of Japan (hereinafter referred to as "GOJ") and JICA, and Approval by the Japanese Cabinet

(3) Implementation

Exchange of Notes
- The Notes exchanged between the GOJ and the government of the Recipient

Grant Agreement (hereinafter referred to as "the G/A")
- Agreement concluded between JICA and the Recipient

Banking Arrangement (hereinafter referred to as "the B/A")
- Opening of bank account by the Recipient in a bank in Japan (hereinafter referred to as "the Bank") to receive the grant

Construction works/procurement
- Implementation of the project (hereinafter referred to as "the Project") on the basis of the G/A

(4) Ex-post Monitoring and Evaluation
- Monitoring and evaluation at post-implementation stage

2. Preparatory Survey

(1) Contents of the Survey

The aim of the Survey is to provide basic documents necessary for the appraisal of the the Project made by the GOJ and JICA. The contents of the Survey are as follows:

- Confirmation of the background, objectives, and benefits of the Project and also institutional capacity of relevant agencies of the Recipient necessary for the implementation of the Project.
- Evaluation of the feasibility of the Project to be implemented under the Japanese Grant from a technical, financial, social and economic point of view.
- Confirmation of items agreed between both parties concerning the basic concept of the Project.
- Preparation of an outline design of the Project.
- Estimation of costs of the Project.
- Confirmation of Environmental and Social Considerations

The contents of the original request by the Recipient are not necessarily approved in their initial form. The Outline Design of the Project is confirmed based on the guidelines of the Japanese Grant.

JICA requests the Recipient to take measures necessary to achieve its self-reliance in the implementation of the Project. Such measures must be guaranteed even though they may fall outside of the jurisdiction of the executing agency of the Project. Therefore, the contents of the Project are confirmed by all relevant organizations of the Recipient based on the Minutes of Discussions.

(2) Selection of Consultants

For smooth implementation of the Survey, JICA contracts with (a) consulting firm(s). JICA selects (a) firm(s) based on proposals submitted by interested firms.

(3) Result of the Survey

JICA reviews the report on the results of the Survey and recommends the GOJ to appraise the implementation of the Project after confirming the feasibility of the Project.

3. Basic Principles of Project Grants

(1) Implementation Stage

1) The E/N and the G/A

After the Project is approved by the Cabinet of Japan, the Exchange of Notes (hereinafter referred to as "the E/N") will be signed between the GOJ and the Government of the Recipient to make a pledge for assistance, which is followed by the conclusion of the G/A between JICA and the Recipient to define the necessary articles, in accordance with the E/N, to implement the Project, such as conditions of disbursement, responsibilities of the Recipient, and procurement conditions. The terms and conditions generally applicable to the Japanese Grant are stipulated in the "General Terms and Conditions for Japanese Grant (January 2016)."

2) Banking Arrangements (B/A) (See "Financial Flow of Japanese Grant (A/P Type)" for details)

a) The Recipient shall open an account or shall cause its designated authority to open an account under the name of the Recipient in the Bank, in principle. JICA will disburse the Japanese Grant in Japanese yen for the Recipient to cover the obligations incurred by the Recipient under the verified contracts.

b) The Japanese Grant will be disbursed when payment requests are submitted by the Bank to JICA under an Authorization to Pay (A/P) issued by the Recipient.

3) Procurement Procedure

The products and/or services necessary for the implementation of the Project shall be procured in accordance with JICA's procurement guidelines as stipulated in the G/A.

4) Selection of Consultants

In order to maintain technical consistency, the consulting firm(s) which conducted the Survey will be recommended by JICA to the Recipient to continue to work on the Project's implementation after the E/N and G/A.

5) Eligible source country

In using the Japanese Grant disbursed by JICA for the purchase of products and/or services, the eligible source countries of such products and/or services shall be Japan and/or the Recipient. The Japanese Grant may be used for the purchase of the products and/or services of a third country as eligible, if necessary, taking into account the quality, competitiveness and economic rationality of products and/or services necessary for achieving the objective of the Project. However, the prime contractors, namely, constructing and procurement firms, and the prime consulting firm, which enter into contracts with the Recipient, are limited to "Japanese nationals", in principle.

6) Contracts and Concurrence by JICA

The Recipient will conclude contracts denominated in Japanese yen with Japanese nationals. Those contracts shall be concurred by JICA in order to be verified as eligible for using the Japanese Grant.

7) Monitoring

The Recipient is required to take their initiative to carefully monitor the progress of the Project in order to ensure its smooth implementation as part of their responsibility in the G/A, and to regularly report to JICA about its status by using the Project Monitoring Report (PMR).

8) Safety Measures

The Recipient must ensure that the safety is highly observed during the implementation of the Project.

9) Construction Quality Control Meeting

Construction Quality Control Meeting (hereinafter referred to as the "Meeting") will be held for quality assurance and smooth implementation of the Works at each stage of the Works. The member of the Meeting will be composed by the Recipient (or executing agency), the Consultant, the Contractor and JICA. The functions of the Meeting are as followings:

a) Sharing information on the objective, concept and conditions of design from the Contractor, before start of construction.

b) Discussing the issues affecting the Works such as modification of the design, test, inspection, safety control and the Client's obligation, during of construction.

(2) Ex-post Monitoring and Evaluation Stage

1) After the project completion, JICA will continue to keep in close contact with the Recipient in order to monitor that the outputs of the Project is used and maintained properly to attain its expected outcomes.

2) In principle, JICA will conduct ex-post evaluation of the Project after three years from the completion. It is required for the Recipient to furnish any necessary information as JICA may reasonably request.

(3) Others

1) Environmental and Social Considerations

The Recipient shall carefully consider environmental and social impacts by the Project and must comply with the environmental regulations of the Recipient and JICA Guidelines for Environmental and Social Considerations (April, 2010).

2) Major undertakings to be taken by the Government of the Recipient

For the smooth and proper implementation of the Project, the Recipient is required to undertake necessary measures including land acquisition, and bear an advising commission of the A/P and payment commissions paid to the Bank as agreed with the GOJ and/or JICA. The Government of the Recipient shall ensure that customs duties, internal taxes and other fiscal levies which may be imposed in the Recipient with respect to the purchase of the Products and/or the Services be exempted or be borne by its designated authority without using the Grant and its accrued interest, since the grant fund comes from the Japanese taxpayers.

3) Measures to ensure more efficient implementation of the Grant

i) In the event that the E/N and the G/A concerning a project cannot be signed by the end of the following Japanese fiscal year of the cabinet decision concerned by the GOJ, the authorities concerned of the two Governments will discuss the cancellation of the project.

ii) In the event that the period, specified in the G/A, during which the grant is available expires before the completion of the disbursement, the authorities concerned of the GO J will thoroughly review the status, situation and perspective of the implementation of the project concerned before extending the said period. The authorities concerned of the two Governments will discuss the termination of the project including a refund, unless there are concrete prospects for its completion.

iii) Regardless of the period mentioned in ii) above, the authorities concerned of the two Governments will, in the event that five years have passed since the cabinet decision concerned by the GOJ before the completion of the disbursement, except as otherwise confirmed between them, discuss the termination of a project including a refund, unless there are concrete prospects for its completion.

4) Proper Use

The Recipient is required to maintain and use properly and effectively the products and/or services under the Project (including the facilities constructed and the equipment purchased), to assign staff necessary for this operation and maintenance and to bear all the expenses other than those covered by the Japanese Grant.

5) Export and Re-export

The products purchased under the Japanese Grant should not be exported or re-exported from the Recipient.

Project Monitoring Report
on
Project for Strengthening Electricity Resilience in Hospitals Using Renewable Energy
Grant Agreement No. XXXXXXX

20XX, Month

Organizational Information

Signer of the G/A (Recipient)	Person in Charge (Designation) Contacts Address: Phone/FAX: Email:
Executing Agency	Person in Charge (Designation) Contacts Address: Phone/FAX: Email:
Line Ministry	Person in Charge (Designation) Contacts Address: Phone/FAX: Email:

General Information:

Project Title	
E/N	Signed date: Duration:
G/A	Signed date: Duration:
Source of Finance	Government of Japan: Not exceeding JPY _____ mil. Government of (_____): _____

1: Project Description

1-1 Project Objective

1-2 Project Rationale

- Higher-level objectives to which the project contributes (national/regional/sectoral policies and strategies)
- Situation of the target groups to which the project addresses

1-3 Indicators for measurement of "Effectiveness"

Quantitative indicators to measure the attainment of project objectives		
Indicators	Original (Yr)	Target (Yr)
Qualitative indicators to measure the attainment of project objectives		

2: Details of the Project

2-1 Location

Components	Original *(proposed in the outline design)*	Actual
1.		

2-2 Scope of the work

Components	Original* *(proposed in the outline design)*	Actual*
1.		

Reasons for modification of scope (if any).

(PMR)

2-3 Implementation Schedule

Items	Original		Actual
	(proposed in the outline design)	*(at the time of signing the Grant Agreement)*	

Reasons for any changes of the schedule, and their effects on the project (if any)

2-4 **Obligations by the Recipient**

2-4-1 **Progress of Specific Obligations**
See Attachment 2.

2-4-2 **Activities**
See Attachment 3.

2-4-3 **Report on RD**
See Attachment 11.

2-5 **Project Cost**

2-5-1 **Cost borne by the Grant(Confidential until the Bidding)**

Components			Cost (Million Yen)	
	Original *(proposed in the outline design)*	Actual *(in case of any modification)*	Original[1),2)] *(proposed in the outline design)*	Actual
	1.			
Total				

Note: 1) Date of estimation:
2) Exchange rate: 1 US Dollar = Yen

2-5-2 **Cost borne by the Recipient**

Components			Cost (1,000 Taka)	
	Original *(proposed in the outline design)*	Actual *(in case of any modification)*	Original[1),2)] *(proposed in the outline design)*	Actual
	1.			

Note: 1) Date of estimation:
2) Exchange rate: 1 US Dollar =

Reasons for the remarkable gaps between the original and actual cost, and the countermeasures (if any)

(PMR)

2-6 **Executing Agency**
- Organization's role, financial position, capacity, cost recovery etc,
- Organization Chart including the unit in charge of the implementation and number of employees.

Original *(at the time of outline design)* name: role: financial situation: institutional and organizational arrangement (organogram): human resources (number and ability of staff):
Actual *(PMR)*

2-7 **Environmental and Social Impacts**

- The results of environmental monitoring based on Attachment 5 (in accordance with Schedule 4 of the Grant Agreement).
- The results of social monitoring based on in Attachment 5 (in accordance with Schedule 4 of the Grant Agreement).
- Disclosed information related to results of environmental and social monitoring to local stakeholders (whenever applicable).

3: Operation and Maintenance (O&M)

3-1 **Physical Arrangement**
- Plan for O&M (number and skills of the staff in the responsible division or section, availability of manuals and guidelines, availability of spareparts, etc.)

Original *(at the time of outline design)*
Actual *(PMR)*

3-2 **Budgetary Arrangement**
- Required O&M cost and actual budget allocation for O&M

Original *(at the time of outline design)*

Actual *(PMR)*

4: Potential Risks and Mitigation Measures

- Potential risks which may affect the project implementation, attainment of objectives, sustainability
- Mitigation measures corresponding to the potential risks

Assessment of Potential Risks *(at the time of outline design)*

Potential Risks	Assessment
1. (Description of Risk)	Probability: High/Moderate/Low
	Impact: High/Moderate/Low
	Analysis of Probability and Impact:
	Mitigation Measures:
	Action required during the implementation stage:
	Contingency Plan (if applicable):
2. (Description of Risk)	Probability: High/Moderate/Low
	Impact: High/Moderate/Low
	Analysis of Probability and Impact:
	Mitigation Measures:
	Action required during the implementation stage:
	Contingency Plan (if applicable):
3. (Description of Risk)	Probability: High/Moderate/Low
	Impact: High/Moderate/Low
	Analysis of Probability and Impact:
	Mitigation Measures:
	Action required during the implementation stage:

	Contingency Plan (if applicable):
Actual Situation and Countermeasures	
(PMR)	

5: Evaluation and Monitoring Plan (after the work completion)

5-1 Overall evaluation

Please describe your overall evaluation on the project.

5-2 Lessons Learnt and Recommendations

Please raise any lessons learned from the project experience, which might be valuable for the future assistance or similar type of projects, as well as any recommendations, which might be beneficial for better realization of the project effect, impact and assurance of sustainability.

5-3 Monitoring Plan of the Indicators for Post-Evaluation

Please describe monitoring methods, section(s)/department(s) in charge of monitoring, frequency, the term to monitor the indicators stipulated in 1-3.

Monitoring sheet on price of specified materials

1. Initial Conditions (Confirmed)

	Items of Specified Materials	Initial Volume A	Initial Unit Price (¥) B	Initial total Price C=A×B	1% of Contract Price D	Condition of payment	
						Price (Decreased) E=C−D	Price (Increased) F=C+D
1	Item 1	●●t	●	●	●	●	●
2	Item 2	●●t	●	●	●		
3	Item 3						
4	Item 4						
5	Item 5						

2. Monitoring of the Unit Price of Specified Materials

(1) Method of Monitoring : ●●

(2) Result of the Monitoring Survey on Unit Price for each specified materials

	Items of Specified Materials	1st ○month, 2015	2nd ○month, 2015	3rd ○month, 2015	4th	5th	6th
1	Item 1						
2	Item 2						
3	Item 3						
4	Item 4						
5	Item 5						

(3) Summary of Discussion with Contractor (if necessary)

-
-
-

G/A NO. XXXXXXX
PMR prepared on DD/MM/YY

Attachment

1. Project Location Map
2. Specific obligations of the Recipient which will not be funded with the Grant
3. Monthly Report submitted by the Consultant
4. Appendix - Photocopy of Contractor's Progress Report (if any)
   - Consultant Member List
   - Contractor's Main Staff List
5. Check list for the Contract (including Record of Amendment of the Contract/Agreement and Schedule of Payment)
6. Environmental Monitoring Form / Social Monitoring Form
7. Monitoring sheet on price of specified materials (Quarterly)
8. Report on Proportion of Procurement (Recipient Country, Japan and Third Countries) (PMR (final)only)
9. Pictures (by JPEG style by CD-R) (PMR (final)only)
10. Equipment List (PMR (final)only)
11. Drawing (PMR (final)only)
12. Report on RD (After project)
13. Report on the Management of Safety for Construction Works

Attachment 12

Report on the Management of Safety for Construction Works

Month/Year 2022 年×月	Cumulative number of labor 労働延人数	Cumulative number of public accident 公衆災害件数	Cumulative hours worked 延べ実労働時間数	Number of deaths and injuries due to industrial accidents 労働災害による死傷者				Frequency rate 度数率	Severity rate 強度率
					Death and injuries 死傷者数	Aggregated number of calendar days absent 延べ休業日数	Aggregated number of work-days lost 延べ労働損失日数		
This Month 当月				Death 死者					
				More than 4 calendar days absent 休業 4 日以上					
				1 to 3 calendar days absent 休業 1～3 日					
				Total 計					
Total including this month 当月迄累計				Death 死者					
				More than 4 calendar days absent 休業 4 日以上					
				1 to 3 calendar days absent 休業 1～3 日					
				Total 計					

Note 注)

1. Frequency rate is the frequency of occurrence of industrial accidents.
   Frequency rate = (Number of deaths and injuries due to industrial accidents ÷ Cumulative hours worked) × 1,000,000
   度数率＝（労働災害による死傷者数÷延べ実労働時間数）×100 万時間
2. Severity rate is degree of seriousness of the industrial accident.
   Severity rate = (Aggregated number of work-days lost ÷ Cumulative hours worked) × 1,000
   強度率＝（延べ労働損失日数÷延べ実労働時間数）1000 時間
3. Aggregated number of work-days lost = Aggregated number of calendar days absent ×(300÷365)
   Death（7,500 days）: death as a result of an industrial accident includes not only instantaneous death but also death as a result of occupational injury or disease.
   延べ労働損失日数＝延べ休業日数×（300÷365）・・・死亡 7500 日（即死のほか負傷が原因で死亡したものを含む）
4. Frequency rate and severity rate are rounding off the third decimal place.
   度数率・強度率は小数点第 3 位以下四捨五入

Attachment 7

Report on Proportion of Procurement (Recipient Country, Japan and Third Countries)
(Actual Expenditure by Construction and Equipment each)

	Domestic Procurement (Recipient Country) A	Foreign Procurement (Japan) B	Foreign Procurement (Third Countries) C	Total D
Construction Cost	(A/D%)	(B/D%)	(C/D%)	
Direct Construction Cost	(A/D%)	(B/D%)	(C/D%)	
others	(A/D%)	(B/D%)	(C/D%)	
Equipment Cost	(A/D%)	(B/D%)	(C/D%)	
Design and Supervision Cost	(A/D%)	(B/D%)	(C/D%)	
Total	(A/D%)	(B/D%)	(C/D%)	

Annex 5

Major Undertakings to be taken by the Government of Sri Lanka

1. Specific obligations of the Government of Sri Lanka which will not be funded with the Grant

(1) Before the Tender

NO	Items	Deadline	In charge	Estimated Cost	Ref.
1	To sign the banking arrangement (B/A) with a bank in Japan (the Agent Bank) to open bank account for the Grant	within 1 month after the signing of the G/A	MOH		
2	To issue A/P to the Agent Bank for the payment to the consultant within 1 month after the signing of the contract(s)	within 1 month after the signing of the contract(s)	MOH		
3	To bear the following commissions to the Agent Bank for the banking services based upon B/A				
	1) Advising commission of A/P (Authorization to Pay)	within 1 month after the signing of the contract(s)	MOH		
	2) Payment commission for A/P	every payment	MOH		
4	To submit Project Monitoring Report (with the result of Detailed Design)	before preparation of the bidding documents	MOH		
	Major undertakings to be taken by three hospitals in general:				
5	To secure and clear the following lands 1) Project sites (approx. 12m x 3m (36m^2) for each) for container of PV system at each hospital.	before notice of the bidding	Each hospital		
6	To obtain the planning, zoning, building permit from the Urban Development Authority (UDA)	before notice of the bidding	Each hospital		
7	To obtain the interconnection license from the Ceylon Electricity Board (CEB)	before notice of the bidding	Each hospital		
8	To obtain tree cutting /transplanting permit from relevant authority if necessary.	before notice of the bidding	Each hospital		
9	To clear, level and reclaim the following sites 1) Leveling and reclaiming the sites for container of PV system at each hospital, if necessary. 2) Securing temporary storage yard at each hospital site (approx. 16m x 30m (500m^2)) 3) Securing plots for site offices of the Consultant and the Supplier (approx. 30m^2 each)	before notice of the bidding	Each hospital		
	Major undertakings to be taken by Teaching Hospital Kurunegala in particular				
11	To remove unused incinerator by the maternity building to vacate a space for the container of PV system.	before notice of the bidding	TH Kurunegala		
	Major undertakings to be taken by Teaching Hospital Ratnapura in particular				
12	To construct a retaining wall and reinforce a slope which goes down from the parking lot in front of the main office where a container of PV system is to be installed.	before notice of the bidding	TH Ratnapura		

(2) During the Project Implementation

NO	Items	Deadline	In charge	Estimated Cost	Ref.
1	To issue A/P to the Agent Bank for the payment to the supplier and the contractor	within 1 month after the signing of the contract(s)	MOH		
2	To bear the following commissions to the Agent Bank for the banking services based upon the B/A		MOH		
	1) Advising commission of A/P	within 1 month after the signing of the contract(s)	MOH		
	2) Payment commission for A/P	every payment	MOH		
3	to ensure prompt unloading and customs clearance at ports of disembarkation in the country of the Recipient and to assist the Supplier(s) with internal transportation therein	during the Project	MOH		
4	To accord Japanese physical persons and/or physical persons of third countries whose services may be required in connection with the supply of the products and the services such facilities as may be necessary for their entry into the country of the Recipient and stay therein for the performance of their work	during the Project	MOH		
5	To ensure that customs duties, internal taxes and other fiscal levies which may be imposed in the country of the Recipient with respect to the purchase of the products and/or the services be borne by its designated authority without using the Grant;	during the Project	MOH		
6	To bear all the expenses, other than those covered by the Grant, necessary for the implementation of the Project	during the Project	MOH		
7	To notify JICA promptly of any incident or accident, which has, or is likely to have, a significant adverse effect on the environment, the affected communities, the public or workers.	during the construction	MOH		
8	To submit Project Monitoring Report after each work under the contract(s) such as shipping, hand over, installation and operational training	within 1 month after completion of each work	MOH		
9	To submit Project Monitoring Report (final) (including as-built drawings, equipment list, photographs, etc.)	within 1 month after issuance of Certificate of Completion for the works under the contract(s)	MOH		
10	To submit a notice concerning completion of the Project	within 6 months after completion of the Project	MOH		
11	To provide office space necessary for the implementation of the Project in the site(s)	before start of the construction	MOH and each hospital		
12	To ensure the safety of persons engaged in the implementation of the Project	during the Project	MOH		
13	To take necessary measures for security and safety of the Project site	during the construction	MOH and each hospital		

(3) After the Project

NO	Items	Deadline	In charge	Estimated Cost	Ref.

1	To maintain and use properly and effectively the facilities constructed and equipment provided under the Grant Aid 1) Allocation of maintenance cost 2) Operation and maintenance structure 3) Routine check/Periodic inspection	After completion of the construction	MOH and each hospital		
2	To secure budget for contracting the PV system maintenance agreement with outsourcing company.	After completion of the construction	MOH and each hospital		

2. Other obligations of the Government of Japan funded with the Grant

NO	Items	Deadline	Amount (Million Japanese Yen)*
1	To construct facility and provide equipment 1) To conduct the following transportation a) Marin (Air) transportation of the products from Japan to the country of the Recipient b) Internal transportation from the port of disembarkation to the project site		
	2) To provide equipment with installation and commissioning		
2	To implement detailed design, bidding support and procurement supervision (Consulting Service)		
3	Contingencies		
	Total		XXX

* The Amount is provisional. This is subject to the approval of the Government of Japan.

5. Field Report

PREPARATORY SURVEY
FOR
THE PROJECT FOR STRENGTHENING ELECTRICITY RESILIENCE IN HOSPITALS USING RENEWABLE ENERGY

FIELD REPORT

8th May 2023

Prepared and Submitted by:

for 近藤和晃

Mr. Kyoji FUJII
Chief Consultant,
JICA Study Team

Confirmed and Agreed by:

Dr. Sunil De Alwis
Consultant in Medical Administration
Additional Secretary (Medical Services)
Ministry of Health
The Implementing Agency for the Project

JICA STUDY TEAM

Yachiyo Engineering Co.,Ltd.

Contents

1. Outline of the Project 1
1.1 Background of the Project 1
1.2 Framework for the Project 1
1.3 Scope of the Japanese side 1
1.4 Obligation/Undertakings of the Sri Lankan side for the Project 2
2. Tentative design at the stage of the first field survey 3
2.1 Design condition 3
2.2 Applicable Standards 3
2.3 Technical requirements for building 4
2.3.1 Sri Jayewardenepura General Hospital 4
2.3.2 Teaching Hospital Ratnapura 4
2.3.3 Teaching Hospital Kurunegala 5
2.4 Technical requirements for equipment 6
2.4.1 General description of the System 6
2.4.2 Sri Jayewardenepura General Hospital 7
2.4.3 Teaching Hospital Ratnapura 10
2.4.4 Teaching Hospital Kurunegala 15
2.5 Procurement Plan of Spare Parts and Maintenance Tools 18
2.6 Training plan 18
3. Tentative Implementation Schedule of the Project 18
4. Drawings 20

- GA-01 Site location map
- GA-02 System diagram
- SJ-01 PV arrangement plan (SJGH)
- SJ-02 Temporary facilities plan (SJGH)
- SJ-03 Single line diagram (SJGH)
- RT-01 PV arrangement plan (TH Ratnapura)
- RT-02 Temporary facilities plan (TH Ratnapura)
- RT-03 Single line diagram (TH Ratnapura)
- KU-01 PV arrangement plan (TH Kurunegala)
- KU-02 Temporary facilities plan (TH Kurunegala)
- KU-03 Single line diagram (TH Kurunegala)

[Attachment]

- Attachment – 1 Member List of the Study Team
- Attachment – 2 Major Undertakings to be taken by the Sri Lankan side
- Attachment – 3 Tentative Implementation Schedule

1. Outline of the Project

1.1 Background of the Project

JICA sent to Sri Lanka the survey team (the JICA Study Team) headed by Mr. Kyoji Fujii, Team Leader of the JICA Study Team, to conduct the first field survey and the Team stayed in Sri Lanka from 15th April to 8th May, 2023.

The Team continued discussions with the concerned officials of Sri Lanka and the field survey in Sri Lanka.

Sri Jayewardenepura General Hospital (SJGH), Teaching Hospital Ratnapura (TH Ratnapura) and Teaching Hospital Kurunegala (TH Kurunegala) as well as the Ministry of Health (MOH), the responsible ministry, and the JICA Study Team had series of technical discussions to form mutual understandings about the contents, scope, preconditions for the Outline Design, basic specifications, general layouts, and so on of the Project throughout the first field survey. SJGH, THR, THK, MOH and the JICA Study Team agreed to record the following issues described on this Field Report as a conclusion of the discussions.

Components of the Project will be further examined and may be modified through the consultation with the Japanese Ministry of Foreign Affairs and JICA headquarters. It is important for the Sri Lankan side to understand that the Preparatory Survey is not a commitment for the future implementation of the Project.

Particularly, in consideration of the schedule and procedures of Japan's Grant Aid projects, the JICA Study Team explained, and the Sri Lankan side agreed with the JICA Study Team to proceed to the further study, the outline design, planning of the implementation schedule, the cost estimation and so on of the Project in accordance with the mutual understandings made on this field report immediately after the first field survey.

1.2 Framework for the Project

The Ministry of Health (MOH) will be the Executing Agency for the Project.

1.3 Scope of the Japanese side

The Scope of the Japanese side is shown in Table 1-1 and GA-01 Site location map in the Drawings.

Table 1-1 Outline of the Proposed Components

Components	Capacity
1. Sri Jayewardenepura General Hospital (SJGH)	
(1) Procurement and Installation Work	
1. PV generation system	Approx. 440kW
2. Energy management system	200kW x 2
3. Battery energy storage system	1 lot
4. LV distribution line	1 lot
5. Foundation for the Equipment to be installed	1 lot
(2) Procurement Work	
1) Maintenance Tools for the Equipment to be procured	1 lot
2) Spare Parts for the Equipment to be procured	1 lot
2. Teaching Hospital Ratnapura (TH Ratnapura)	
(1) Procurement and Installation Work	
1) PV generation system	Approx. 280kW
2) Energy management system	200kW x 1, 100kW x 1
3) Battery energy storage system	1 lot
4) LV distribution line	1 lot
5) Foundation for the Equipment to be installed	1 lot
(2) Procurement Work	
1) Maintenance Tools for the Equipment to be procured	1 lot
2) Spare Parts for the Equipment to be procured	1 lot
3. Teaching Hospital Kurunegala (TH Kurunegala)	
(1) Procurement and Installation Work	
1) PV generation system	Approx. 250kW
2) Energy management system	200kW x 1
3) Battery energy storage system	1 lot
4) LV distribution line	1 lot
5) Foundation for the Equipment to be installed	1 lot
(2) Procurement Work	
1) Maintenance Tools for the Equipment to be procured	1 lot
2) Spare Parts for the Equipment to be procured	1 lot

[Remark] Quantities shall be examined in the outline design.

1.4 Obligations/Undertakings of the Sri Lankan side for the Project

A Before the Tender announcement

Major undertakings to be taken by three hospitals in general:

A-1 To secure the sites (approx. 12m x 3m (36m2) for each) for container of PV system at each hospital.

A-2 To obtain the planning, zoning, building permit from the Urban Development Authority (UDA).

A-3 To obtain the interconnection license from the Ceylon Electricity Board (CEB).

A-4 To obtain tree cutting /transplanting permit from relevant authority if necessary.

A-5 To clear, level and reclaim the following sites:

- Leveling and reclaiming the sites for container of PV system at each hospital, if necessary.
- Securing temporary storage yard at each hospital site (approx. 16m x 30m (500m2))
- Securing plots for site offices of the Consultant and the Supplier (approx. 30m2 each).

Major undertakings to be taken by Teaching Hospital Kurunegala in particular

A-6 To remove unused incinerator by the maternity building to vacate a space for the container of PV system.

Major undertakings to be taken by Teaching Hospital Ratnapura in particular

A-7 To construct a retaining wall and reinforce a slope which goes down from the parking lot in front of the main office where a container of PV system is to be installed (to be revised).

B After Handing Over

B-1 To secure budget for contracting the PV system maintenance agreement with outsourcing company.

2. Tentative design at the stage of the first field survey

2.1 Design condition

(a) Climate Condition

Table 2-1 Basic Conditions (2020-2022) for Target Area of the Project

Items		COLOMBO	KURUNEGALA	RATNAPURA
Altitude		7 m	116 m	86 m
Ambient Temperature (Degrees Centigrade)	Maximum	33.3	36.7	35.4
	Minimum	23.7	22.1	22.0
	Mean	31.2	32.2	32.2
Maximum Wind Velocity		2.1 m/s	1.3 m/s	2.0 m/s
Annual Rain Fall		2,443 mm/year	2,209 mm/year	4,078 mm/year

(b) System voltage

400/230 V : 3 phase 4 wire system

(c) Frequency

50 Hz

2.2 Applicable Standards

Considering the conditions of Japan's Grant Aid in which Japanese products need to be used, Japanese standards such as JIS (Japanese Industrial Standards), JEC (Japanese Electro-technical Committee's standard), JEM (Japanese Electrical Manufacturers' Association's standard), etc. as well as International Electrical Standard (IEC) shall be applicable for the equipment to be used for the project.

2.3 Technical requirements for building

2.3.1 Sri Jayewardenepura General Hospital (SJGH)

(1) Scope of Work

1) Photovoltaic (PV) panels will be installed on the roof of the Building-B as shown in the site plan.

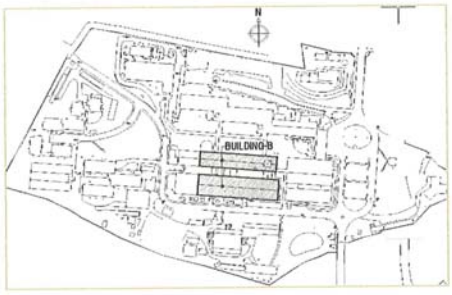


Fig 2-1 Site plan
(Sri Jayewardenepura General Hospital)

(2) Remarks

1) All the roof tiles of the Building-B will be removed because of the damage due to deterioration over time.
2) New steel roofing will be installed on the existing corrugated cement sheet.
3) The Photovoltaic Panels will be installed on the new steel roofing.
4) Japanese side will remove the roofing tiles and transport to the designated area as SJ-02 shows. MOH shall properly treat these tiles.

In September, 2022, preliminary screening survey was conducted and Block-A and Block-B were screened. As result of survey, Block-A became out of scope.

1) 'Block-A' is excluded because the Block-A construction does not include slab structure and the rainwater leakage is observed.

2.3.2 Teaching Hospital Ratnapura

(1) Scope of Work

1) PV panels will be installed on the roof of the Accident and Emergency (A&E) building, JICA building and Blood bank building.



Fig 2-2 Site plan
(Teaching Hospital Ratnapura)

(2) Remarks

1) The building drawings (Architectural, Structural and Electrical drawings) of the Blood bank building shall be provided from the MOH to JICA Study Team by the 9th May. If the drawings are not submitted by the 9th May, installation of PV panels to the Blood bank building will be deleted from the scope of the Project.

In September, 2022, preliminary screening survey was conducted and JICA building, Blood bank building, A&E building, medical legal building and drug store building were screened. As result of survey, 'Medical legal building' and 'Drug store building' became out of scope due to reasons below:

2) Medical legal building is not included in the Project because The roof truss is assembled by wooden materials and the strength cannot be confirmed.
3) Drug store building is not included in the Project because of no building drawings and long distance from JICA buildings.

2.3.3 Teaching Hospital Kurunegala

(1) Scope of Work

1) PV panels will be installed on the roof of the Maternity building as shown in the site plan



Fig 2-3 Site plan (Teaching Hospital Kurunegala)

(2) Remarks

1) In September, 2022, preliminary screening survey was conducted and Maternity building, OPD buiding, Physiotherapy building, and Drug store building were screened. As a result of survey, 'OPD building', 'Physiotherapy building' and 'Drug store building' are not included in the Project because of the long distance and relatively small PV generation capacity.
2) Ward building is studied and identified not to be included in the Project because the building is under construction and above 2nd floor of 4th stories building are extension building. There is no drawing available for the lower parts, therefore the safety of the structure cannot be confirmed.

2.4 Technical requirements for equipment

2.4.1 General description of the System

The roof mounted solar power generation and battery storage system with EMS (Energy Management System) for Sri Jayewardenepura General Hospital (SJGH), Teaching Hospital Ratnapura (TH Ratnapura) and Teaching Hospital Kurunegala (TH Kurunegala) to be supplied under the Project (which is hereunder called "the System") has the following configuration and function.

(1) Configuration

The System mainly consists of a photovoltaic panel, a DC/DC converter, a bidirectional inverter, and a storage battery, and it will play a role of decreasing purchasing power from grid and of securing power in the event of power outage. Outline configuration figure is as mentioned below.

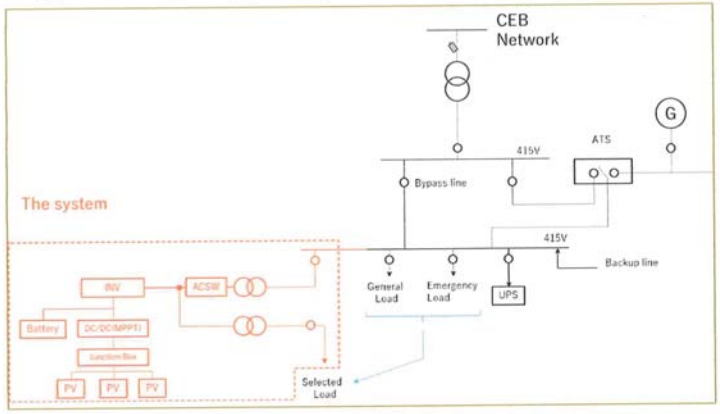


Fig.2-4 Simple configuration of the System interconnected with existing power supply system in the hospital

(2) Function

The power generated by photovoltaic panels inputs DC/DC converter, which has a function of tracking and capturing the maximum power point of solar cells and is converted to appropriate voltage for battery charging and supplying to bidirectional inverter. When the storage battery is fully charged, all the power generated by the solar panels is supplied to the loads connected downstream and surplus is fed to the interconnected Main Distribution Board (MDB). This function contributes to decrease in the purchase of electricity by the hospitals.

In the event of a power failure of MDB side, the System is rapidly isolated from the MDB system, and the battery supplies the power to loads connected downstream continuously.

(3) Selection of Loads to be supplied by the System

Even in the event of a loss of external power, the system will be in stand-alone operation and can be backed up for some time by storage batteries. However, solar power derived from renewable energy sources should not be used to supply power to medical equipment that may directly affect the human body for safety. Therefore, the selection of loads to be supplied from the System has been conducted under the following conditions.

- Since the switching process for individual loads is very complicated, screening of loads to be supplied by the System has been conducted assuming switching at the feeder level of the main distribution board (MDB) of the hospitals.
- No power will be supplied from the system if there is any risks to patients in the hospital based on the impact and likelihood.
- Since the backup function of the power supply continuity is provided by storage batteries, priority has been given as much as possible to supplying power to facilities that are important for the operation of the hospital, such as data servers and blood storage banks, etc.
- The total capacity of the loads directly supplied by the System has been selected to be less than 60% of the rated capacity of the inverter, taking into account the ever-changing load and future load growth. This is to avoid automatic shutdown of a inverter in case of overloading.

2.4.2 Sri Jayewardenepura General Hospital

The following equipment shall be installed for Sri Jayewardenepura General Hospital

(1) PV modules and accessories

Approx. 440kW PV will be installed on the roof of Block –B.

(2) Power conditioner and accessories

Container house(s), in which power conditioner, batteries, control devices, transformers and their related facilities to be equipped, will be installed in the area beyond crossing the road on the south side of the electrical room in Block-B building.

(3) Cable and accessories

DC cables from the solar panels to power conditioner in the container house will be installed through junction boxes and connection boxes to be mounted near the solar panels.

AC cables for interconnection between the System and existing low voltage bus will be conducted at MDB in the electrical room in Blok-B building. Cables from the System for supplying power to existing selected loads will be laid and be switched over at MDB as well. Junction boxes will be mounted near MDB for aforesaid purpose.

Table 2-2 Equipment to be provided for Sri Jayewardenepura General Hospital (tentative)

No.	Equipment	Q'ty	Unit	Major Specifications
(1)	**PV module and accessories**			
a.	PV module	1	lot	• Quantity: 440kW or more (total output) • Type: Mono-crystalline, multi-crystalline silicon, tandem type of crystalline silicon, or amorphous silicon type • Applicable standard: JIS, JEC, JEM, IEC, or equivalent • Degree of protection: IP65 or more • Module output: 410W with a tolerance of +10%, -0%. • Module efficiency: 21.00% or higher • Standard test conditions (STC): Solar irradiation: 1000W/m sq, module temperature: 25oC, Air Mass (AM): 1.5 spectrum
b.	Supporting structure for PV module and fitting material	1	lot	• Type: PV module mounting rail type • Rail material: Aluminum alloy or equivalent • Fitting materials: Provided. • Remark: Fitting materials shall be applicable to the roof part.
c.	Junction box	1	lot	• Enclosure type: Outdoor use, proof from vermin and insect. • Applicable standard: JIS, JEC, JEM, IEC, or equivalent • Protection class of case: IP45 or higher • Material of case: SPHC (JIS G3131) or stronger • Coating of case: Power coating or equivalent • Enclosed function for input circuits: - Number of input circuits: To be specified. - Type: Disconnecting switch - Rated voltage: Maximum power voltage of a string or higher • Enclosed function for output circuits: - Type: Disconnecting switch - Rated voltage: Maximum power voltage of a string or higher • Number of input circuits: To be specified. • Blocking diode for reverse protection: Provided. • Surge protection device (SPD): Class-1

No.	Equipment	Q'ty	Unit	Major Specifications
d.	Collecting box	1	lot	· Enclosure type: Outdoor use, proof from vermin and insect. · Applicable standard: JIS, JEC, JEM, IEC, or equivalent · Protection class of case: IP45 or higher · Material of case: SPHC (JIS G3131) or stronger · Coating of case: Power coating or equivalent · Enclosed function for input circuits: - Number of input circuits: To be specified. - Type: Molded-case circuit breaker (MCCB) - Rated voltage: Maximum power voltage of a string or higher - Ampere frame (AF): total short circuit of connected strings or higher - Blocking diode for reverse protection: Provided · Enclosed function for output circuits: - Type MCCB - Rated voltage: Maximum power voltage of a string or higher - Ampere frame (AF): Total short circuit of connected strings or higher · Number of input circuits: To be specified.
(2)	**Power Conditioning System and accessories**	**1**	**lot**	
a.	DC/AC inverter	2	sets	Rated power output: 200 kW, 3 phase Major function · Grid interconnection operation with solar generated power and storage batteries · Standalone operation with solar generated power and storage batteries · Control of battery charging & discharging
b.	DC/DC converter	2	sets	Rated power: sufficient power for DC/AC inverter operation (200 kW or above) Major function · Maximum power point tracking of solar cells · Capturing solar panel generated power
c.	AC switch	2	sets	Rated power: sufficient power for DC/AC inverter operation (200 kW or above) Major function · Optimal control of loads connected
d.	Insulation transformer 1	2	sets	Rated power: 200 kVA Type: Dry, indoor type Number of phase: 3 Voltage · primary: 400 V · secondary: inverter input voltage Winding: Star (with neutral point pull-out terminal) - Delta

No.	Equipment	Q'ty	Unit	Major Specifications
e.	Insulation transformer 2	2	sets	Rated power: 200 kVA Type: Dry, indoor type Number of phase: 3 Voltage · primary: inverter output voltage · secondary: 400/230 V (to be used with 3 phase 4 wire system) Winding: Delta – Star (with neutral point pull-out terminal)
f.	Battery	2	sets	Type: Lithium-ion Rating: 120 kW, 240 kWh or more
g.	Weather data collection sensor	1	lot	· Pyranometer 1 set · Air temperature sensor with radiation shield 1 set Including necessary accessories for installation and remote monitoring
h.	Energy Management System (EMS)	1	lot	Energy control, storage and management function to be included in the system
i.	Remote monitoring device	1	set	Liquid Crystal Display (LCD) monitor with wall mount metal fitting · Size: 43 inch or more Computer for LCD monitor · VESA mountable · Sufficient specification for communication with EMS and displaying PV condition Necessary accessories for remote signal transmission and communication with EMS
(3)	**Cable and accessories**			
a.	LV panel	1	set	400/230 V AC distribution panel · Molded-case circuit breakers (MCCB) 400/230 V AC, three phase, four wire · Wiring and terminal blocks
b.	Terminal box	1	lot	400/230 V AC cable connection boxes for switching over to new cables of the System from existing ones of selected loads
c.	Power cable and terminal materials	1	lot	Necessary DC & AC power cables and their necessary accessories for connection
d.	Control cable and terminal materials	1	lot	Necessary control & communication cables and their necessary accessories for connection
e.	Grounding material	1	lot	Earthing conductors and accessories
f.	Materials for cable laying	1	lot	Cable tray, conduit, junction box and their necessary accessories including supporting materials
(4)	**Fire detection system**	**1**	**lot**	**Fire detector(s) and monitoring device for container house(s)**

2.4.3 Teaching Hospital Ratnapura

The following equipment shall be installed for Teaching Hospital Ratnapura

(1) PV modules and accessories

Approx. 220kW PV will be installed on the roof of JICA Building.

Approx. 30kW PV will be installed on the roof of A & E Building.

Approx. 30kW PV will be installed on the roof of Blood Bank Building.

(2) Power conditioner and accessories

Container houses, in which power conditioner, batteries, control devices, transformers and their related facilities to be equipped, will be installed at the area between Ward No.2 & No.2B of the Main Building for PV of JICA Building and at the area behind Director Quarters for PV of A & E Building and Blood Bank Building.

(3) LV panel, cable and accessories

DC cables from the solar panels to power conditioner in the container house will be installed through junction boxes and connection boxes to be mounted near the solar panels.

AC cables for interconnection between the System and existing low voltage bus will be conducted at MDB in the electrical room in the JICA Building for solar panels on JICA Building and be conducted at the ATS panel of 72.5 kVA emergency generator for solar panels on A & E and Blood Bank Buildings. Cables from the System for supplying power to existing selected loads will be laid and be switched over at MDB and ATS panel respectively. Junction boxes will be mounted near MDB and ATS panel for aforesaid purpose.

Table 2-3 Equipment to be provided for Teaching Hospital Ratnapura (tentative)

No.	Equipment	Q'ty	Unit	Major Specifications
(1)	**PV module and accessories**			
a.	PV module	1	lot	· Quantity: 280kW or more (total output) · Type: Mono-crystalline, multi-crystalline silicon, tandem type of crystalline silicon, or amorphous silicon type · Applicable standard: JIS, JEC, JEM, IEC, or equivalent · Degree of protection: IP65 or more · Module output: 410W with a tolerance of +10%, -0%. · Module efficiency: 21.00% or higher · Standard test conditions (STC): Solar irradiation: 1000W/m sq, module temperature: 25oC, Air Mass (AM): 1.5 spectrum
b.	Supporting structure for PV module and fitting material	1	lot	· Type: PV module mounting rail type · Rail material: Aluminum alloy or equivalent · Fitting materials: Provided. · Remark: Fitting materials shall be applicable to the roof part.
c.	Junction box	1	lot	· Enclosure type: Outdoor use, proof from vermin and insect. · Applicable standard: JIS, JEC, JEM, IEC, or equivalent · Protection class of case: IP45 or higher · Material of case: SPHC (JIS G3131) or stronger · Coating of case: Power coating or equivalent · Enclosed function for input circuits: - Number of input circuits: To be specified. - Type: Disconnecting switch - Rated voltage: Maximum power voltage of a string or higher · Enclosed function for output circuits: - Type: Disconnecting switch - Rated voltage: Maximum power voltage of a string or higher · Number of input circuits: To be specified. · Blocking diode for reverse protection: Provided. · Surge protection device (SPD): Class-1
d.	Collecting box	1	lot	· Enclosure type: Outdoor use, proof from vermin and insect. · Applicable standard: JIS, JEC, JEM, IEC, or equivalent · Protection class of case: IP45 or higher · Material of case: SPHC (JIS G3131) or stronger · Coating of case: Power coating or equivalent · Enclosed function for input circuits: - Number of input circuits: To be specified. - Type: MCCB - Rated voltage: Maximum power voltage of a string or higher - Ampere frame (AF): Total short circuit of connected strings or higher - Blocking diode for reverse protection: Provided · Enclosed function for output circuits: - Type: MCCB - Rated voltage: Maximum power voltage of a string or higher - Ampere frame (AF): total short circuit of connected strings or higher · Number of input circuits: To be specified.
(2)	**Power Conditioning System and accessories**	**1**	**lot**	
a.	DC/AC inverter-1	1	sets	Rated power output: 200 kW, 3 phase Major function · Grid interconnection operation with solar generated power and storage batteries · Standalone operation with solar generated power and storage batteries · Control of battery charging & discharging

No.	Equipment	Q'ty	Unit	Major Specifications
b.	DC/DC converter-1	1	sets	Rated power: sufficient power for DC/AC inverter operation (200 kW or above) Major function · Maximum power point tracking of solar cells · Capturing solar panel generated power
c.	AC switch-1	1	sets	Rated power: sufficient power for DC/AC inverter operation (200 kW or above) Major function · Optimal control of loads connected
d.	Insulation transformer 1-1	1	sets	Rated power: 200 kVA Type: Dry, indoor type Number of phase: 3 Voltage · primary: 400 V · secondary: inverter input voltage - Winding: Star (with neutral point pull-out terminal) - Delta
e.	Insulation transformer-2-1	1	sets	Rated power: 200 kVA Type: Dry, indoor type Number of phase: 3 Voltage · primary: inverter output voltage · secondary: 400/230 V (to be used with 3 phase 4 wire system) - Winding: Delta – Star (with neutral point pull-out terminal)
f.	Battery-1	1	sets	Type: Lithium-ion Rating: 120 kW, 240 kWh or more
g.	Energy Management System (EMS)-1	1	lot	· Energy control, storage and management function to be included in the system
h.	DC/AC inverter-2	1	sets	Rated power output: 100 kW, 3 phase Major function · Grid interconnection operation with solar generated power and storage batteries · Standalone operation with solar generated power and storage batteries · Control of battery charging & discharging
i.	DC/DC converter-2	1	sets	Rated power: sufficient power for DC/AC inverter operation (100 kW or above) Major function · Maximum power point tracking of solar cells · Capturing solar panel generated power
j.	AC switch-2	1	sets	Rated power: sufficient power for DC/AC inverter operation (100 kW or above) Major function · Optimal control of loads connected

No.	Equipment	Q'ty	Unit	Major Specifications
k.	Insulation transformer 1-2	1	sets	Rated power: 100 kVA Type: Dry, indoor type Number of phase: 3 Voltage · primary: 400 V · secondary: inverter input voltage Winding: Star (with neutral point pull-out terminal) - Delta
l.	Insulation transformer 2-2	1	sets	Rated power: 100 kVA Type: Dry, indoor type Number of phase: 3 Voltage · primary: inverter output voltage · secondary: 400/230 V (to be used with 3 phase 4 wire system) Winding: Delta – Star (with neutral point pull-out terminal)
m.	Battery-2	1	sets	Type: Lithium-ion Rating: 60 kW, 120 kWh or more
n.	Energy Management System (EMS)-2	1	lot	Energy control, storage and management function to be included in the system
o.	Weather data collection sensor	1	lot	· Pyranometer: 1 set · Air temperature sensor with radiation shield: 1 set Including necessary accessories for installation and remote monitoring
p.	Remote monitoring device	1	set	Liquid Crystal Display (LCD) monitor with wall mount metal fitting · Size: 43 inch or more Computer for LCD monitor · VESA mountable · Sufficient specification for communication with EMS and displaying PV condition - Necessary accessories for remote signal transmission and communication with EMS
(3)	**Cable and accessories**			
a.	LV panel	1	set	400/230 V AC distribution panels for connection to MDBs · Molded-case circuit breakers (MCCB) 400/230 V AC, three phase, four wire Wiring and terminal blocks
b.	Terminal box	1	lot	400/230 V AC cable connection boxes for switching over to new cables of the System from existing ones of selected loads
c.	Power cable and terminal materials	1	lot	Necessary DC & AC power cables and their necessary accessories for connection
d.	Control cable and terminal materials	1	lot	Necessary control & communication cables and their necessary accessories for connection
d.	Grounding material	1	lot	Earthing conductors and accessories
f.	Materials for cable laying	1	lot	Concrete pole, cable tray, conduit, junction box and their necessary accessories including supporting materials
(4)	**Fire detection system**	**1**	**lot**	**Fire detector(s) and monitoring device for container house(s)**

2.4.4 Teaching Hospital Kurunegala

The following equipment shall be installed for Teaching Hospital Kurunegala

(1) PV modules and accessories

Approx. 250kW PV will be installed on the roof of Maternity Building.

(2) Power conditioner and accessories

Container house(s), in which power conditioner, batteries, control devices, transformers and their related facilities to be equipped, will be installed in the area where the unused incinerator located near the Maternity Building. The incinerator will be demolished and removed by Sri Lankan side before the Bid Announcement of the Project.

(3) LV panel, cable and accessories

DC cables from the solar panels to power conditioner in the container house will be installed through junction boxes and connection boxes to be mounted near the solar panels.

AC cables for interconnection between the System and existing low voltage bus will be conducted at MDB fed from 1,000 kVA transformer in the electrical room near the Maternity Building. Cables from the System for supplying power to existing selected loads will be laid and be switched over at MDBs fed from 1,000 kVA and 800 kVA transformers respectively. Terminal boxes will be mounted near MDBs for aforesaid purpose.

Table 2-4 Equipment to be provided for Teaching Hospital Kurunegala (tentative)

No.	Equipment	Q'ty	Unit	Major Specifications
(1)	**PV module and accessories**			
a.	PV module	1	lot	• Quantity: 250kW or more (total output) • Type: Mono-crystalline, multi-crystalline silicon, tandem type of crystalline silicon, or amorphous silicon type • Applicable standard: JIS, JEC, JEM, IEC, or equivalent • Degree of protection: IP65 or more • Module output: 410W with a tolerance of +10%, -0%. • Module efficiency: 21.00% or higher • Standard test conditions (STC): Solar irradiation: 1000W/m sq, module temperature: 25oC, Air Mass (AM): 1.5 spectrum
b.	Supporting structure for PV module and fitting material	1	lot	• Type: PV module mounting rail type • Rail material: Aluminum alloy or equivalent • Fitting materials: Provided. • Remark: Fitting materials shall be applicable to the roof part.
c.	Junction box	1	lot	• Enclosure type: Outdoor use, proof from vermin and insect. • Applicable standard: JIS, JEC, JEM, IEC, or equivalent • Protection class of case: IP45 or higher • Material of case: SPHC (JIS G3131) or stronger

No.	Equipment	Q'ty	Unit	Major Specifications
d.	Collecting box	1	lot	• Coating of case: Power coating or equivalent • Enclosed function for input circuits: - Number of input circuits: To be specified. - Type: Disconnecting switch - Rated voltage: Maximum power voltage of a string or higher • Enclosed function for output circuits: - Type: Disconnecting switch - Rated voltage: Maximum power voltage of a string or higher • Number of input circuits: To be specified. • Blocking diode for reverse protection: Provided. • Surge protection device (SPD): Class-1 • Enclosure type: Outdoor use, proof from vermin and insect. • Applicable standard: JIS, JEC, JEM, IEC, or equivalent • Protection class of case: IP45 or higher • Material of case: SPHC (JIS G3131) or stronger • Coating of case: Power coating or equivalent • Enclosed function for input circuits: - Number of input circuits: To be specified. - Type: MCCB - Rated voltage: Maximum power voltage of a string or higher - Ampere frame (AF): Total short circuit of connected strings or higher - Blocking diode for reverse protection: Provided • Enclosed function for output circuits: - Type MCCB - Rated voltage: Maximum power voltage of a string or higher - Ampere frame (AF): total short circuit of connected strings or higher • Number of input circuits: To be specified.
(2)	**Power Conditioning System and accessories**	**1**	**lot**	
a.	DC/AC inverter	1	sets	Rated power output: 200 kW, 3 phase Major function • Grid interconnection operation with solar generated power and storage batteries • Standalone operation with solar generated power and storage batteries • Control of battery charging & discharging
b.	DC/DC converter	1	sets	Rated power: sufficient power for DC/AC inverter operation (200 kW or above) Major function • Maximum power point tracking of solar cells • Capturing solar panel generated power

No.	Equipment	Q'ty	Unit	Major Specifications
c.	AC switch	1	sets	Rated power: sufficient power for DC/AC inverter operation (200 kW or above) Major function ・ Optimal control of loads connected
d.	Insulation transformer	1	sets	Rated power: 200 kVA Type: Dry, indoor type Number of phase: 3 Voltage ・ primary: 400 V ・ secondary: inverter input voltage ・ Winding: Star (with neutral point pull-out terminal) - Delta
e.	Insulation transformer 2	1	sets	Rated power: 200 kVA Type: Dry, indoor type Number of phase: 3 Voltage ・ primary: inverter output voltage ・ secondary: 400/230 V (to be used with 3 phase 4 wire system) - Winding: Delta – Star (with neutral point pull-out terminal)
f.	Battery	1	sets	Type: Lithium-ion Rating: 120 kW, 240 kWh or more
g.	Weather data collection sensor	1	lot	・ Pyranometer: 1 set ・ Air temperature sensor with radiation shield: 1 set Including necessary accessories for installation and remote monitoring
h.	Energy Management System (EMS)	1	lot	Energy control, storage and management function to be included in the system
i.	Remote monitoring device	1	set	Liquid Crystal Display (LCD) monitor with wall mount metal fitting ・ size: 43 inch or more Computer for LCD monitor ・ VESA mountable ・ Sufficient specification for communication with EMS and displaying PV condition - Necessary accessories for remote signal transmission and communication with EMS
(3)	**Cable and accessories**			
a.	LV panel	2	sets	400/230 V AC distribution panels for connection to MDBs ・ Molded-case circuit breakers (MCCB) 400/230 V AC, three phase, four wire Wiring and terminal blocks
b.	Terminal box	1	lot	400/230 V AC cable connection boxes for switching over to new cables of the System from existing ones of selected loads
c.	Power cable and terminal materials	1	lot	Necessary DC & AC power cables and their necessary accessories for connection

No.	Equipment	Q'ty	Unit	Major Specifications
d.	Control cable and terminal materials	1	lot	Necessary control & communication cables and their necessary accessories for connection
e.	Grounding material	1	lot	Earthing conductors and accessories
f.	Materials for cable laying	1	lot	Cable tray, conduit, concrete pole, junction box and their necessary accessories including supporting materials
(4)	Fire detection system	1	lot	Fire detector(s) and monitoring device for container house(s)

2.5 Procurement Plan of Spare Parts and Maintenance Tools

Capability of sustainable operation and maintenance for the equipment of the Project by the Recipient is one of conditions for the Japan's Grant Aid. The Sri Lankan side shall keep operation and maintenance for the equipment of the Project properly by himself, including procurement of spare parts. On the other hand, the warranty period for the Project is 1 year after the completion certificate. To secure operation and maintenance for the equipment of the Project for the warranty period, the Spare parts required for the period shall be provided as the scope of the Japanese.

Possession of maintenance tools for proper operation and maintenance for the equipment of the Project by the Recipient is one of conditions for the Japan's Grant Aid. However, the special tools required for operation and maintenance of the equipment of the Project shall be provided as the scope of the Japanese.

Spare parts and maintenance tools listed in Table 2-5 and Table 2-6 are recommended to be procured. More detailed parts, tools, test equipment and the quantity will be explained in the Draft Final Report.

Table 2-5 Recommended Spare Part List

No.	Name of spareparts	Quantity		
		SR	KU	RT
(1)	**PV module and accessories**			
1.	PV module	3% (pc)	3% (pc)	3% (pc)
2.	Junction box	2pc	2pc	2pc
3.	Collecting box	1pc	1pc	1pc
(2)	**Power conditioner and accessories**			
1.	Cooling fan	1pc each	1pc each	1pc each
2.	MCCB	1pc each	1pc each	1pc each
3.	Electromagnetic contactor	1pc each	1pc each	1pc each
(3)	**Cable and accessories**			
1.	MCCB (LV panel)	1pc each	1pc each	1pc each
2.	Electromagnetic contactor (LV panel)	1pc each	1pc each	1pc each
3.	Cable	3% of each cable length	3% of each cable length	3% of each cable length

[Note] pc: piece

Table 2-6 Recommended maintenance tool list

No.	Name of maintenance tool	Quantity		
		SR	KU	RT
(1)	Digital Multi Meter	1unit	1unit	1unit
(2)	Insulation resistance tester	1unit	1unit	1unit
(3)	Voltage detector	1unit	1unit	1unit
(4)	Clamp meter	1unit	1unit	1unit
(5)	Earth resistance tester	1unit	1unit	1unit
(6)	Electrical tool set	1unit	1unit	1unit
(7)	Combination tool set	1unit	1unit	1unit

2.6 Training plan

On-the-job training (OJT) shall be carried out during the construction period. Through the OJT, maintenance and operation staff of each hospital will be able to experience practical skill from Manufacturer's engineers. Contents of OJT are proposed as follows;

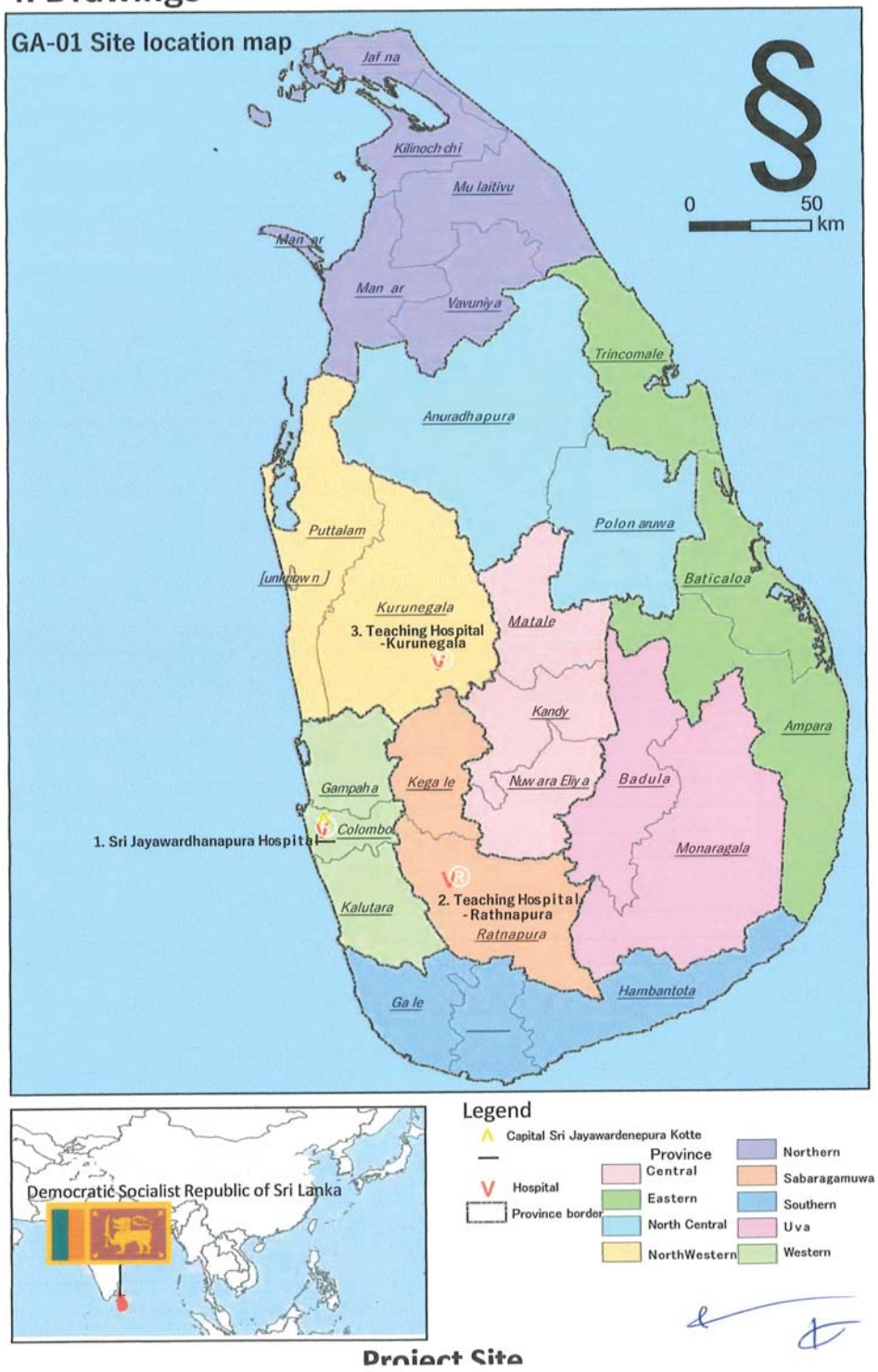
- Detection of abnormal condition through the EMS (i.e. alarm)
- Routine maintenance
- Trouble-shooting

3. Tentative Implementation Schedule of the Project

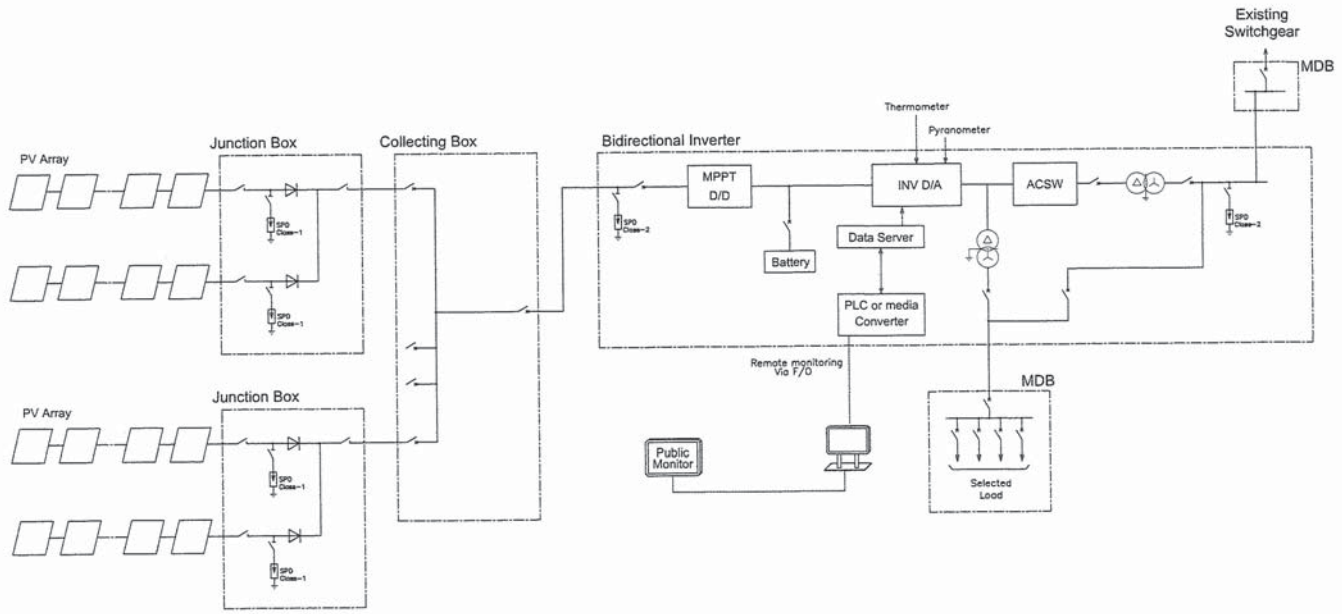
The tentative implementation schedule is shown in Attachment-3. In case that the Project is approved by the Japanese Government, the Project will proceed as below in the earliest scenario. The installation work of the Project will start in January, 2024. It is important for both sides to understand that the Preparatory Survey is not a commitment for the future implementation of the Project.

- The Exchange of Notes between the Sri Lanka and Japanese Government shall be signed in December, 2023.
- The Bid Opening will be held in May 2024.
- Installation work of the Project will start in October, 2024.
- The implementation work will be performed in series at each hospital, and the handover will be as follows:
  - (a) Sri Jayewardenepura General Hospital: June, 2025
  - (b) Teaching Hospital Kurunegala: September, 2025
  - (c) Teaching Hospital Ratnapura: December, 2025

4. Drawings



GA-02 System diagram

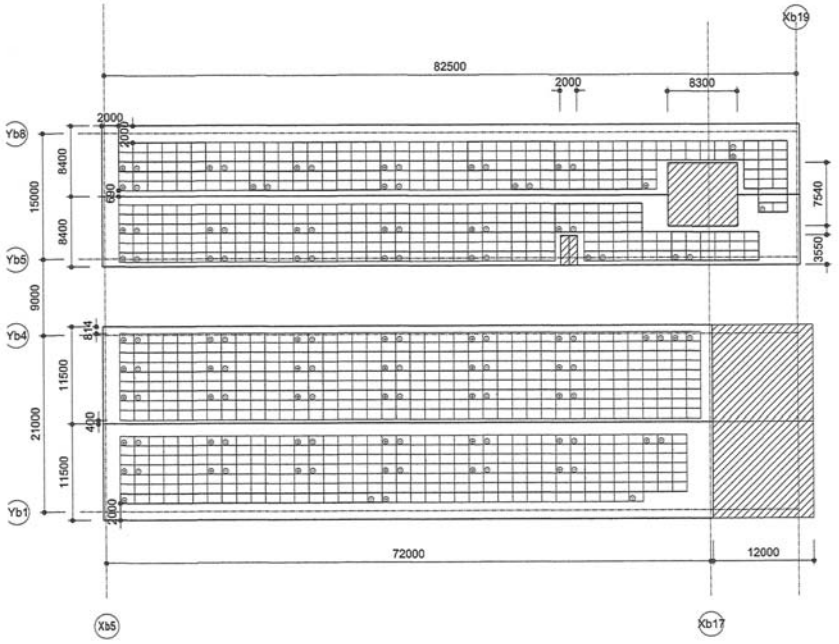


Legend

PV	Photo Voltaic
SPD	Surge Protection Device
MPPT	Maximum Power Point Tracking
INV	Inverter
ACSW	Semiconductor Switch

GA-2 System Diagram

SJ-01 PV arrangement plan (SJGH)

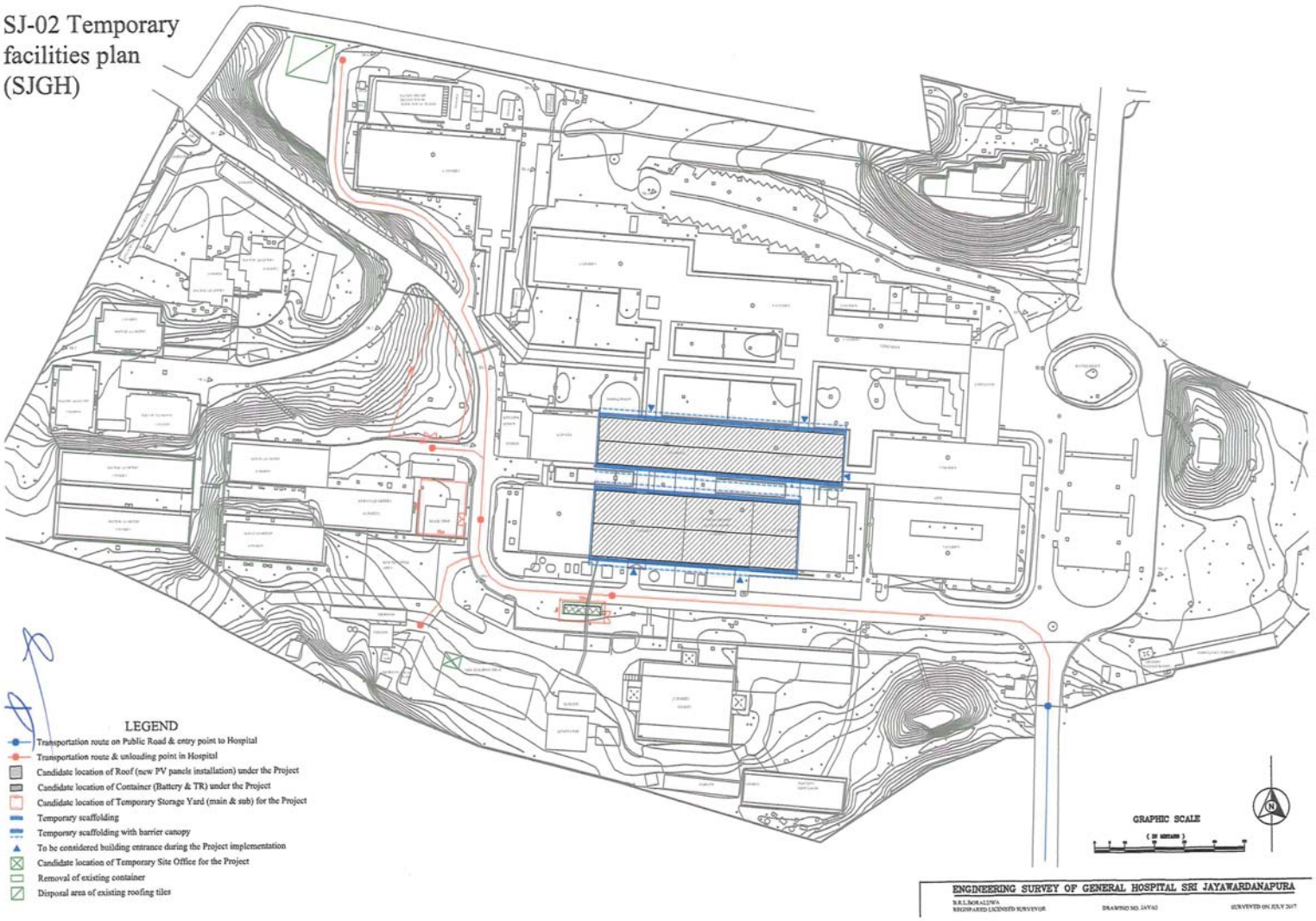


Total: 1,080 Panel

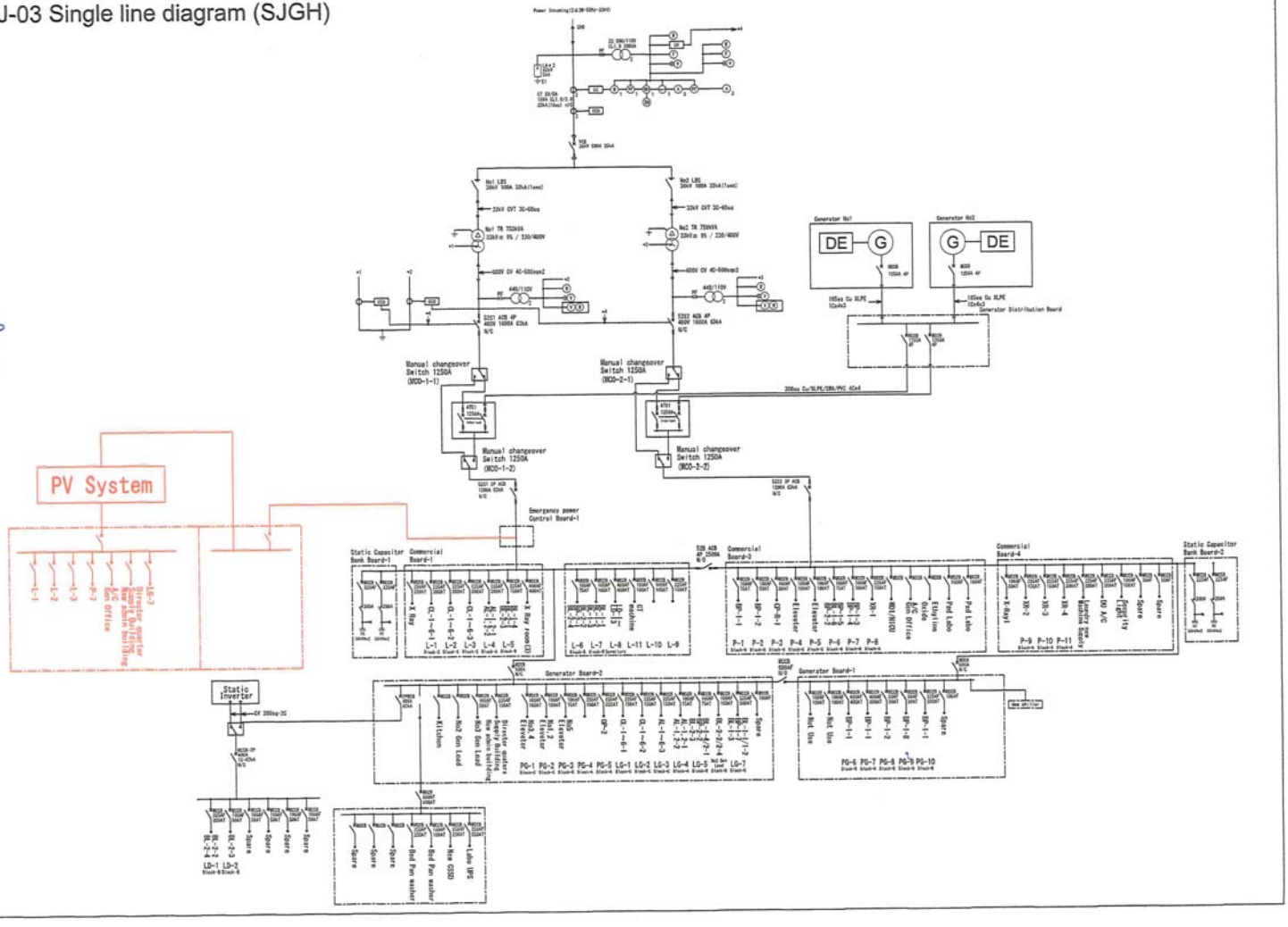
SJ-1 PV arrangement plan

(Block-B)

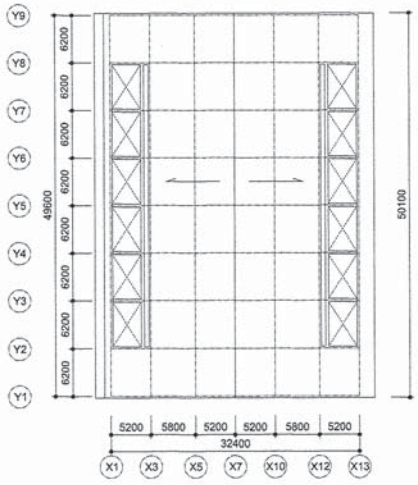
SJ-02 Temporary facilities plan (SJGH)



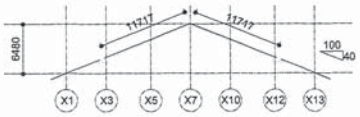
SJ-03 Single line diagram (SJGH)



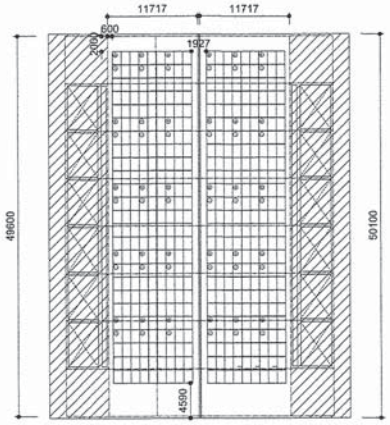
RT-01 PV arrangement plan (TH Ratnapura)



屋根平面図



屋根断面図

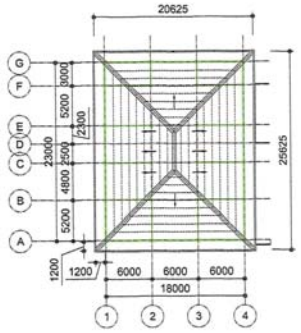


270 270

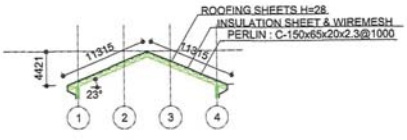
Total: 540 Panel

RT−1−1 PV arrangement Plan
(JICA building

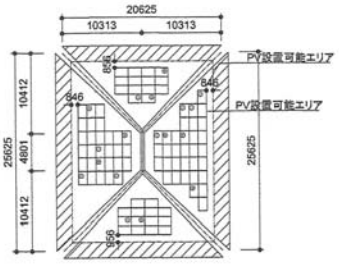




屋根平面図（南側棟屋）



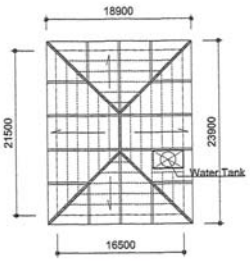
屋根断面図



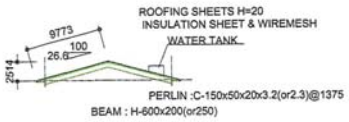
Total: 90 Panel

RT−1−2 PV arrangement plan
(A&E building

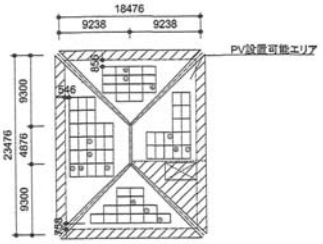




屋根平面図



屋根断面図



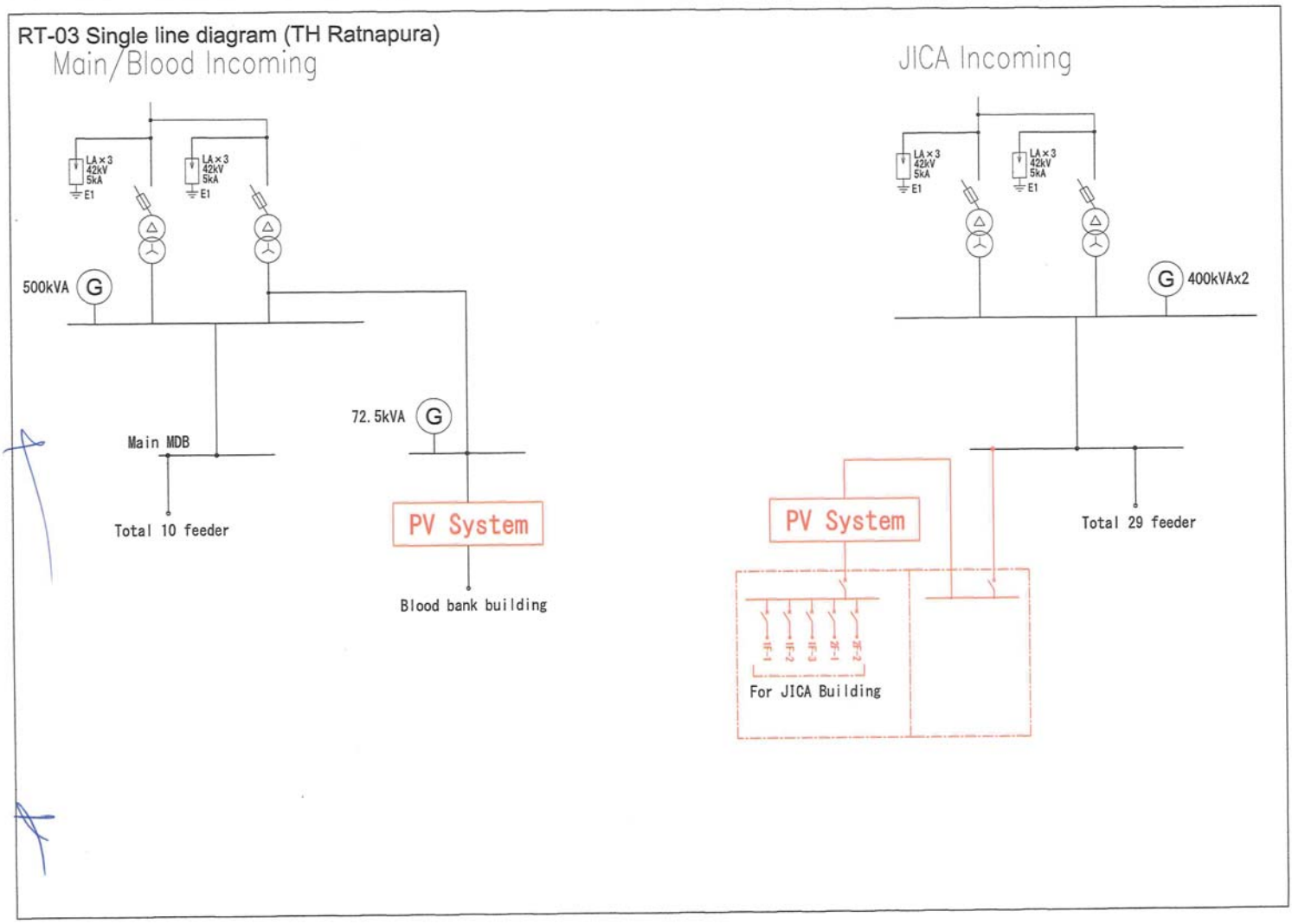
Total: 70 Panel

RT−1−3 PV arrangement plan
(Blood Bank building

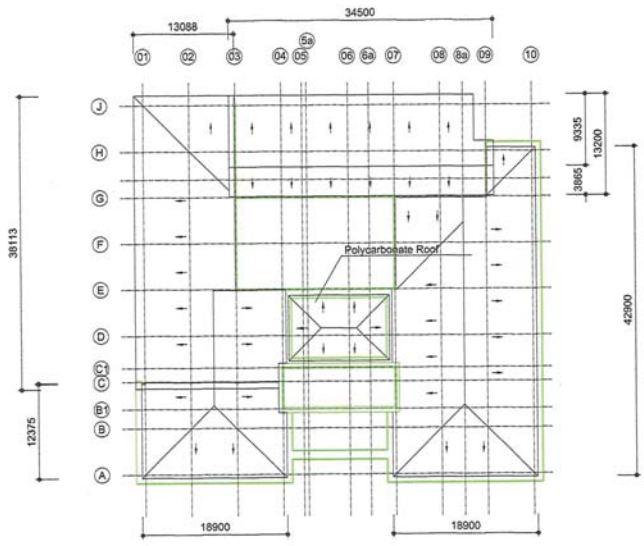
RA-02 Temporary facilities plan (TH Ratnapura)



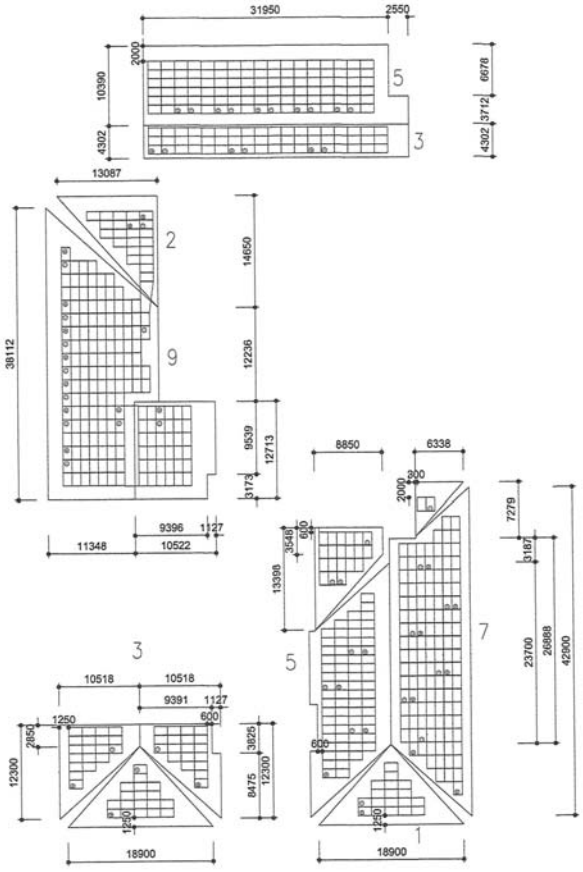
RT-03 Single line diagram (TH Ratnapura)



KU-01 PV arrangement plan (TH Kurunegala)



Maternity Complex 屋根伏図



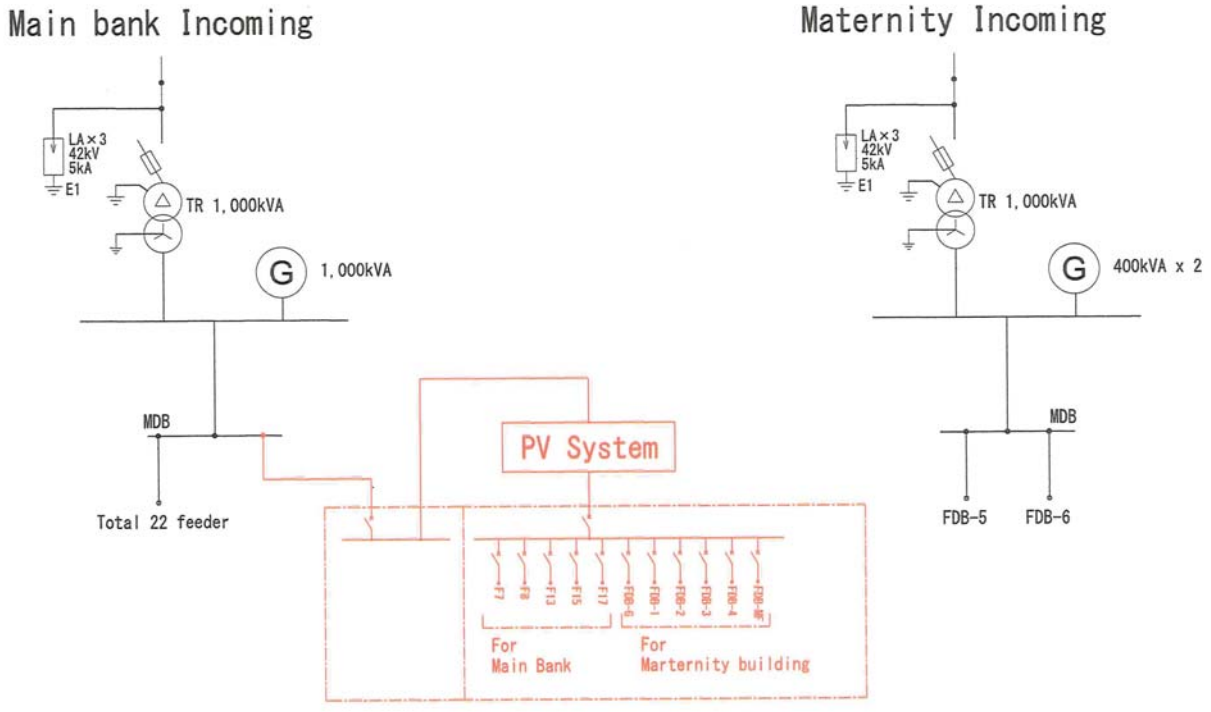
Total: 630 Panel

KU−1 PV arrangement plan

KU-02 Temporary facilities plan (TH Kurunegala)



KU-03 Single Line Diagram (TH Kurunegala)



Attachment-1

Member List of the Study Team

NAME	ASSIGNMENT	ORGANIZATION	REMARK
Kyoji FUJII	Team leader / PV generation plan (1)	Yachiyo Engineering Co., Ltd. (YEC)	
Makoto ABE	PV generation plan (2)	YEC	Work in Japan only
Hidemi HASHIMOTO	Battery energy storage system	YEC	
Kazuaki KONDO	Deputy team leader / Equipment plan (1)	YEC	
Taro NAKAMURA	Equipment plan (2)	West Japan Engineering Consultants, Inc. (WJEC)	
Keiichiro OHASHI	Equipment plan (3)	WJEC	
Ichiro MASUDA	Facility plan (1)	YEC	
Hisayuki YAMAMOTO	Facility plan (2)	YEC	
Kosei ITO	Facility plan (3)	YEC	
Hironori KOMATSU	Procurement and installation plan & cost estimation (Facilities)	YEC	
Keiya FUJIWARA	Procurement and installation plan & cost estimation (Equipment)	YEC	

Attachment-2

Major Undertakings to be taken by the Sri Lankan side

(1) Before the Tender

NO	Items	Deadline	In charge	Estimated Cost	Ref.
1	To sign the banking arrangement (B/A) with a bank in Japan (the Agent Bank) to open bank account for the Grant	within 1 month after the signing of the G/A	MOH		
2	To issue A/P to the Agent Bank for the payment to the consultant within 1 month after the signing of the contract(s)	within 1 month after the signing of the contract(s)	MOH		
3	To bear the following commissions to the Agent Bank for the banking services based upon B/A				
	1) Advising commission of A/P (Authorization to Pay)	within 1 month after the signing of the contract(s)	MOH		
	2) Payment commission for A/P	every payment	MOH		
4	To submit Project Monitoring Report (with the result of Detailed Design)	before preparation of the bidding documents	MOH		
	Major undertakings to be taken by three hospitals in general:				
5	To secure and clear the following lands 1) Project sites (approx. 12m x 3m (36m^2) for each) for container of PV system at each hospital.	before notice of the bidding	Each hospital		
6	To obtain the planning, zoning, building permit from the Urban Development Authority (UDA)	before notice of the bidding	Each hospital		
7	To obtain the interconnection license from the Ceylon Electricity Board (CEB)	before notice of the bidding	Each hospital		
8	To obtain tree cutting /transplanting permit from relevant authority if necessary.	before notice of the bidding	Each hospital		
9	To clear, level and reclaim the following sites 1) Leveling and reclaiming the sites for container of PV system at each hospital, if necessary. 2) Securing temporary storage yard at each hospital site (approx. 16m x 30m (500m^2)) 3) Securing plots for site offices of the Consultant and the Supplier (approx. 30m^2 each)	before notice of the bidding	Each hospital		
	Major undertakings to be taken by Teaching Hospital Kurunegala in particular				
11	To remove unused incinerator by the maternity building to vacate a space for the container of PV system.	before notice of the bidding	TH Kurunegala		
	Major undertakings to be taken by Teaching Hospital Ratnapura in particular				
12	To construct a retaining wall and reinforce a slope which goes down from the parking lot in front of the main office where a container of PV system is to be installed (To be revised).	before notice of the bidding	TH Ratnapura		

(2) During the Project Implementation

NO	Items	Deadline	In charge	Estimated Cost	Ref.
1	To issue A/P to the Agent Bank for the payment to the supplier and the contractor	within 1 month after the signing of the contract(s)	MOH		
2	To bear the following commissions to the Agent Bank for the banking services based upon the B/A		MOH		
	1) Advising commission of A/P	within 1 month after the signing of the contract(s)	MOH		
	2) Payment commission for A/P	every payment	MOH		
3	to ensure prompt unloading and customs clearance at ports of disembarkation in the country of the Recipient and to assist the Supplier(s) with internal transportation therein	during the Project	MOH		
4	To accord Japanese physical persons and/or physical persons of third countries whose services may be required in connection with the supply of the products and the services such facilities as may be necessary for their entry into the country of the Recipient and stay therein for the performance of their work	during the Project	MOH		
5	To ensure that customs duties, internal taxes and other fiscal levies which may be imposed in the country of the Recipient with respect to the purchase of the products and/or the services be borne by its designated authority without using the Grant;	during the Project	MOH		
6	To bear all the expenses, other than those covered by the Grant, necessary for the implementation of the Project	during the Project	MOH		
7	To notify JICA promptly of any incident or accident, which has, or is likely to have, a significant adverse effect on the environment, the affected communities, the public or workers.	during the construction	MOH		
8	To submit Project Monitoring Report after each work under the contract(s) such as shipping, hand over, installation and operational training	within 1 month after completion of each work	MOH		
9	To submit Project Monitoring Report (final) (including as-built drawings, equipment list, photographs, etc.)	within 1 month after issuance of Certificate of Completion for the works under the contract(s)	MOH		
10	To submit a notice concerning completion of the Project	within 6 months after completion of the Project	MOH		
11	To provide office space necessary for the implementation of the Project in the site(s)	before start of the construction	MOH and each hospital		
12	To ensure the safety of persons engaged in the implementation of the Project	during the Project	MOH		
13	To take necessary measures for security and safety of the Project site	during the construction	MOH and each hospital		

(3) After the Project

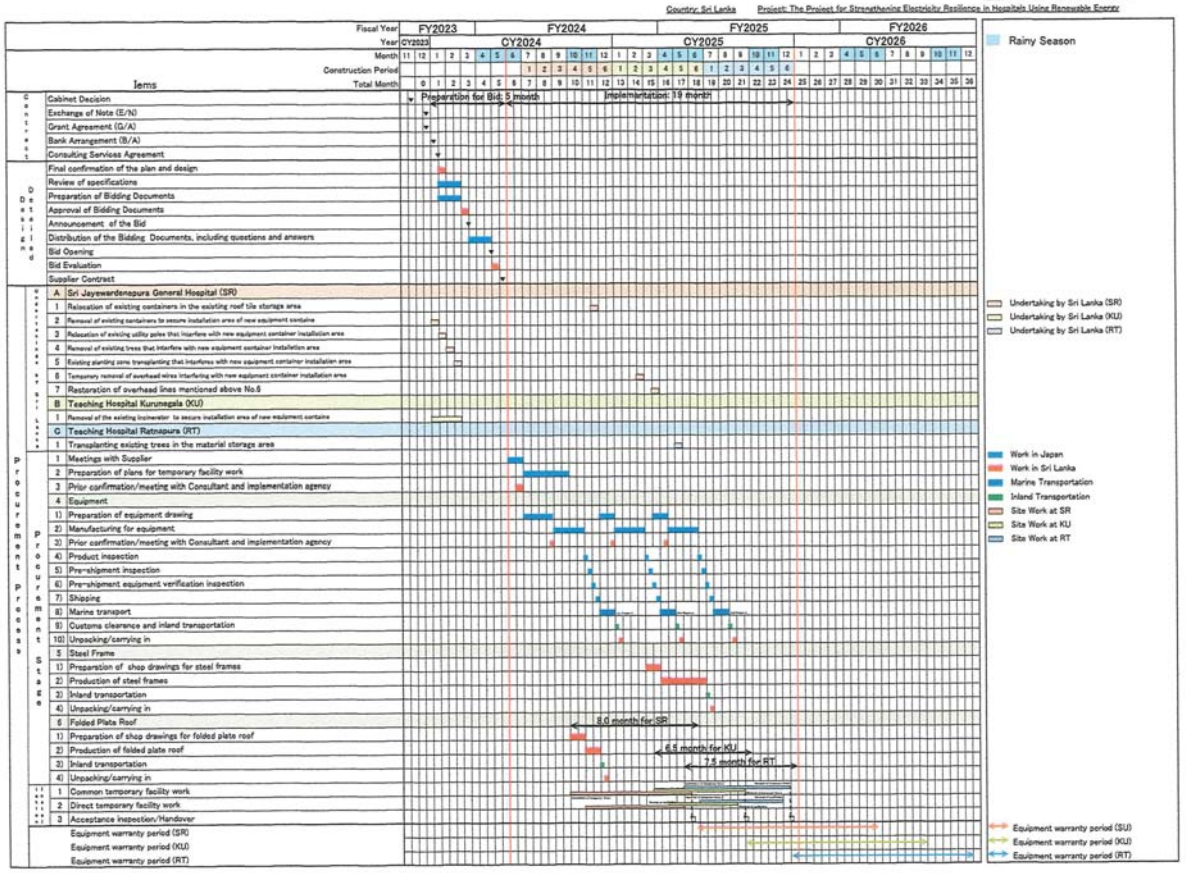
NO	Items	Deadline	In charge	Estimated Cost	Ref.
1	To maintain and use properly and effectively the facilities constructed and equipment provided under the Grant Aid 1) Allocation of maintenance cost 2) Operation and maintenance structure 3) Routine check/Periodic inspection	After completion of the construction	MOH and each hospital		
2	To secure budget for contracting the PV system maintenance agreement with outsourcing company.	After completion of the construction	MOH and each hospital		

Attachment-3

Tentative implementation schedule

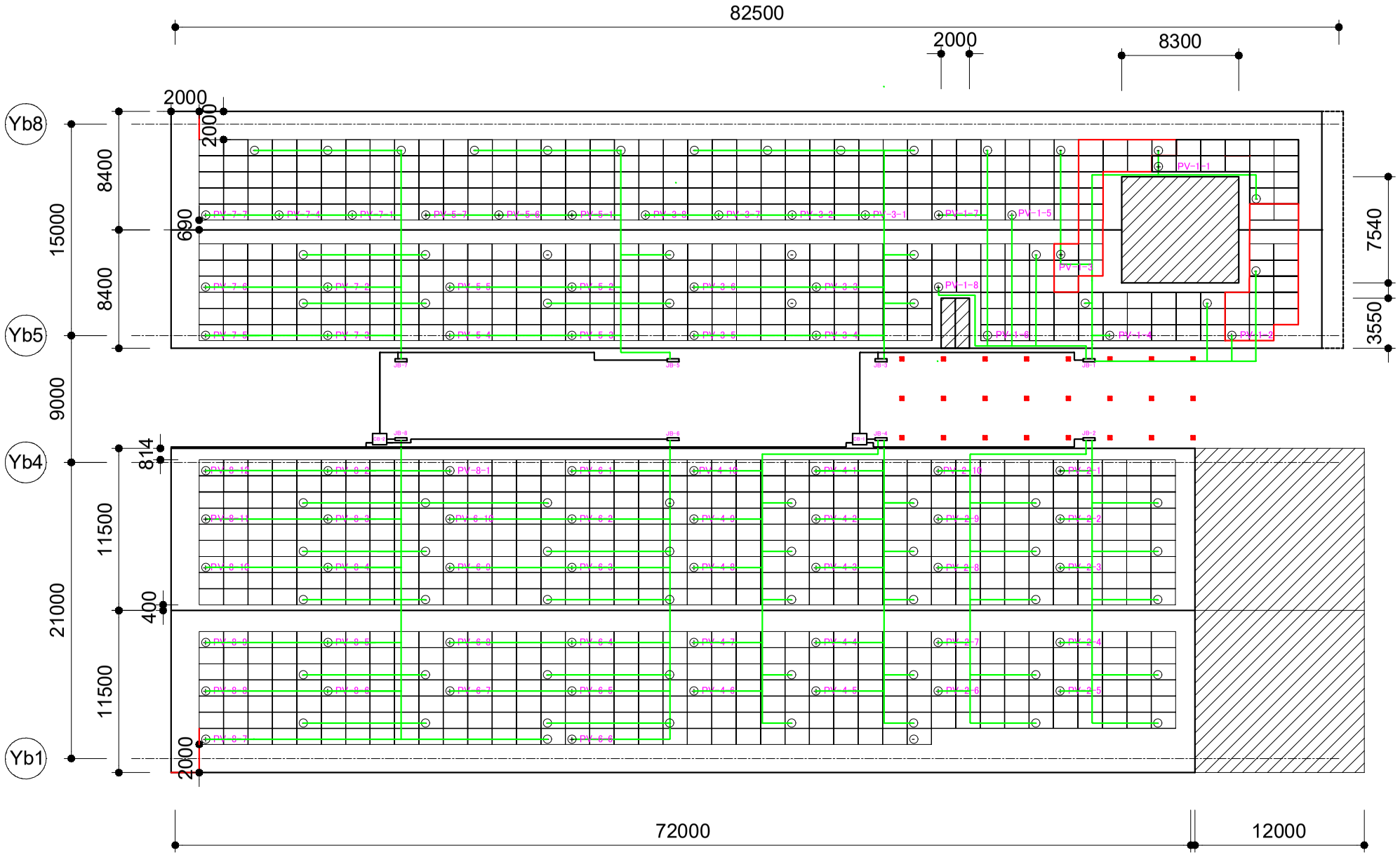
Consultant: Yachiyo Engineering Co., Ltd.

Country: Sri Lanka　Project: The Project for Strengthening Electricity Resilience in Hospitals Using Renewable Energy

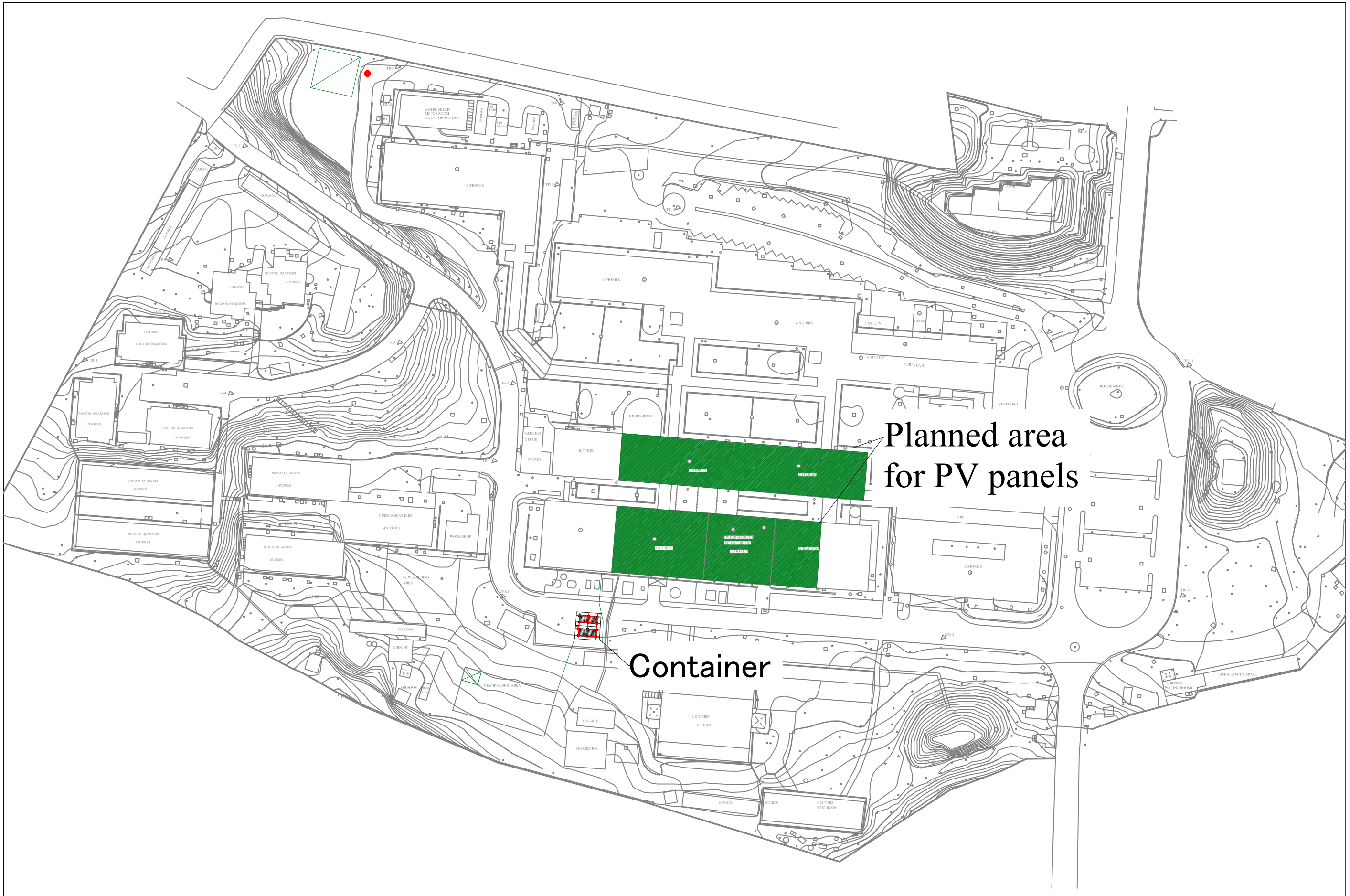


6. Outline Design Drawing

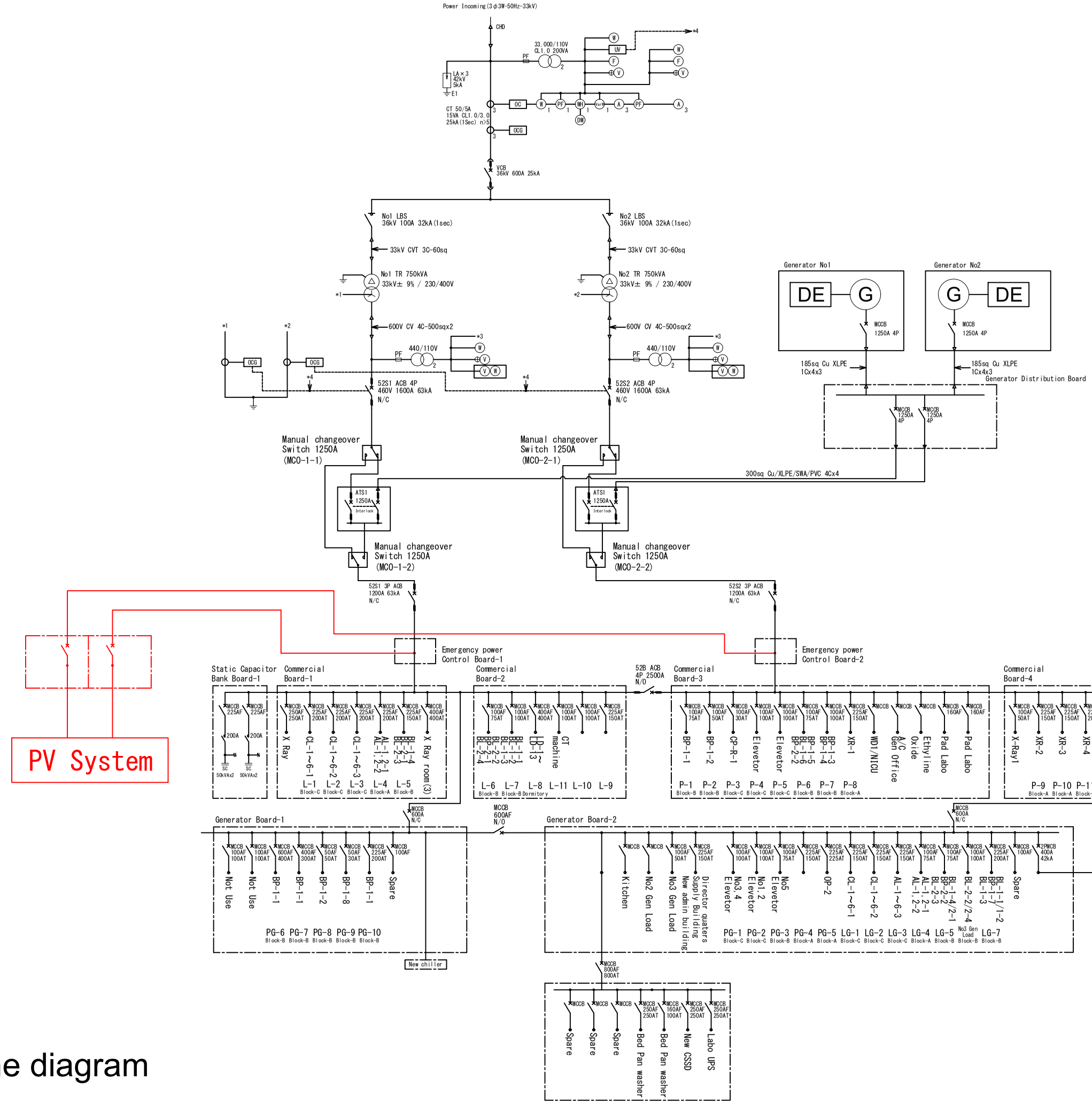
6-1. Equipment drawings (SJGH)



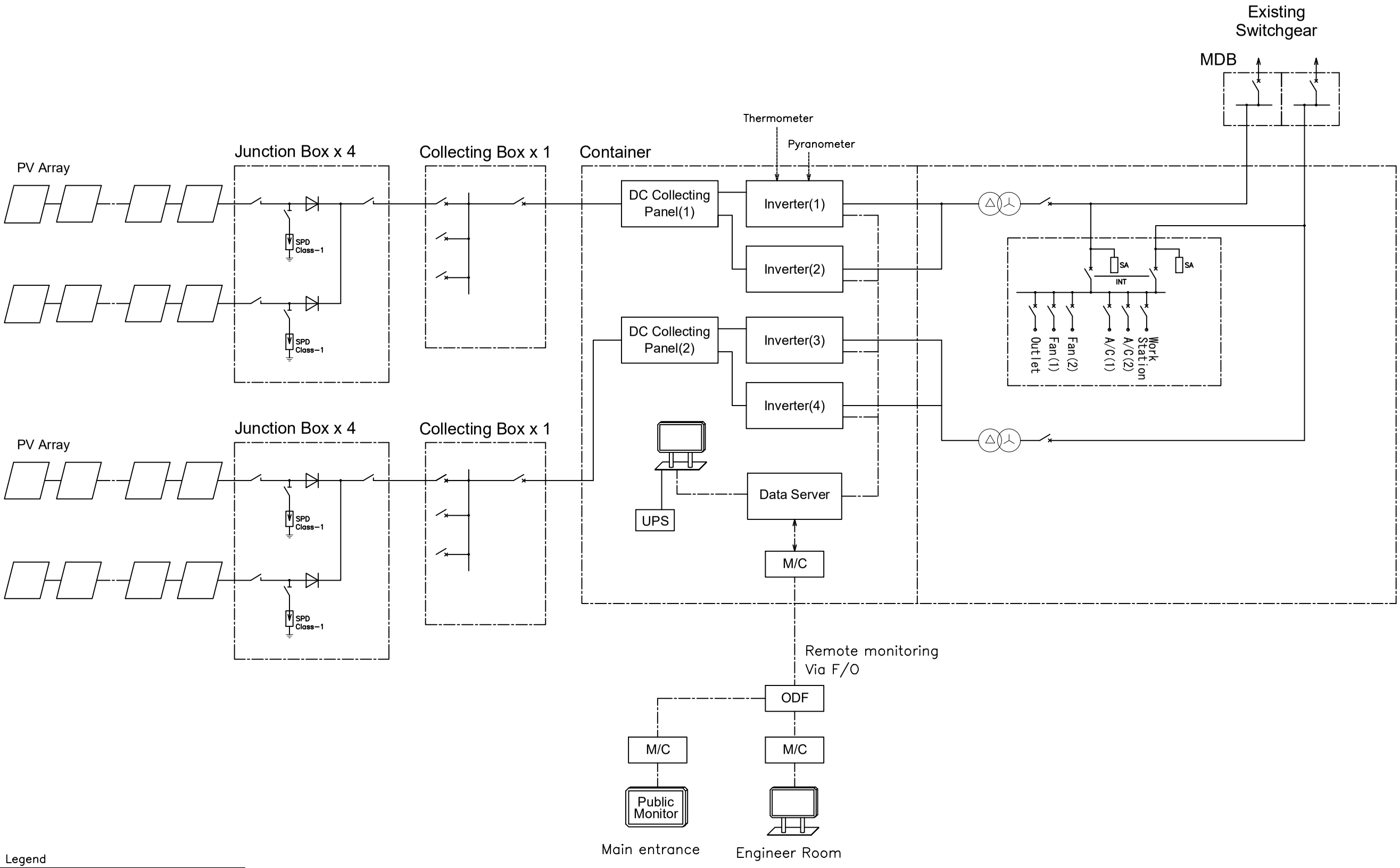
SE-1 Layout Plan of PV Panel



SE-2 Overall layout plan



SE-03 Single Line diagram



Legend

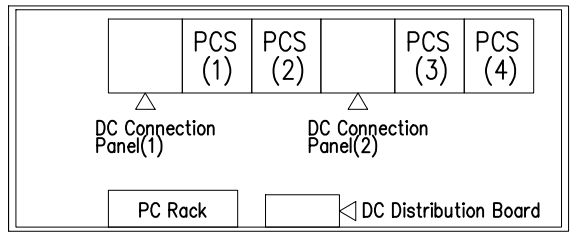
PV	Photo Voltaic
SPD	Surge Protection Device
INV	Inverter
M/C	Media Converter
ODF	Optical Distribution Frame
SA	Surge Arester

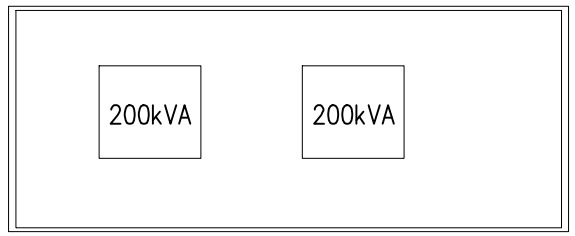
Power Line

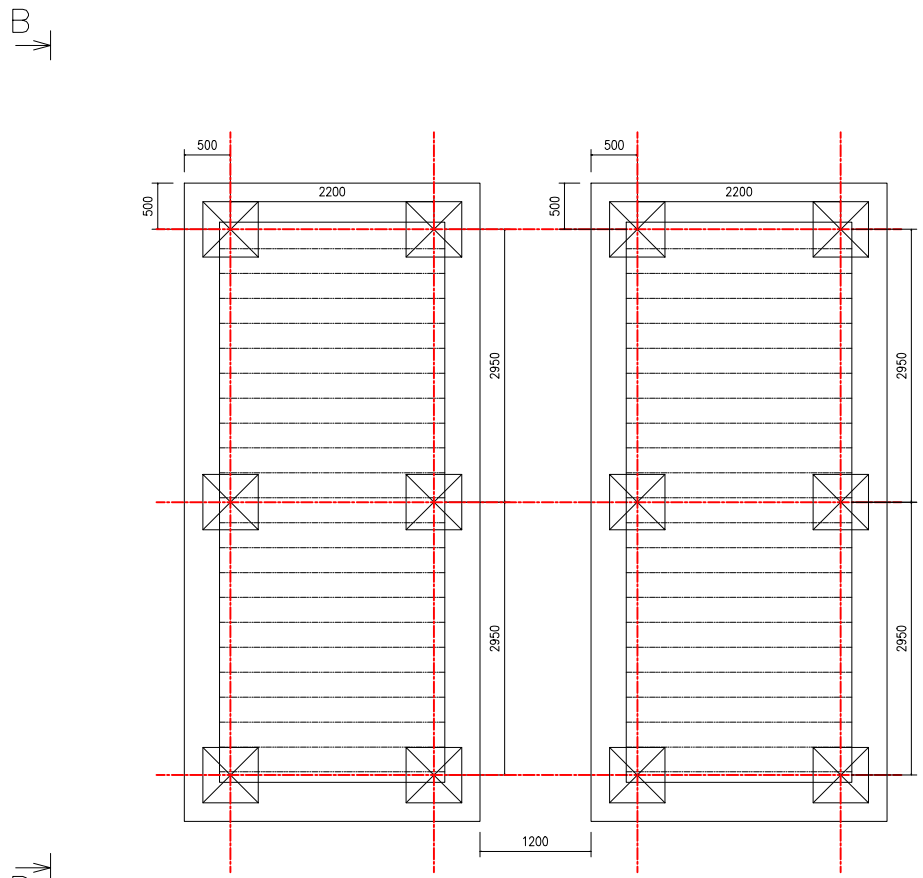
Control & communication Line

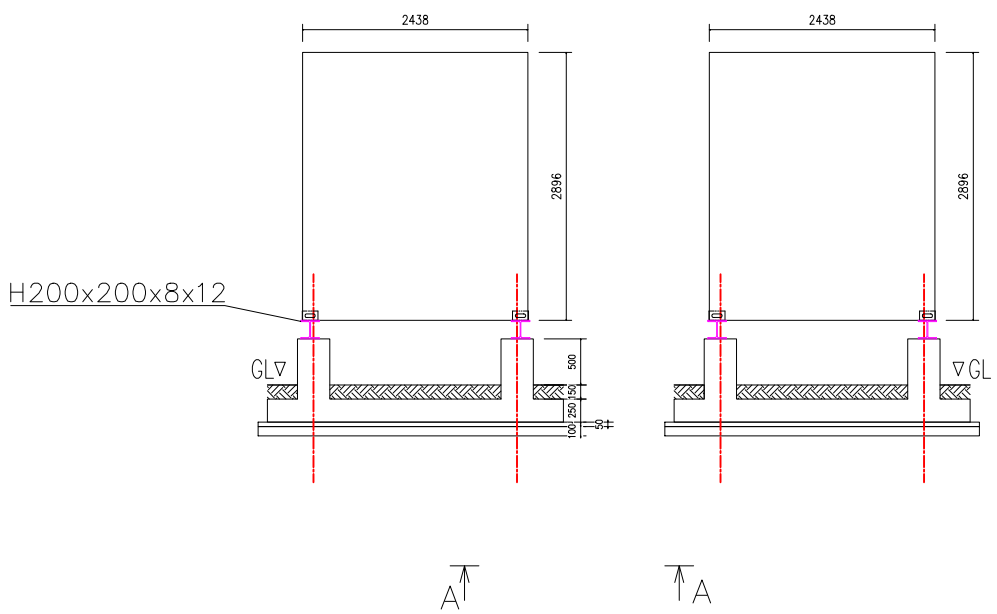
SE-4 System Configuration

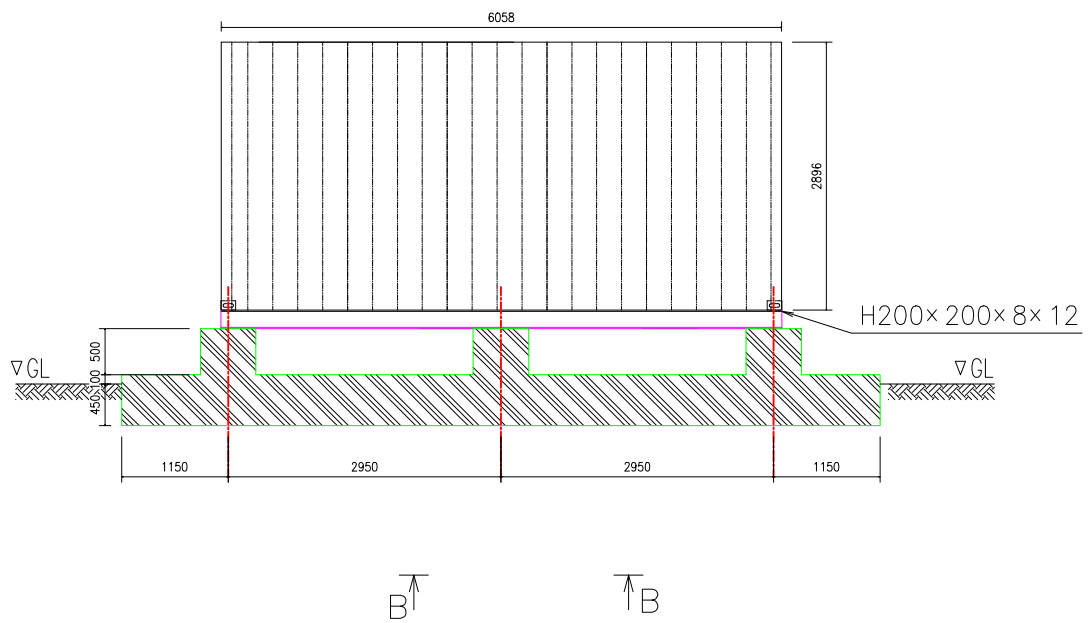
20ft (HC)











SE–5 Layout plan of container



SE-6 Cable route plan

AC cable 240mm2x4Cx1
DC cable 95mm2x1Cx2x2
with cable tray

Buried cable
with FEP pipe

M/H

M/H

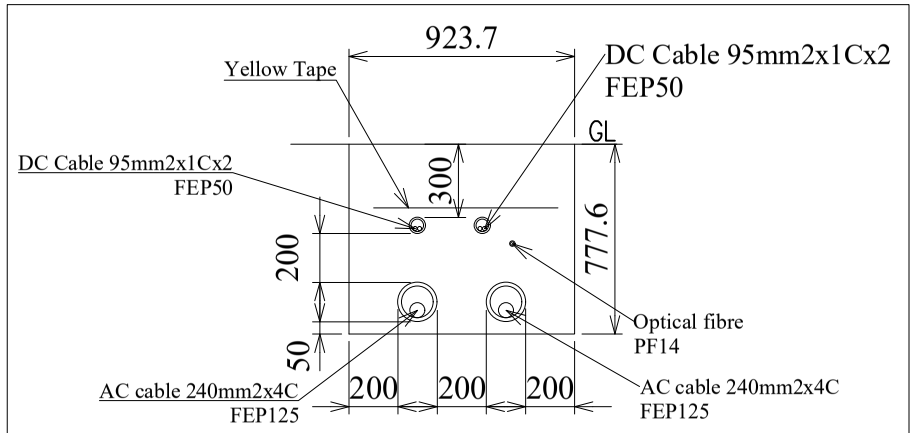
Container

AC cable 150mm2 x4C x1

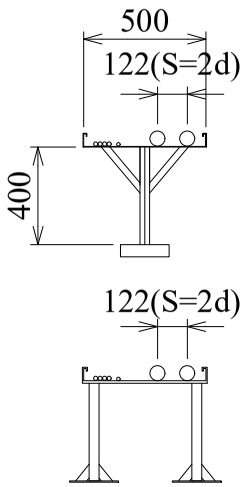
Engineer RM-1
Workshop-1
Boiler RM
New SWGR
UPS
PL-370
LV Panel(I)
LV Panel(II)

GPS-1

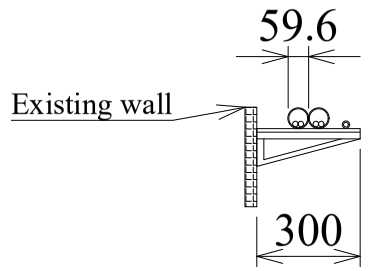
EW BUILDING AREA



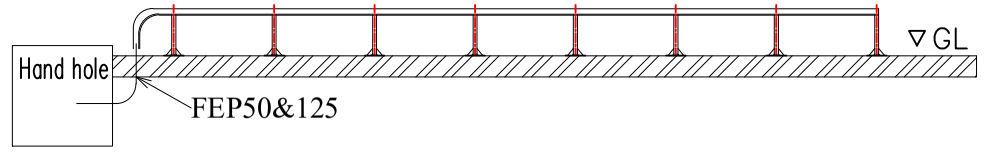
A-A



B-B

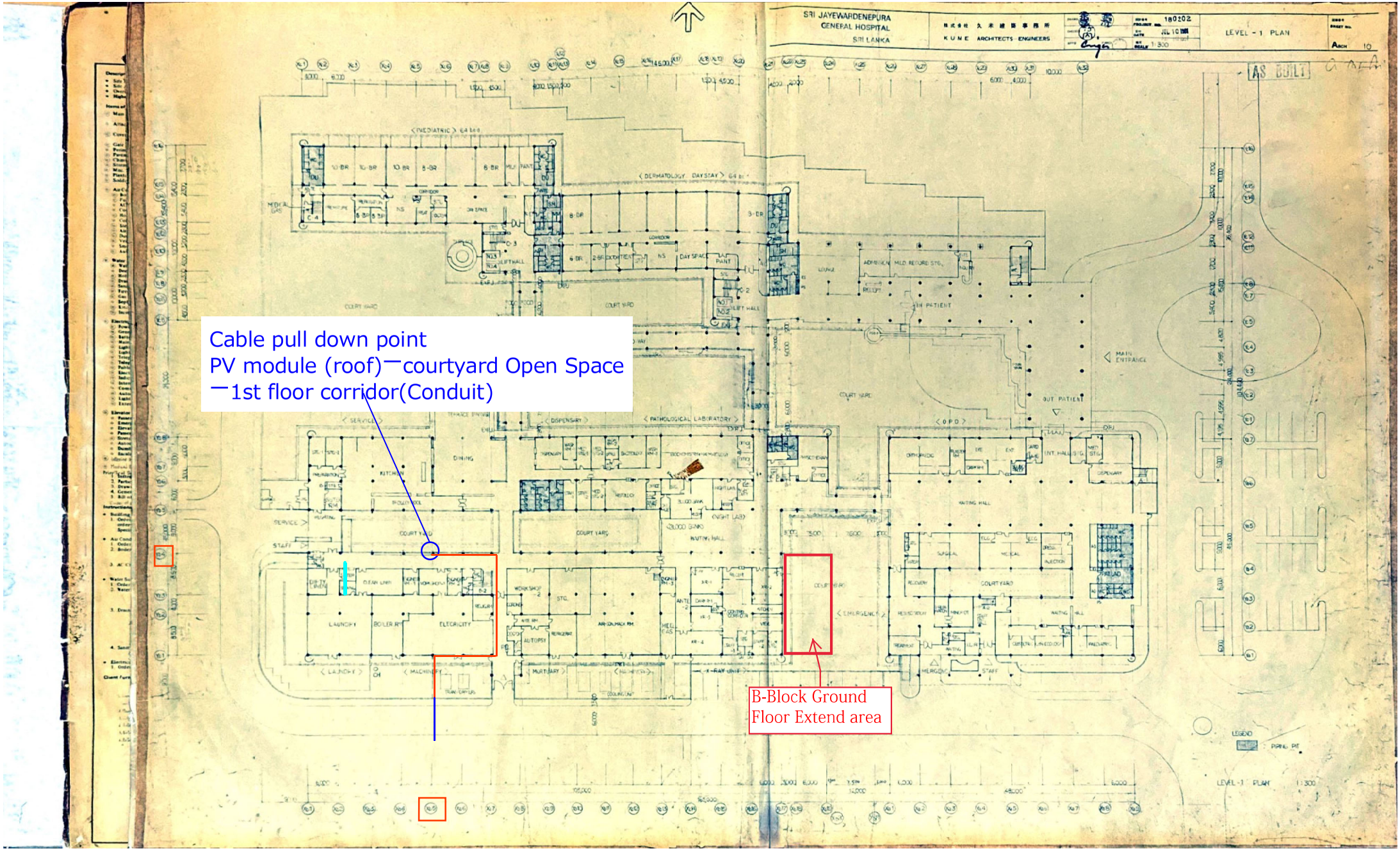


D-D

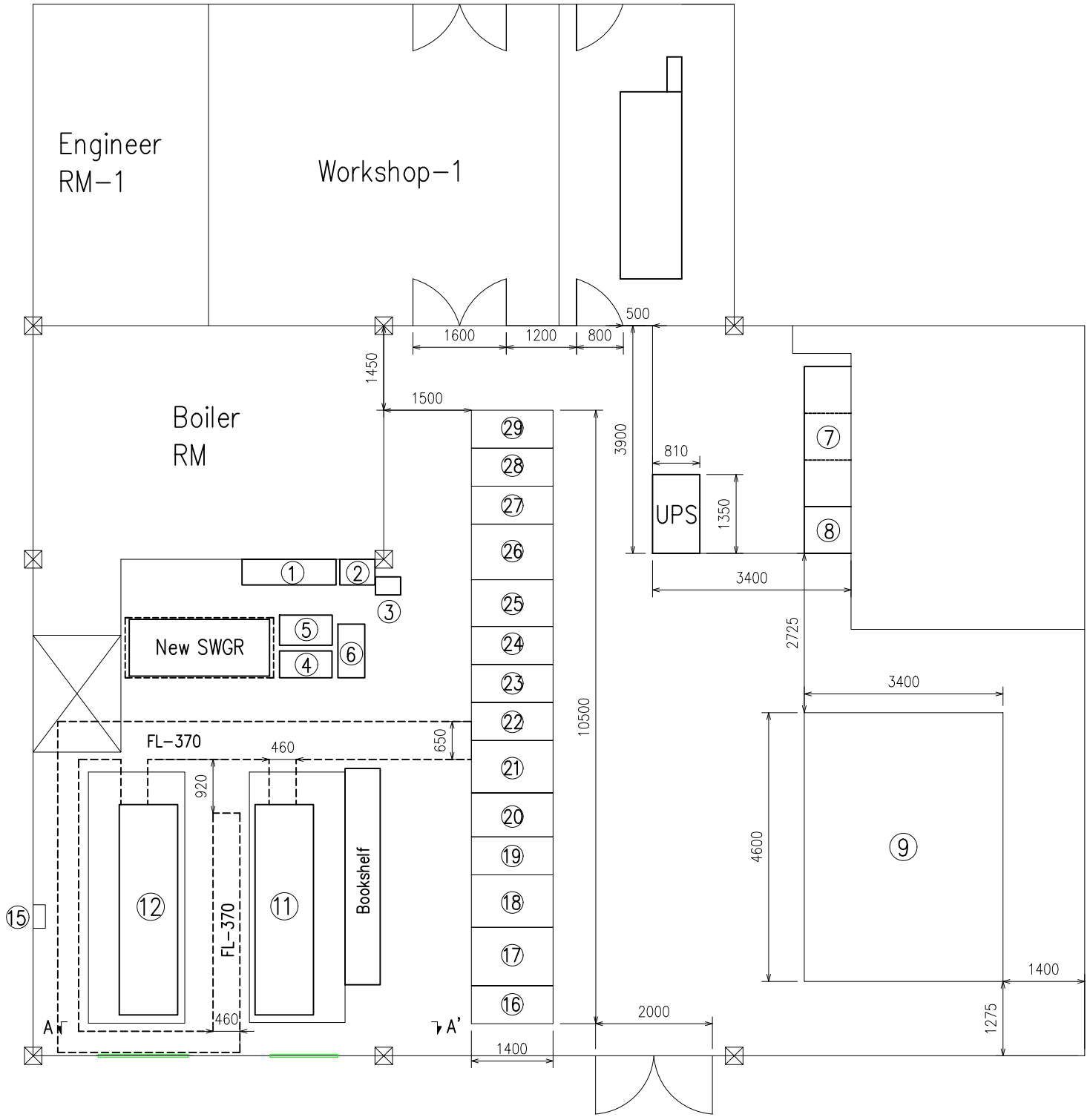


C-C

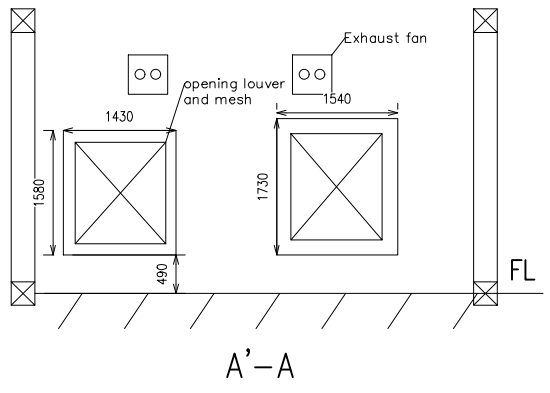
SE-6 Cable route plan



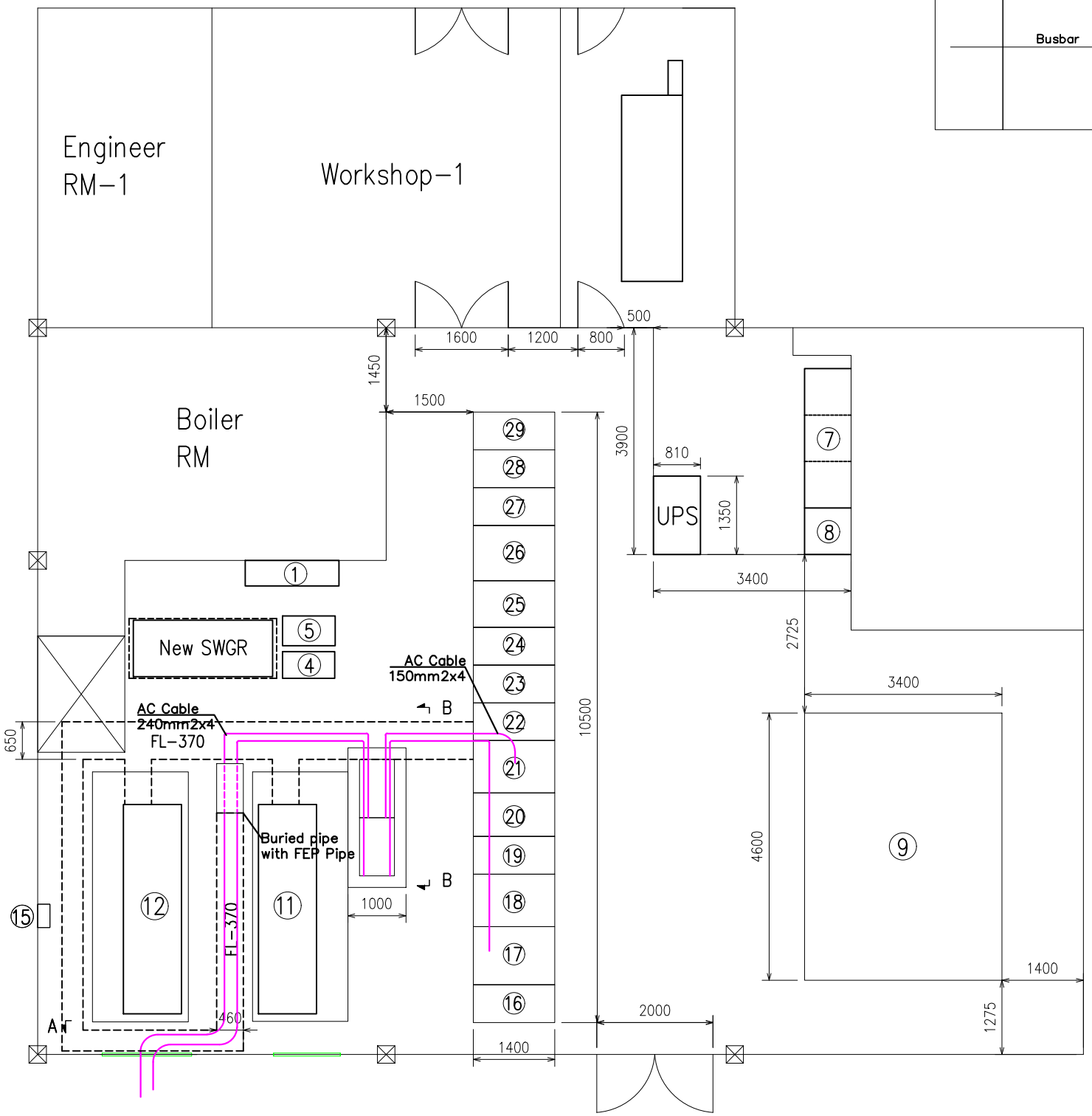
SE-6 Cable route plan

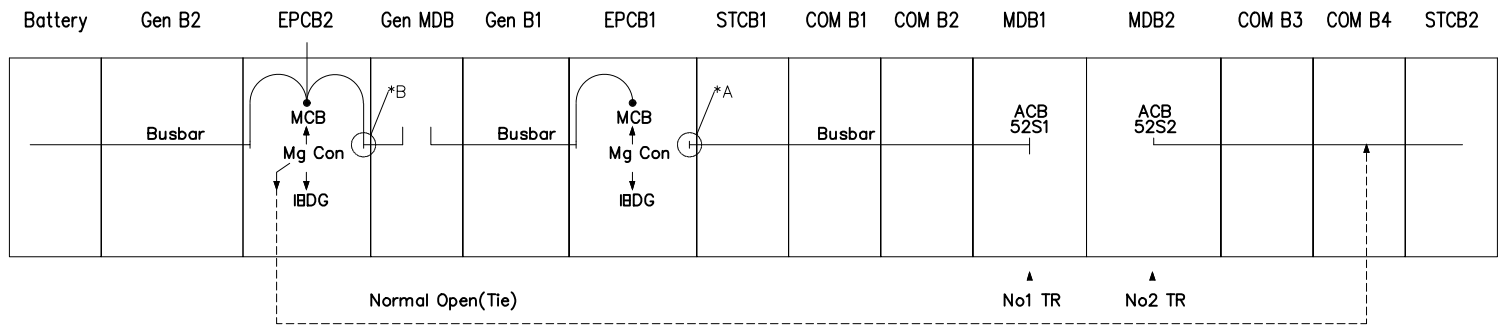


No.	Name of panel	Note	No.	Name of panel	Note
①	Station pump	1,610(W) x 440(D)	⑯	Battery board	650W x 1,400D
②	Oil gear pump panel	600(W) x 440(D)	⑰	Generator Board 2	1,000W x 1,400D
③	Chiller panel		⑱	Emergency power Control Board 2	900W x 1,400D
④	Cabinet		⑲	Generator Main distribution Board	650W x 1,400D
⑤	Cabinet		⑳	Generator Board 1	750W x 1,400D
⑥	Cabinet		㉑	Emergency power Control Board 1	900W x 1,400D
⑦	Battery Cabinet	2400(W) x 800(D)	㉒	Static Capacitor board 1	650W x 1,400D
⑧	DC Charger	800(W) x 800(D)	㉓	Commercial board 1	650W x 1,400D
⑨	33kV Switchgear	4,600W) x 3,400(D)	㉔	Commercial board 2	650W x 1,400D
⑩	Main distribution board	9,850(W) x 2,000(D)	㉕	Main distribution board 1	800W x 1,400D
⑪	400V ATS PAnel (No1 Incomer)	3,600(W) x 1,000(D)?	㉖	Main distribution board 2	950W x 1,400D
⑫	400V ATS PAnel (No2 Incomer)	3,600(W) x 1,000(D)?	㉗	Commercial board 3	650W x 1,400D
⑬	Elevator Panel(1)	500(W) x 220(D)	㉘	Commercial board 4	650W x 1,400D
⑭	Elevator Panel(2)	500(W) x 220(D)	㉙	Static Capacitor board 2	650W x 1,400D
⑮	Tank Box	400(W) x 210(D)			

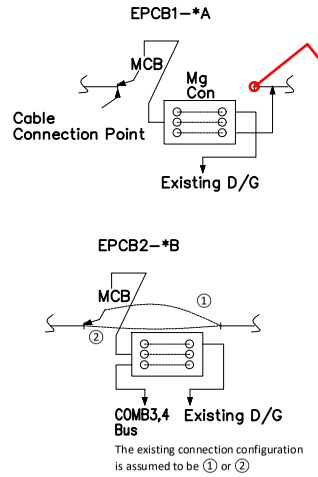


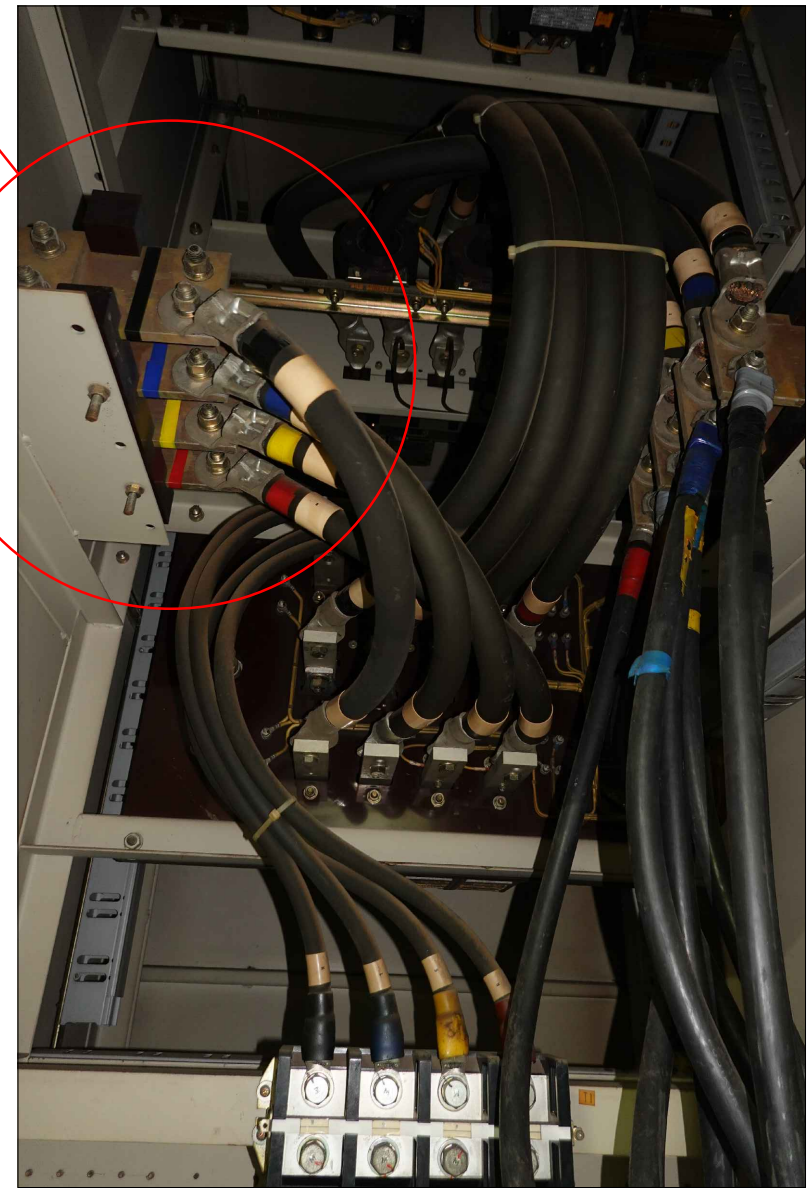
SE-6 Cable route plan

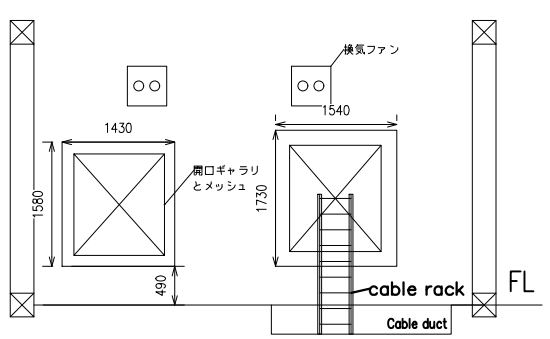




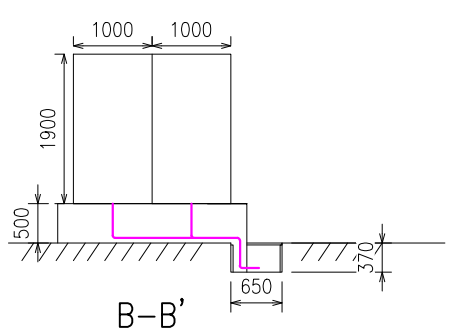
Panel (D) 1,400mm
Panel (H) 2,300mm
GL~bottom of ceiling beam 3,150mm height
GL~bottom of ceiling 3,840mm height







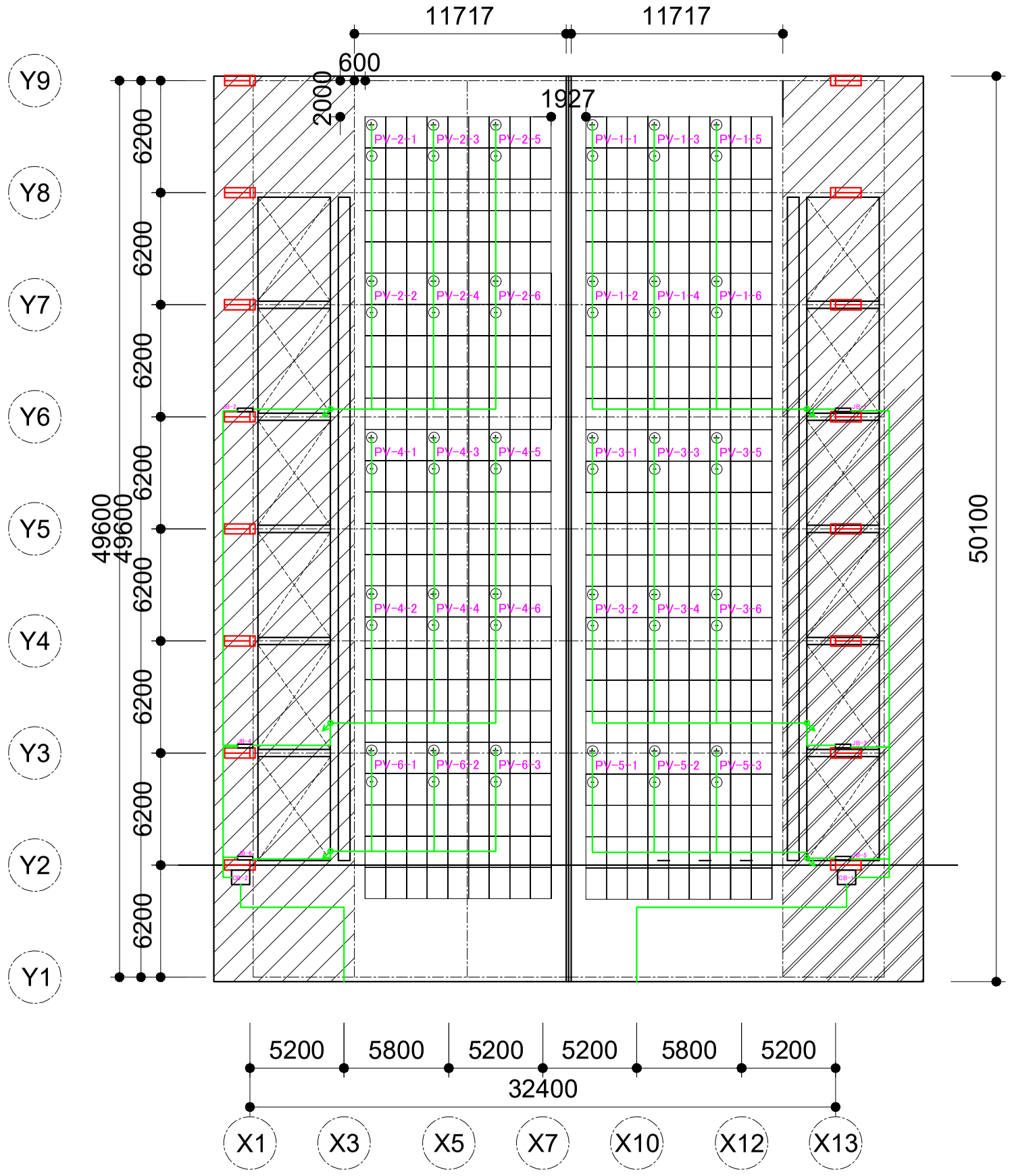
A'-A



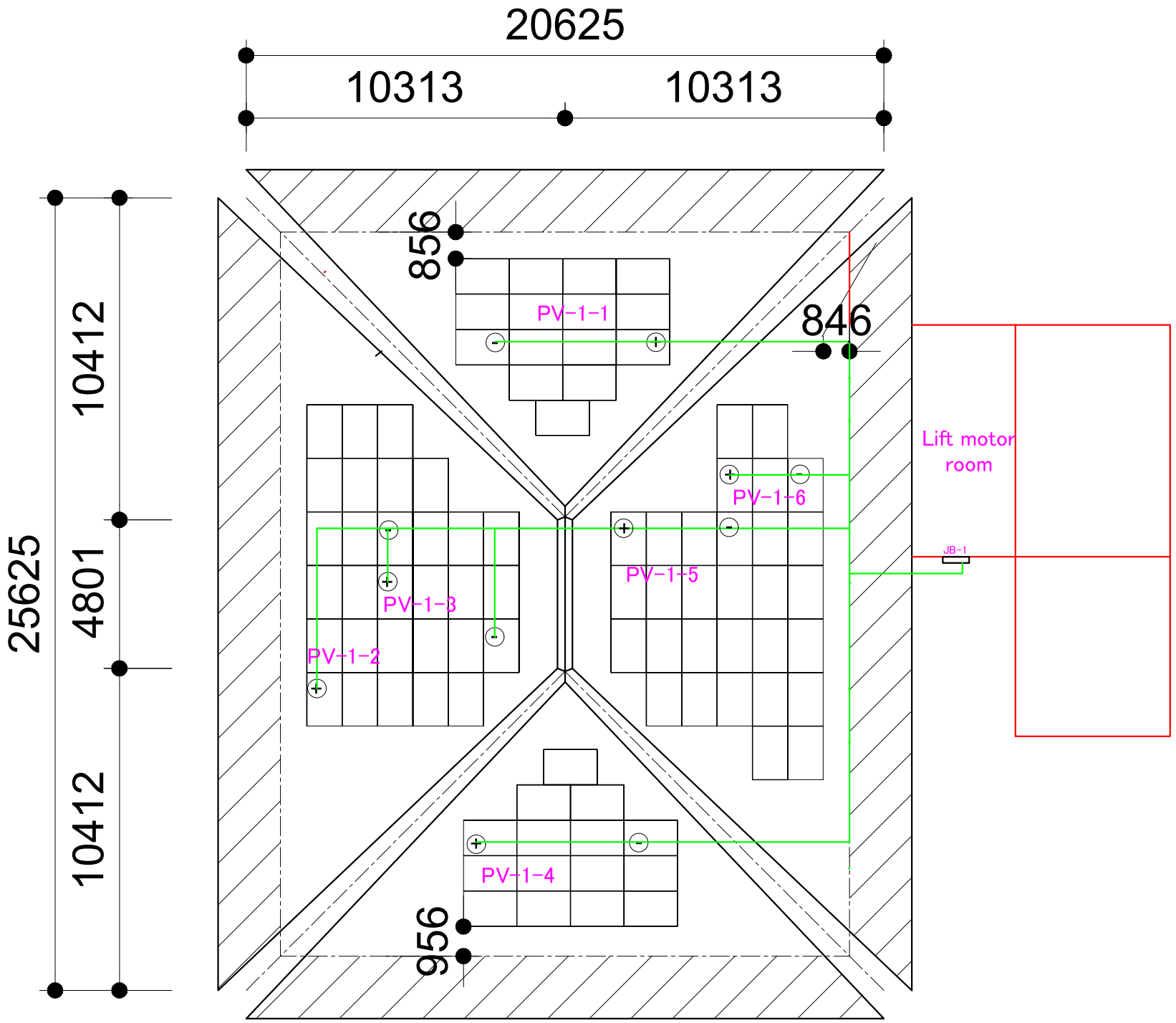
B-B'

SE-6 Cable route plan

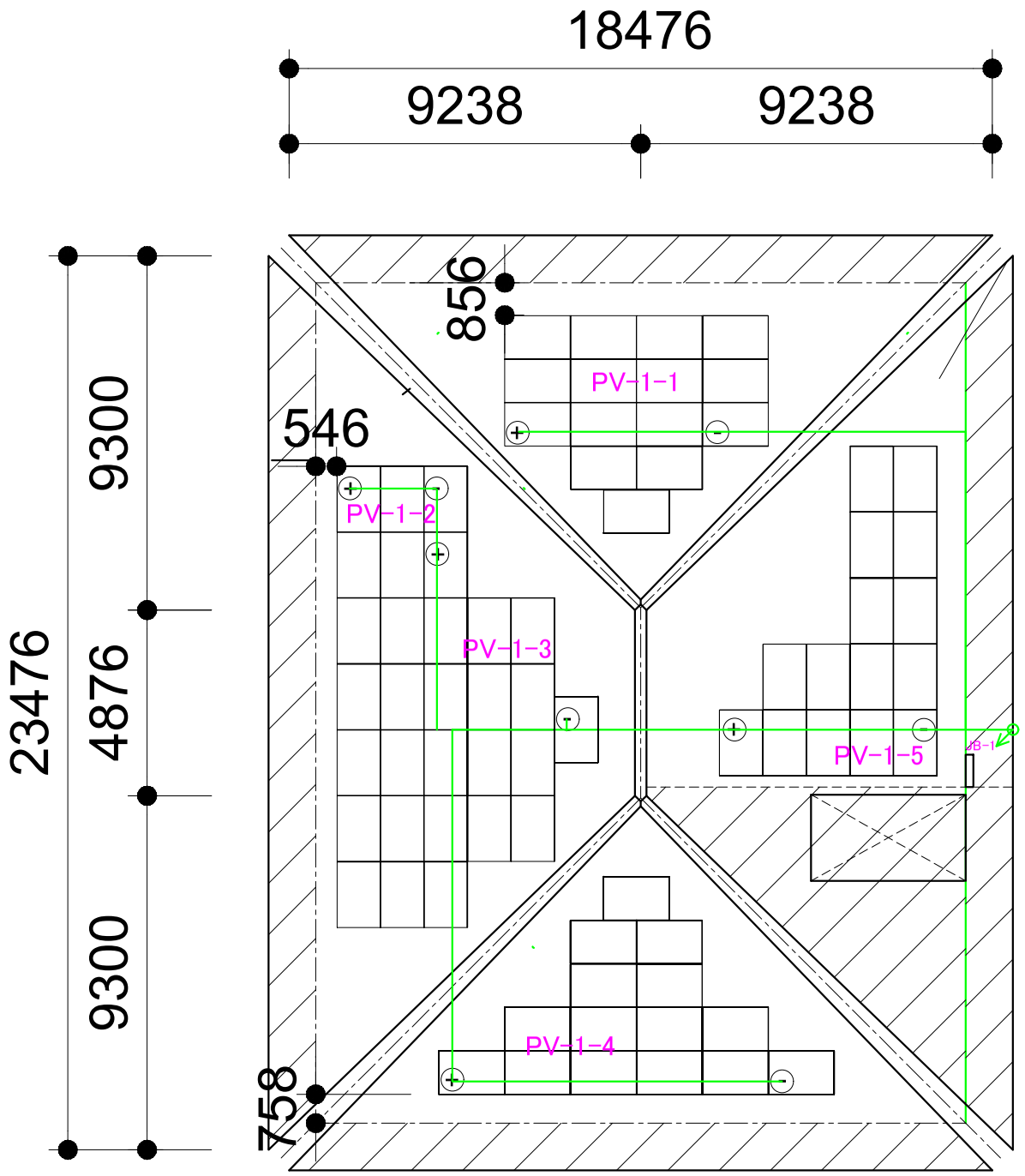
6-2. Equipment drawings (TH Ratnapura)



RE-1-1 Layout Plan of PV Panel (JICA building)



RE-1-2 Layout Plan of PV Panel (A&E building)



RE-1-3 Layout Plan of PV Panel (Blood Bank building)

Container(1)

A&E building

Blood Bank building

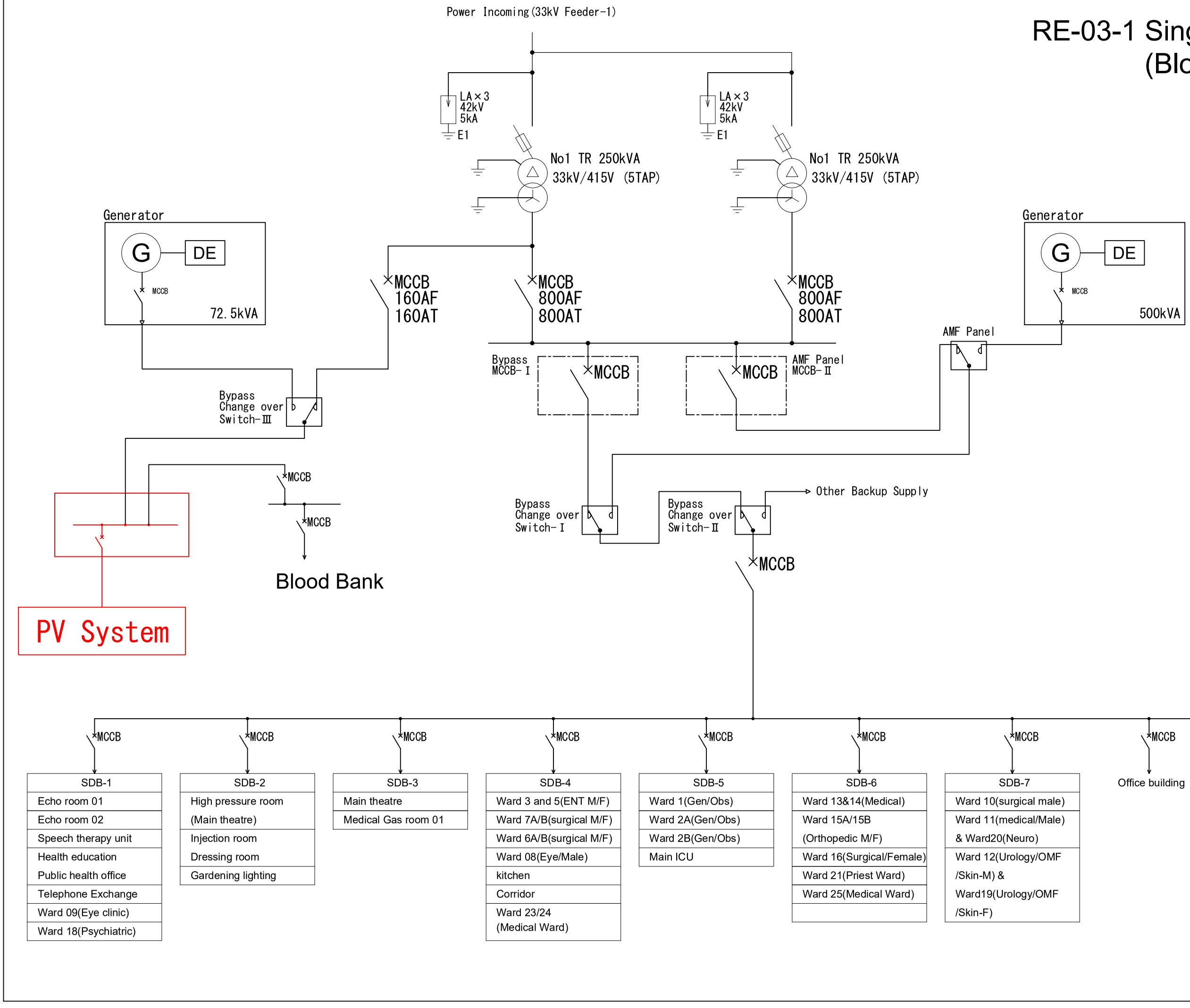
JICA building

Container(2)

GRAPHIC SCALE
(IN METERS)
0 5 10 20 30 40 50

RE-2 Overall Layout Plan

RE-03-1 Single Line Diagram (Blood Bank)



SDB-1
Echo room 01
Echo room 02
Speech therapy unit
Health education Public health office
Telephone Exchange
Ward 09(Eye clinic)
Ward 18(Psychiatric)

SDB-2
High pressure room (Main theatre)
Injection room Dressing room
Gardening lighting

SDB-3
Main theatre
Medical Gas room 01

SDB-4
Ward 3 and 5(ENT M/F)
Ward 7A/B(surgical M/F)
Ward 6A/B(surgical M/F)
Ward 08(Eye/Male)
kitchen
Corridor
Ward 23/24 (Medical Ward)

SDB-5
Ward 1(Gen/Obs)
Ward 2A(Gen/Obs)
Ward 2B(Gen/Obs)
Main ICU

SDB-6
Ward 13&14(Medical)
Ward 15A/15B (Orthopedic M/F)
Ward 16(Surgical/Female)
Ward 21(Priest Ward)
Ward 25(Medical Ward)

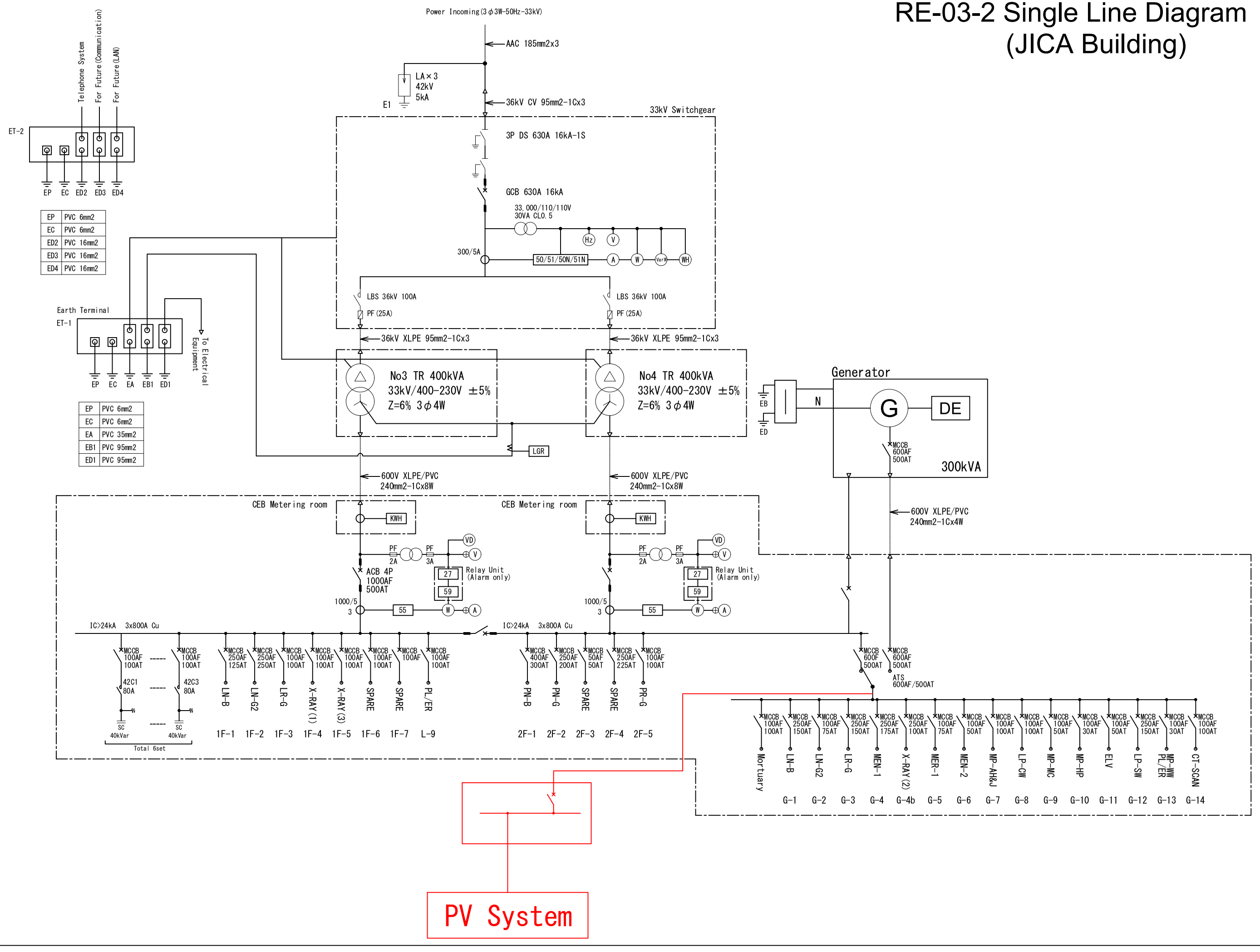
SDB-7
Ward 10(surgical male)
Ward 11(medical/Male) & Ward20(Neuro)
Ward 12(Urology/OMF /Skin-M) & Ward19(Urology/OMF /Skin-F)

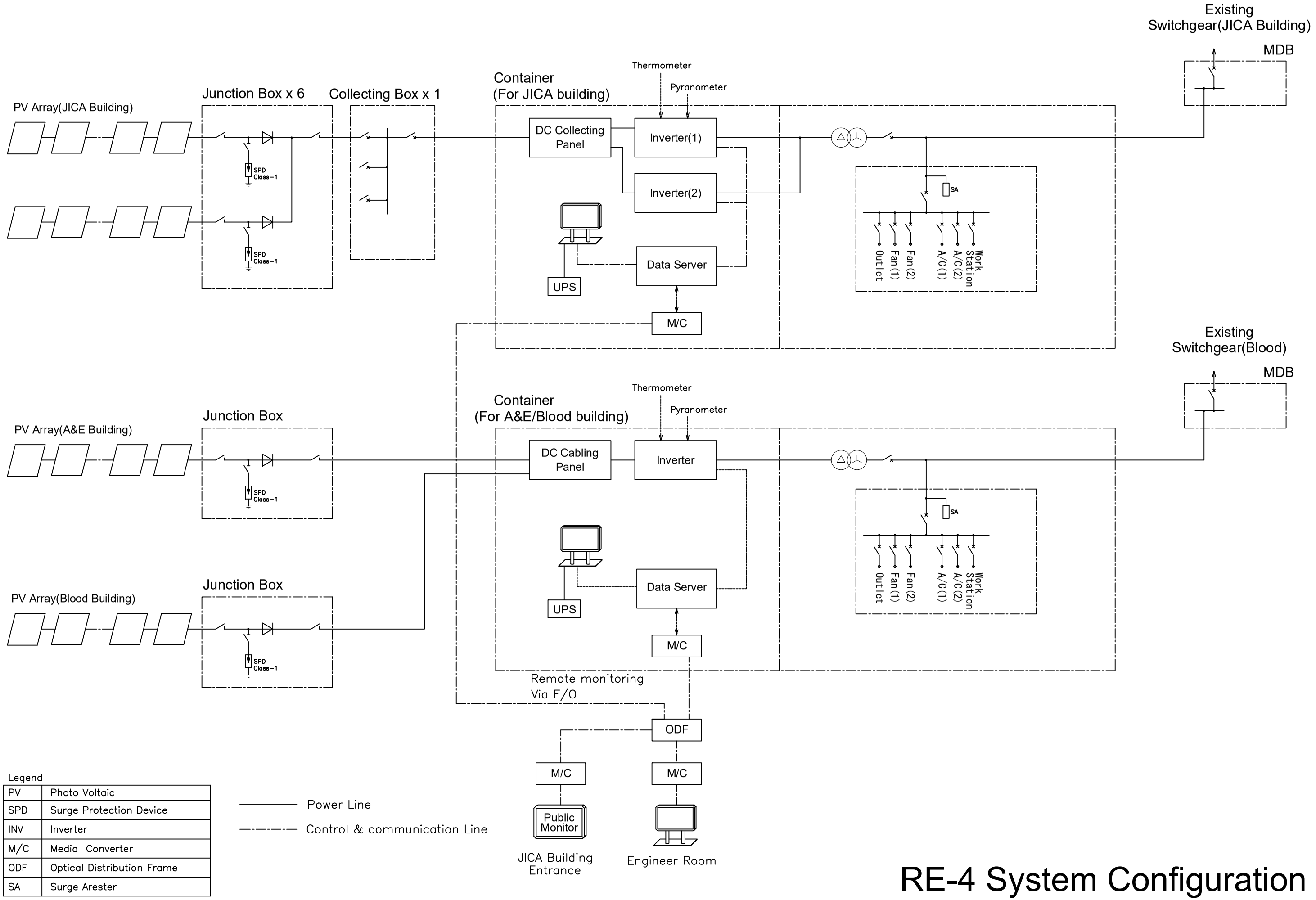
Office building

2 Lifts

OT/AC(Main Theatre)

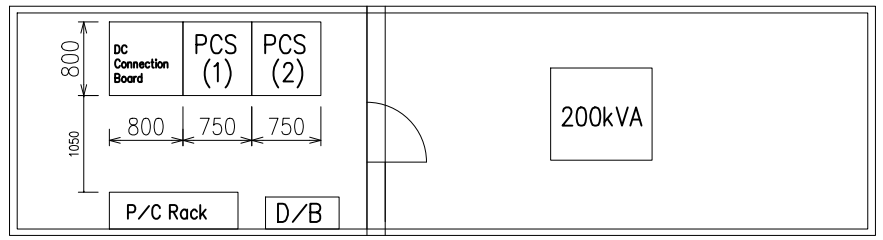
RE-03-2 Single Line Diagram (JICA Building)

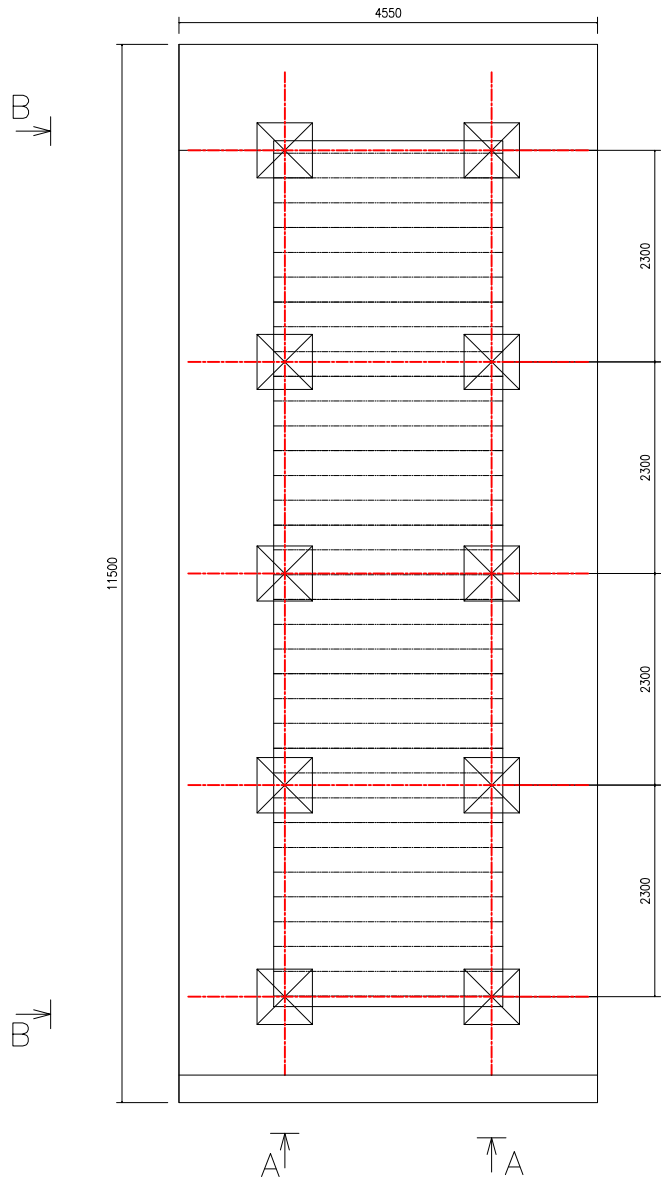


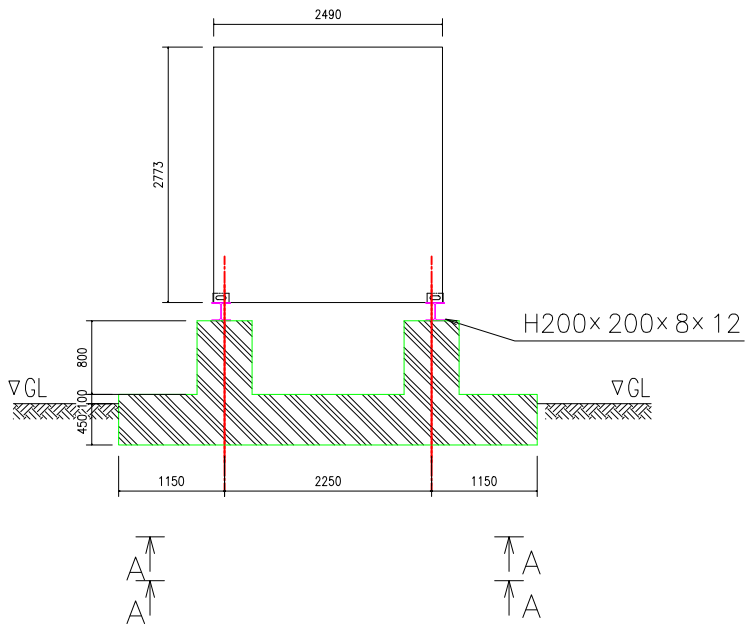


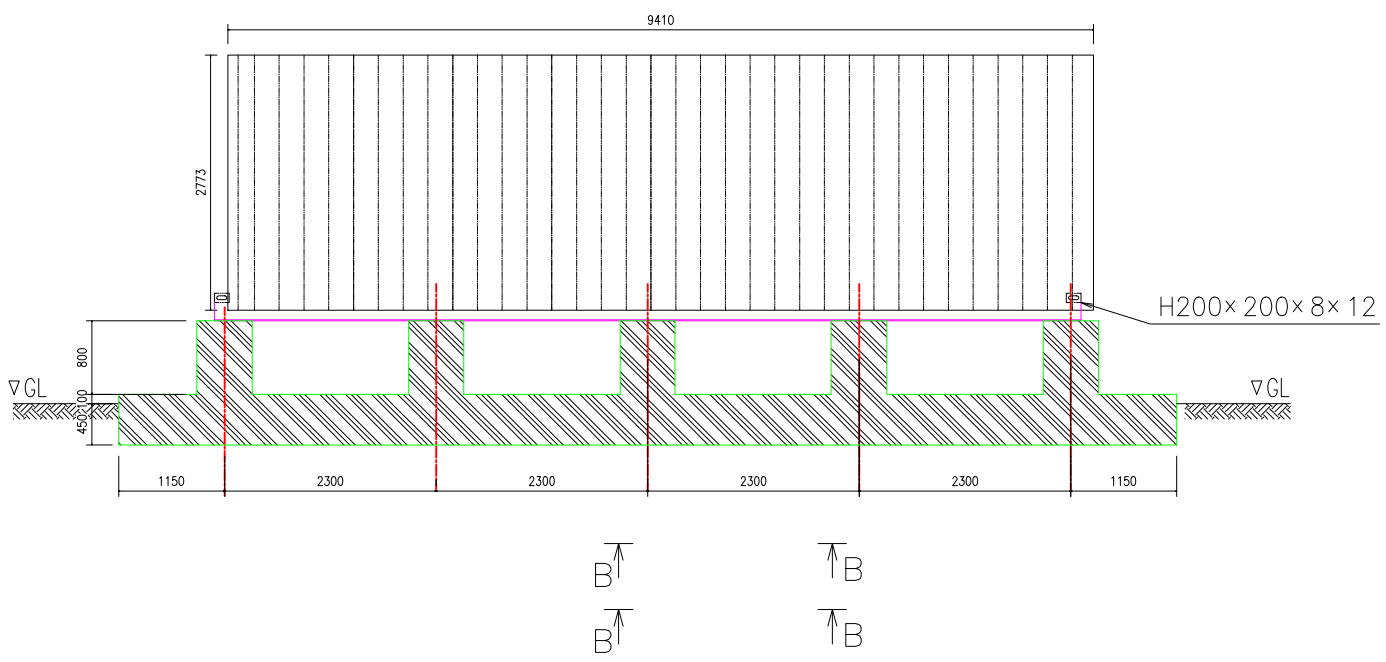
RE-4 System Configuration

31ft



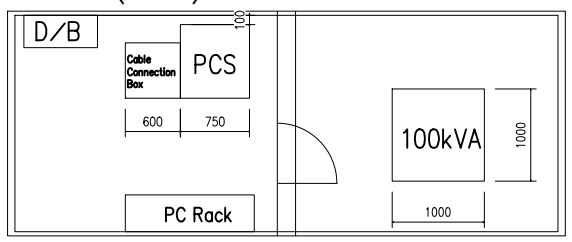


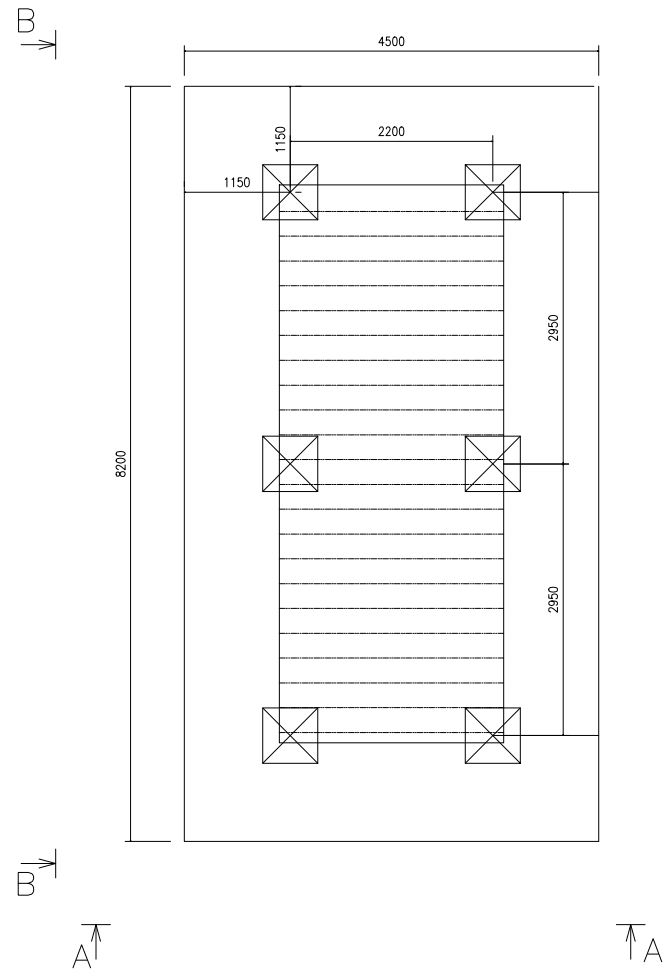


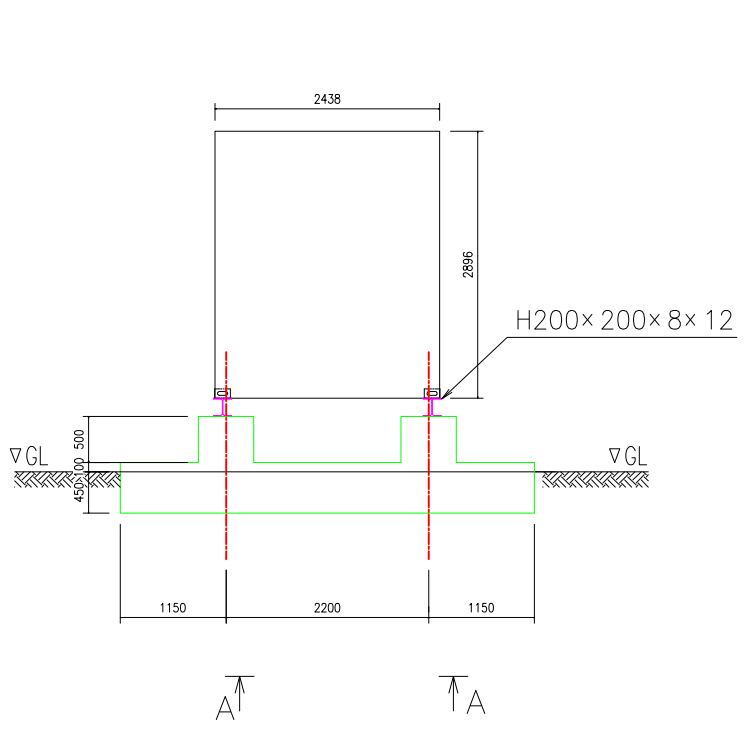


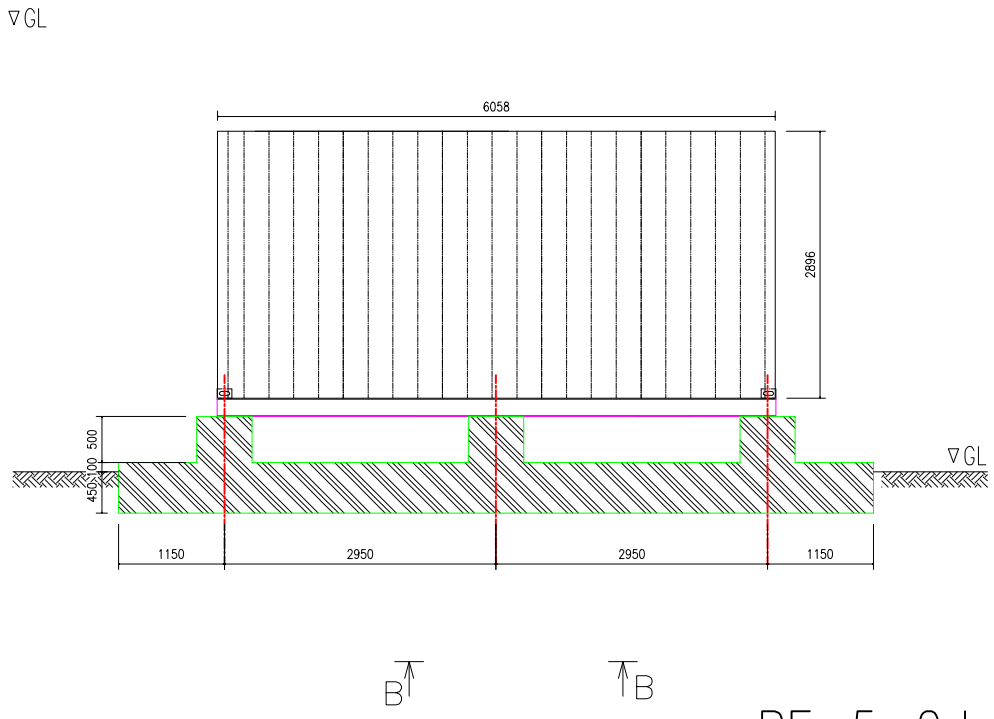
RE-5-1 Layout plan of container
(JICA Building)

20ft (HC)









RE–5–2 Layout plan of container
(A&E and Blood Bank)

DC cable
70mm2x1Cx2
with conduit pipe

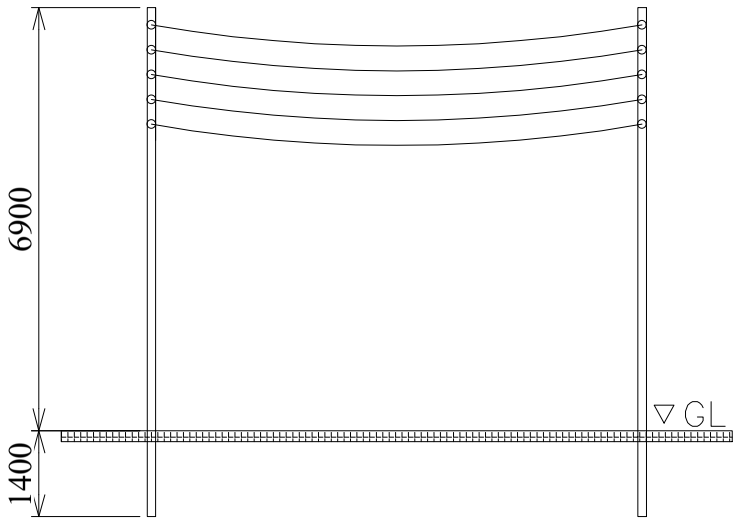
Terminal Box

LV Box(1)

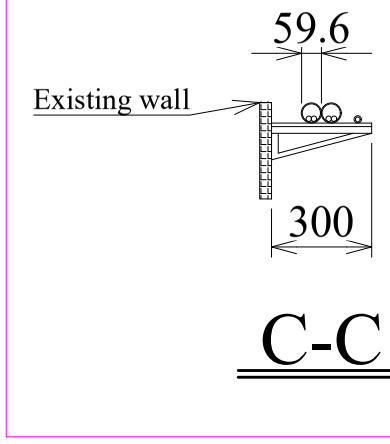
DC Cable 50mm2x1Cx2

DC cable
70mm2x1Cx2x2
AC cable 185mm2x4Cx2
with cable tray

8.3m-LV Pole（CEB standard）

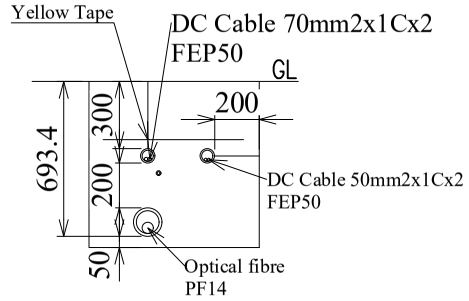


A-A



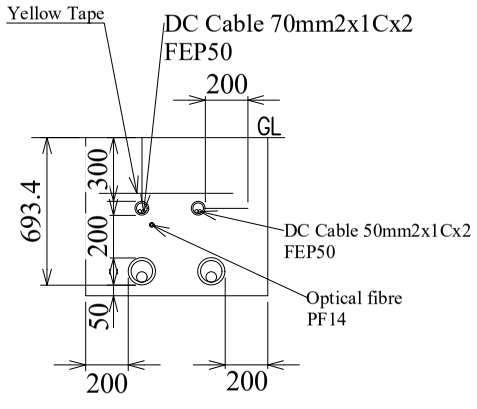
C-C

ラトナプラ blood,A&E



B-B

ラトナプラ JICA

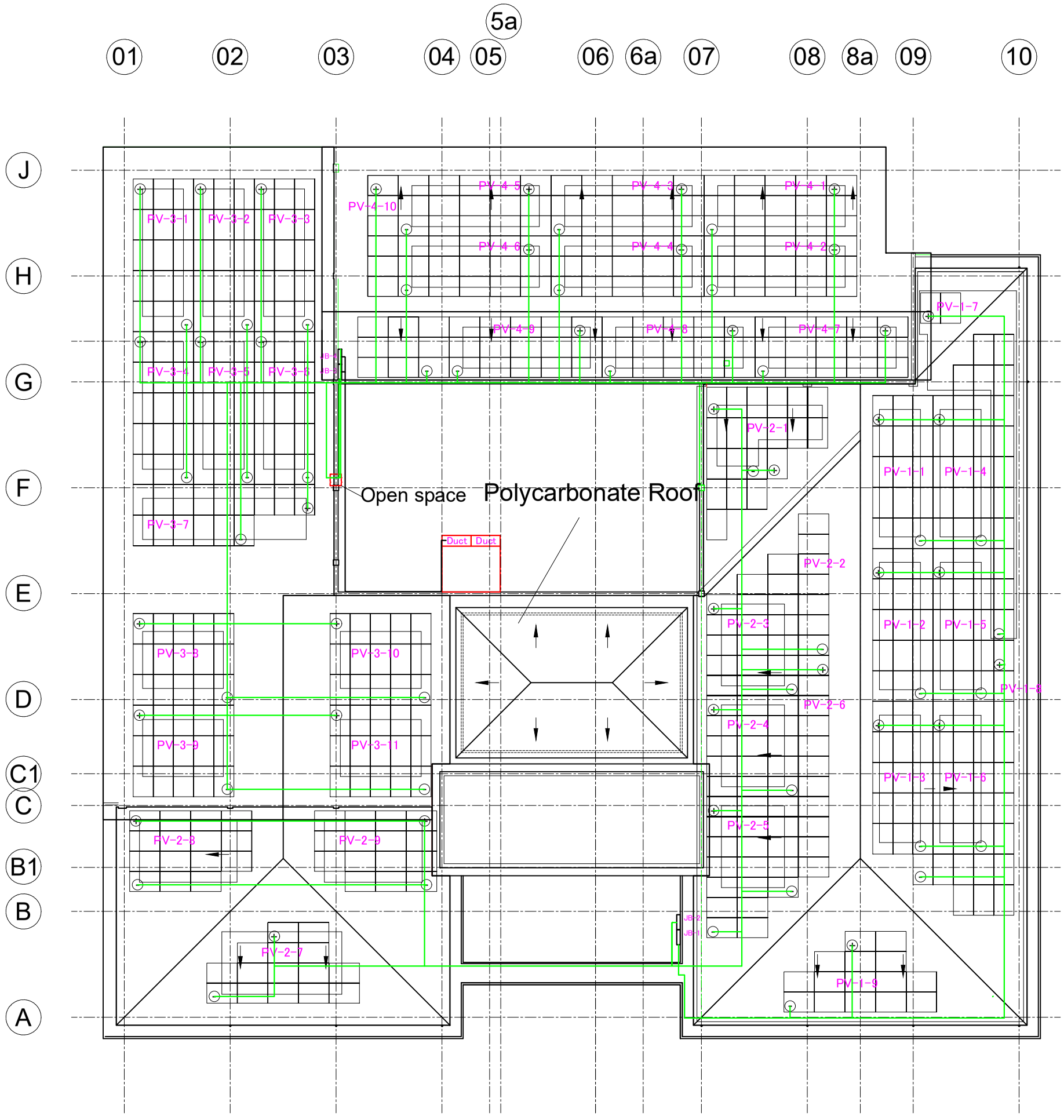


D-D

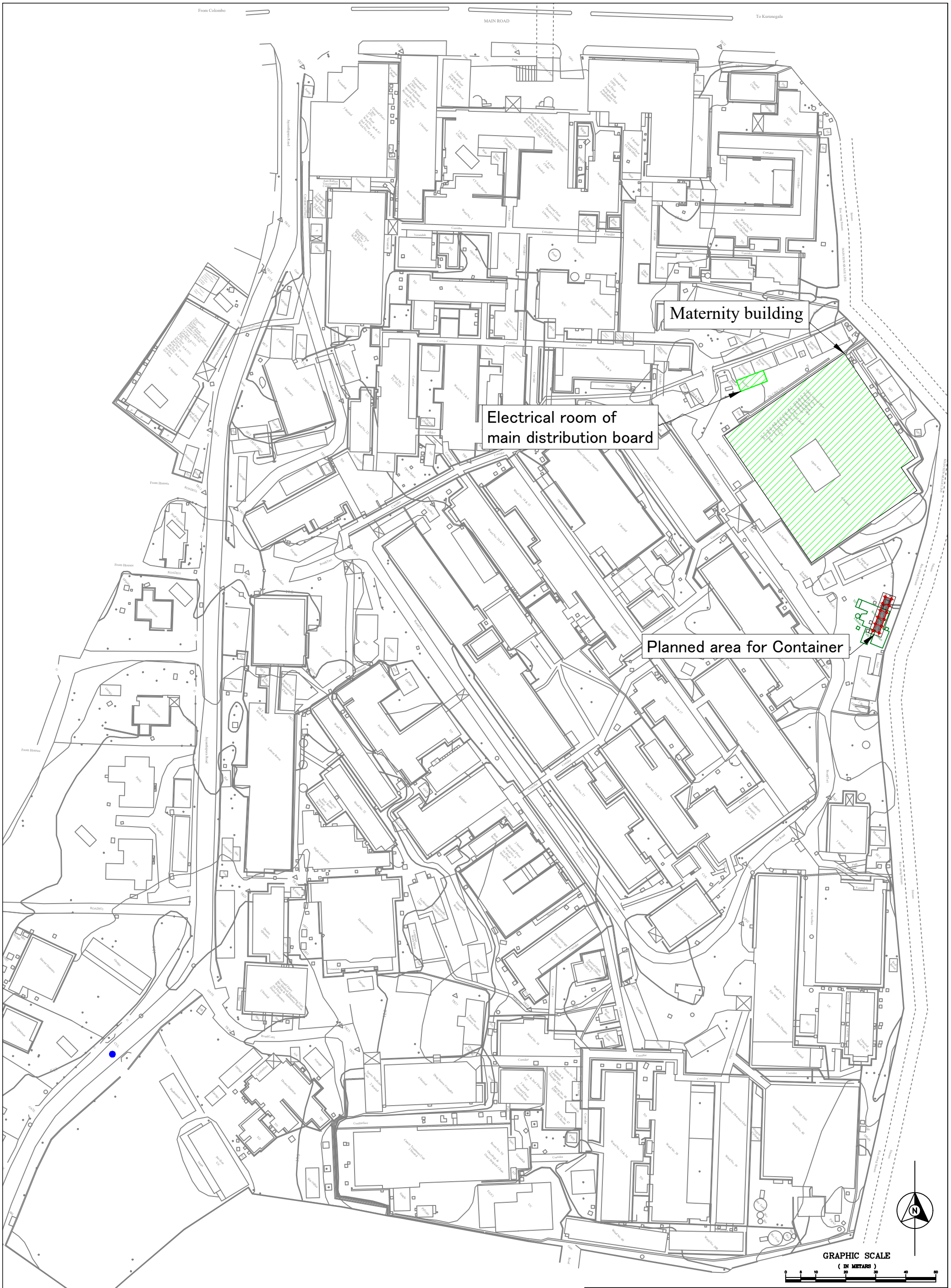
GRAPHIC SCALE
(IN METARS)
0 5 10 20 30 40 50

RE-6 Cable Route Plan

6-3. Equipment drawings (TH Kurunegala)

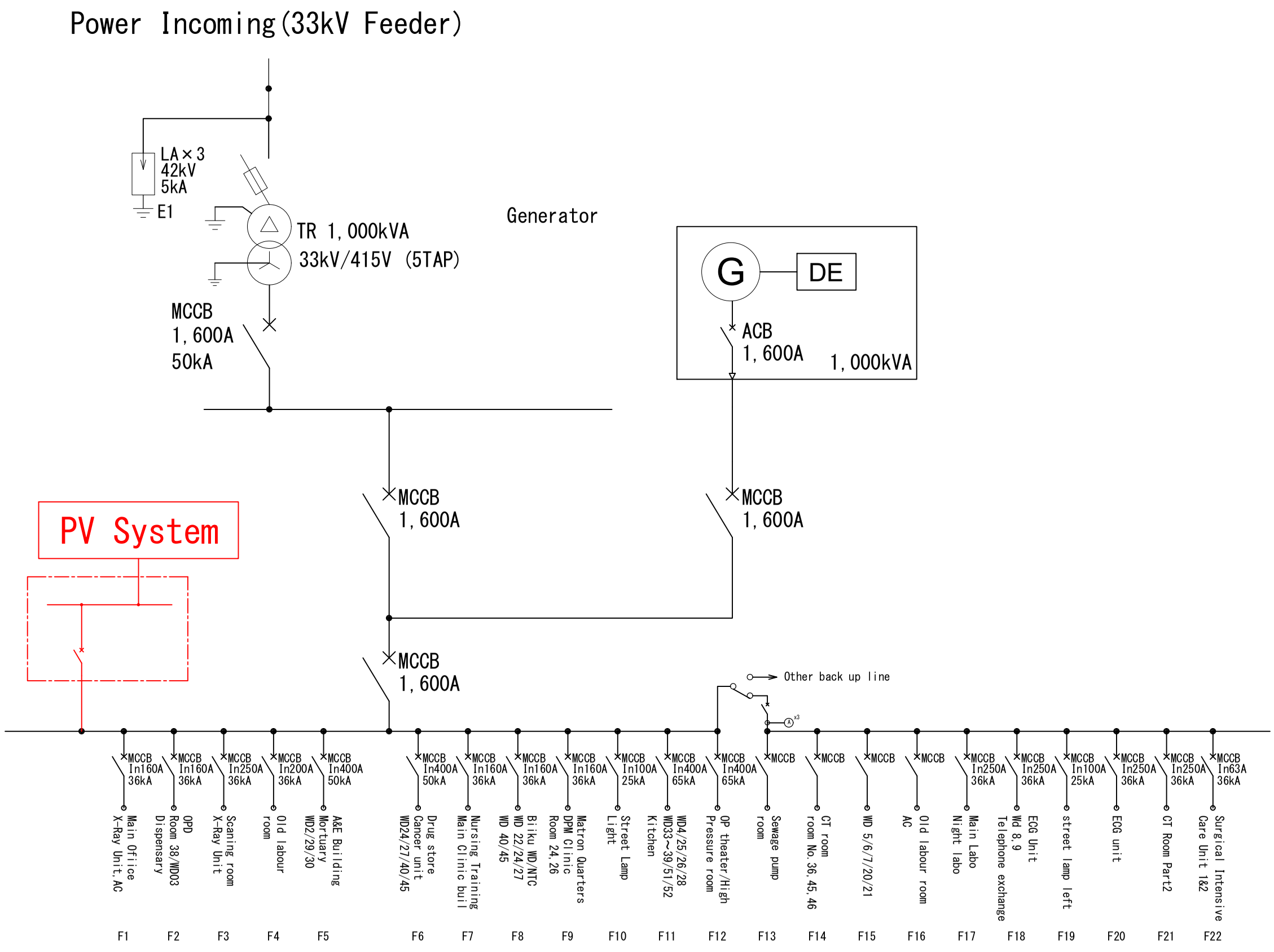


KE-1 Layout of PV Panel



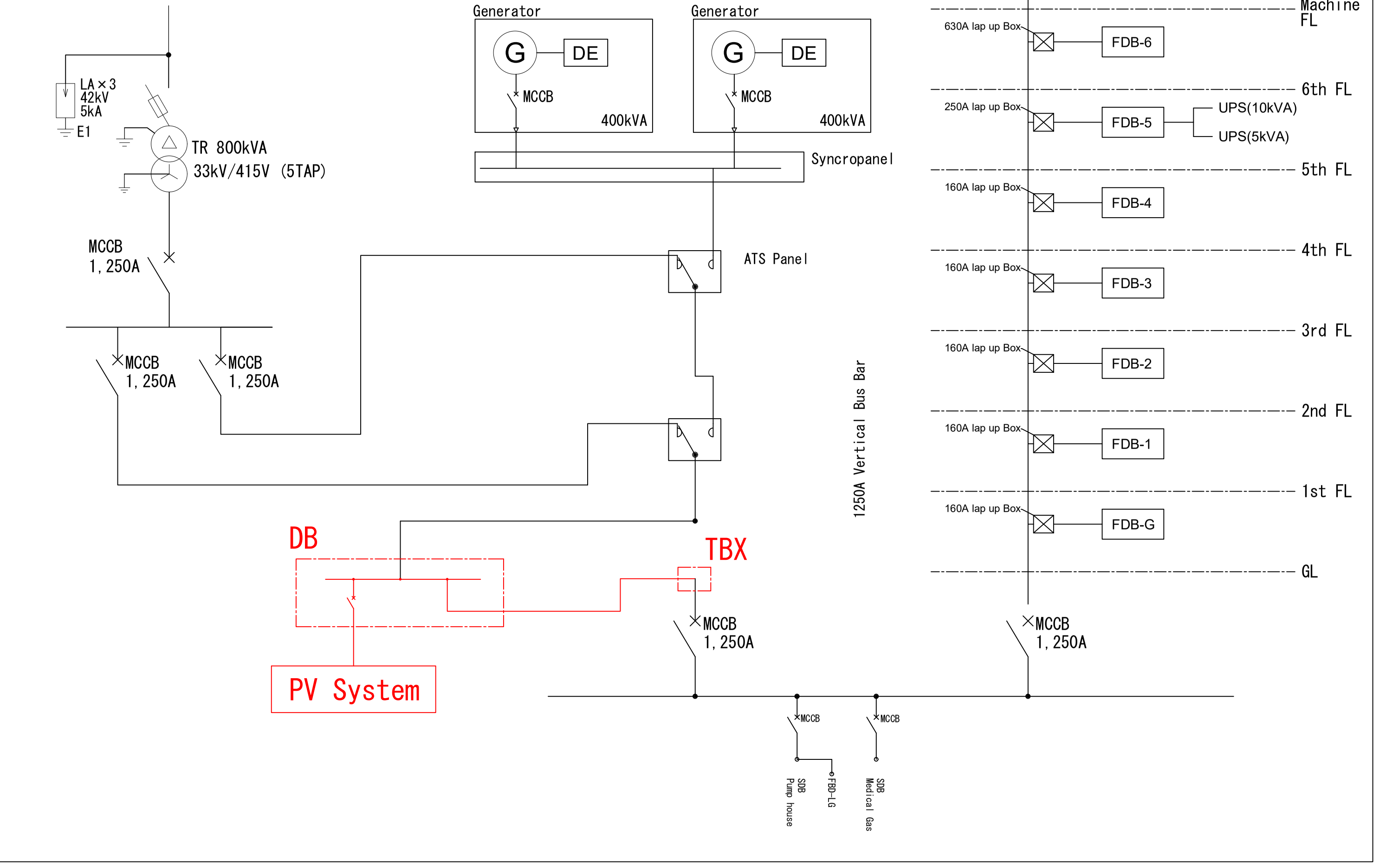
KE-2 Overall layout Plan

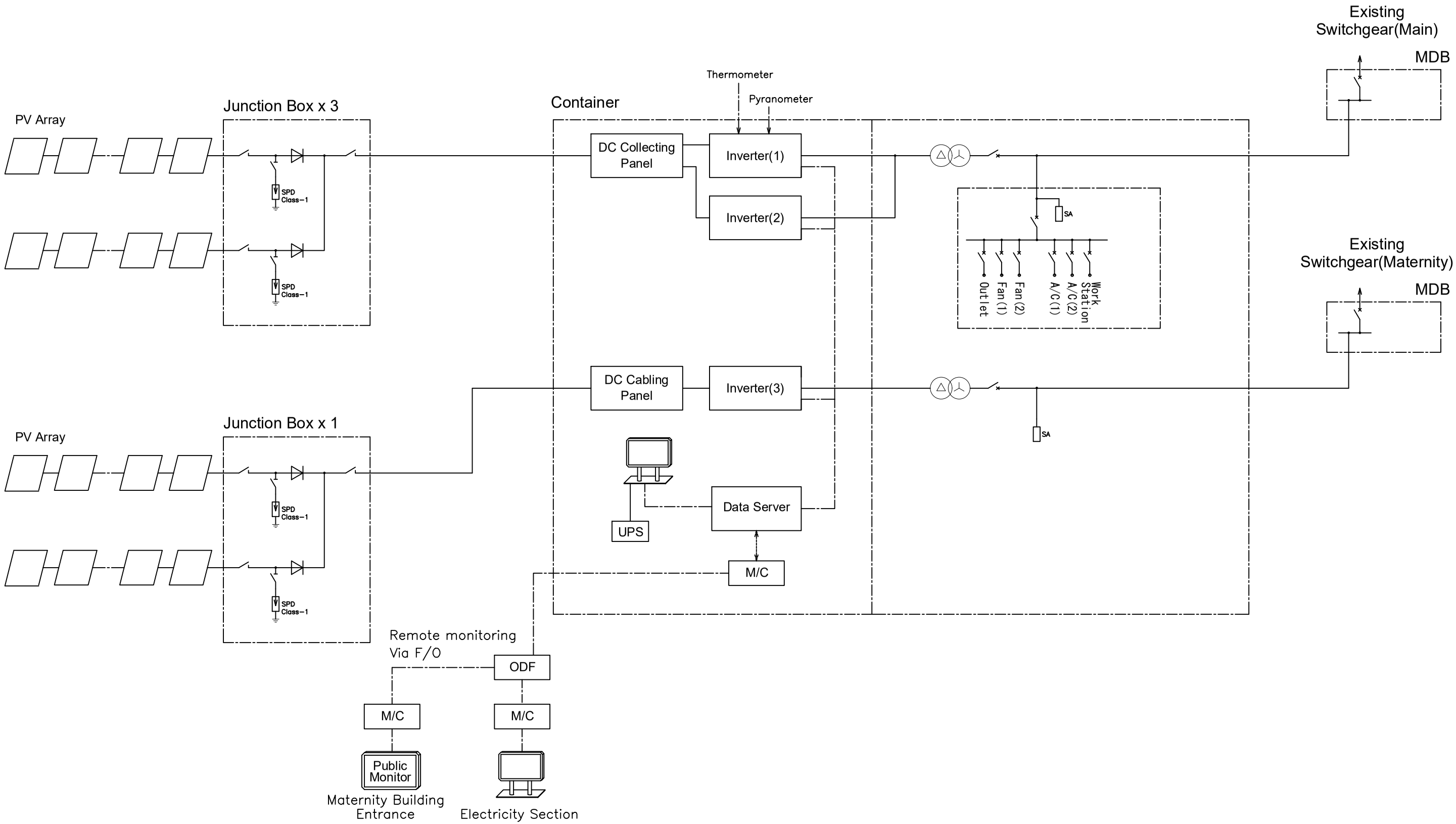
KE-3-1_Single Line Diagram(Main system)



KE-3-2_Single Line Diagram (Maternity system)

Power Incoming(33kV Feeder)





Legend

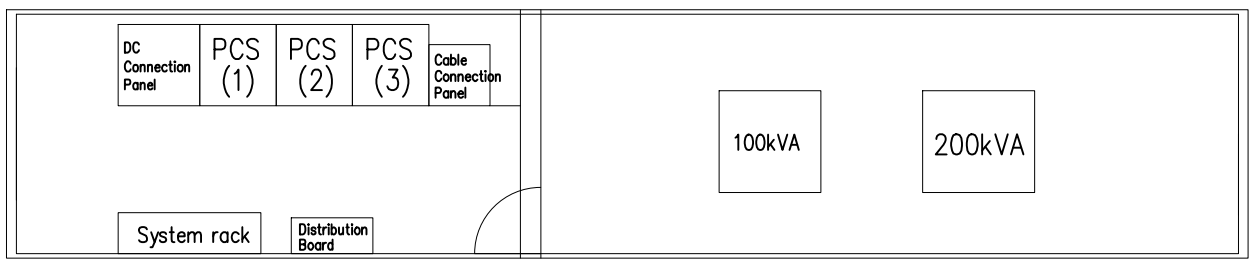
PV	Photo Voltaic
SPD	Surge Protection Device
INV	Inverter
M/C	Media Converter
ODF	Optical Distribution Frame
SA	Surge Arester

Power Line

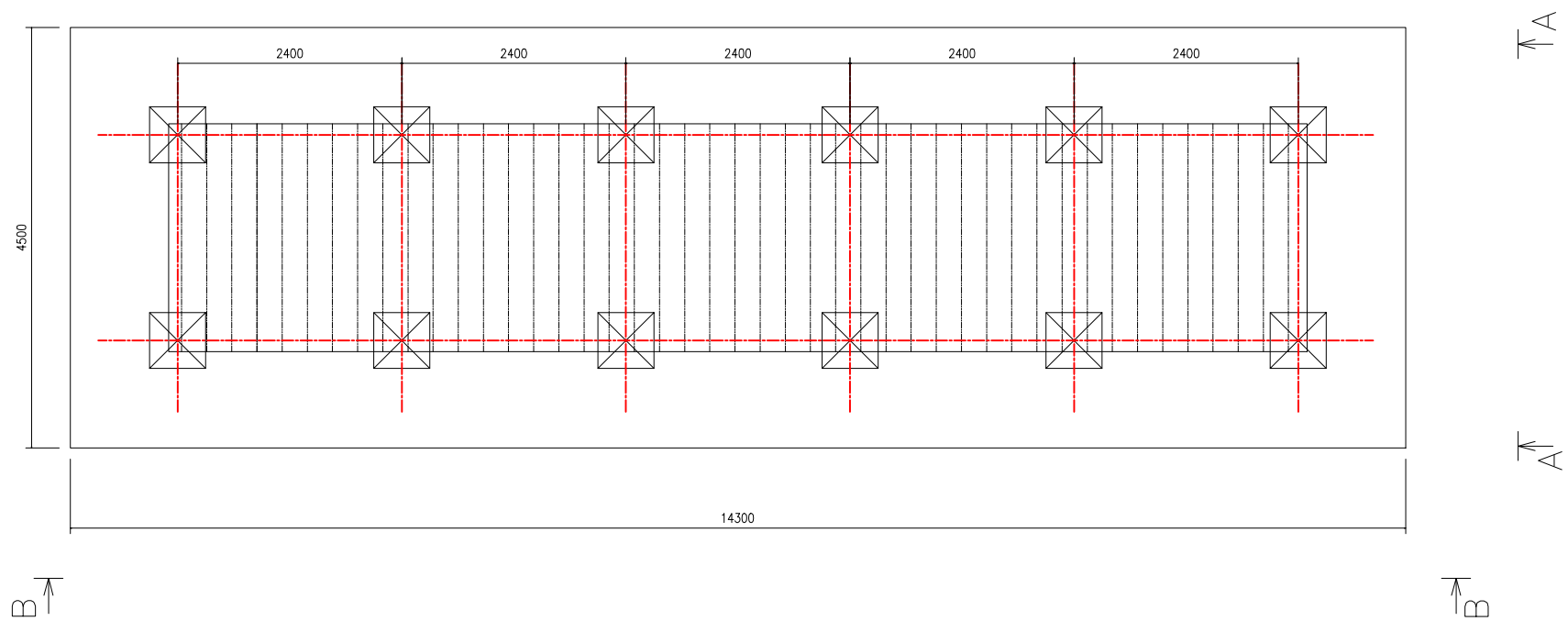
Control & communication Line

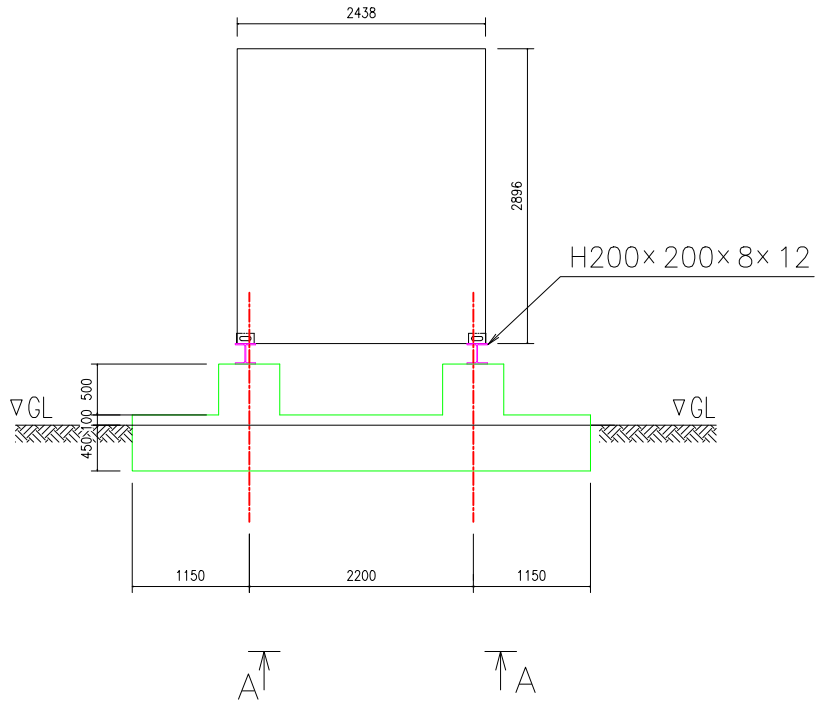
KE-4 System Configuration

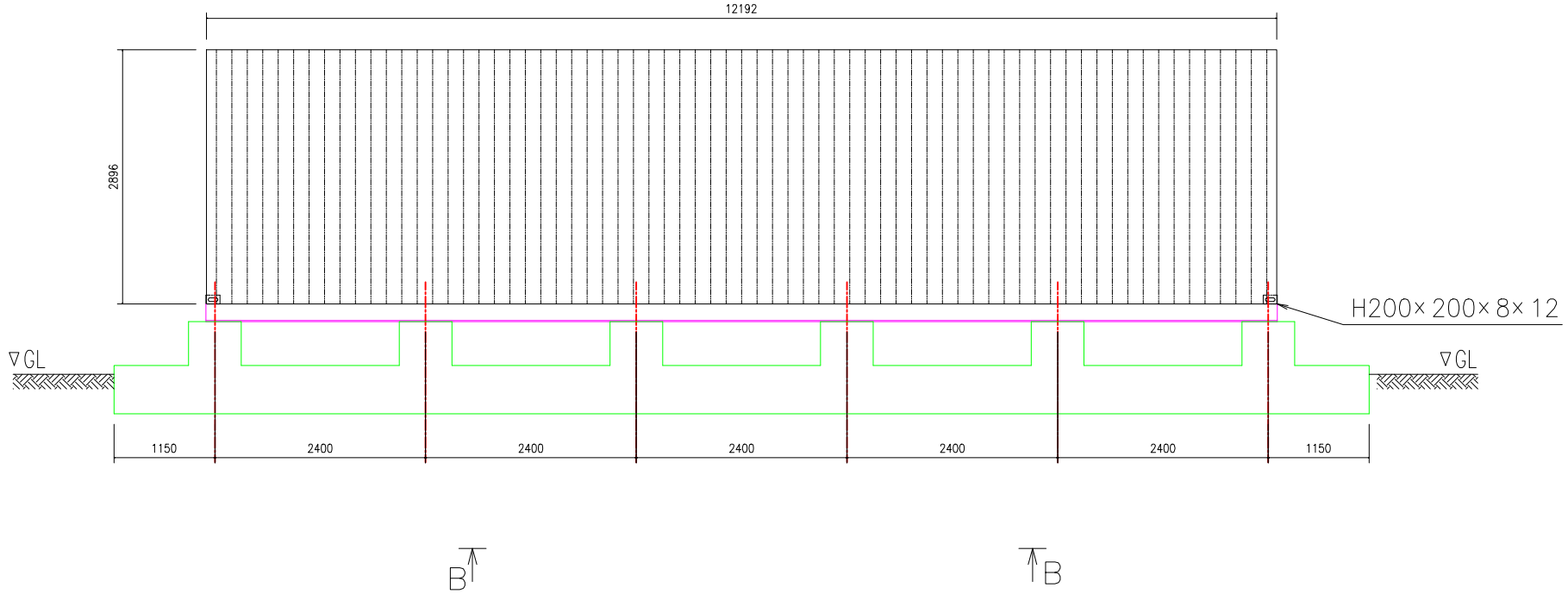
40ft(HC)



12,000W x 2,350D x 2,690H(内寸)
12,192W x 2,438D x 2,896H(外寸)







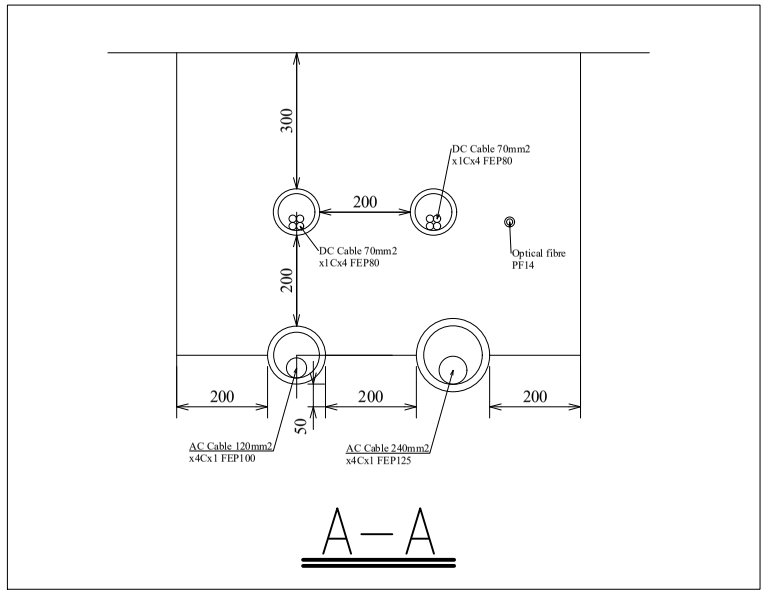
KE-5-1 Layout plan of container

AC Cable
240sqx4Cx1
&F/O x1

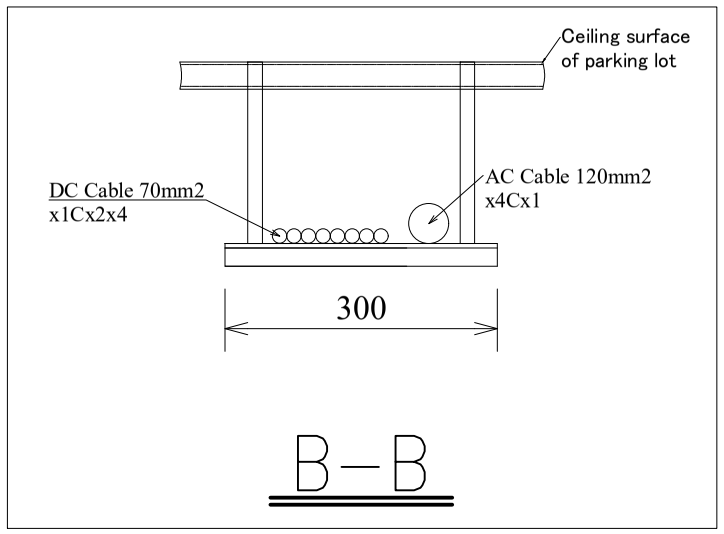
DC Cable 70sq x 1C x 2 x 4
AC Cable 120sq x 4C x1

DC Cable 70sq x 4x2
& Control Cable

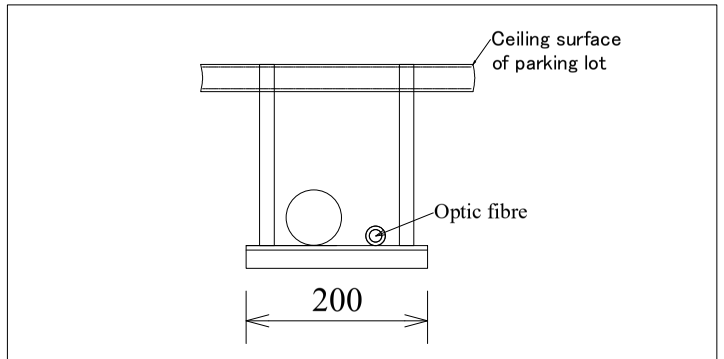
Container



A—A



B—B

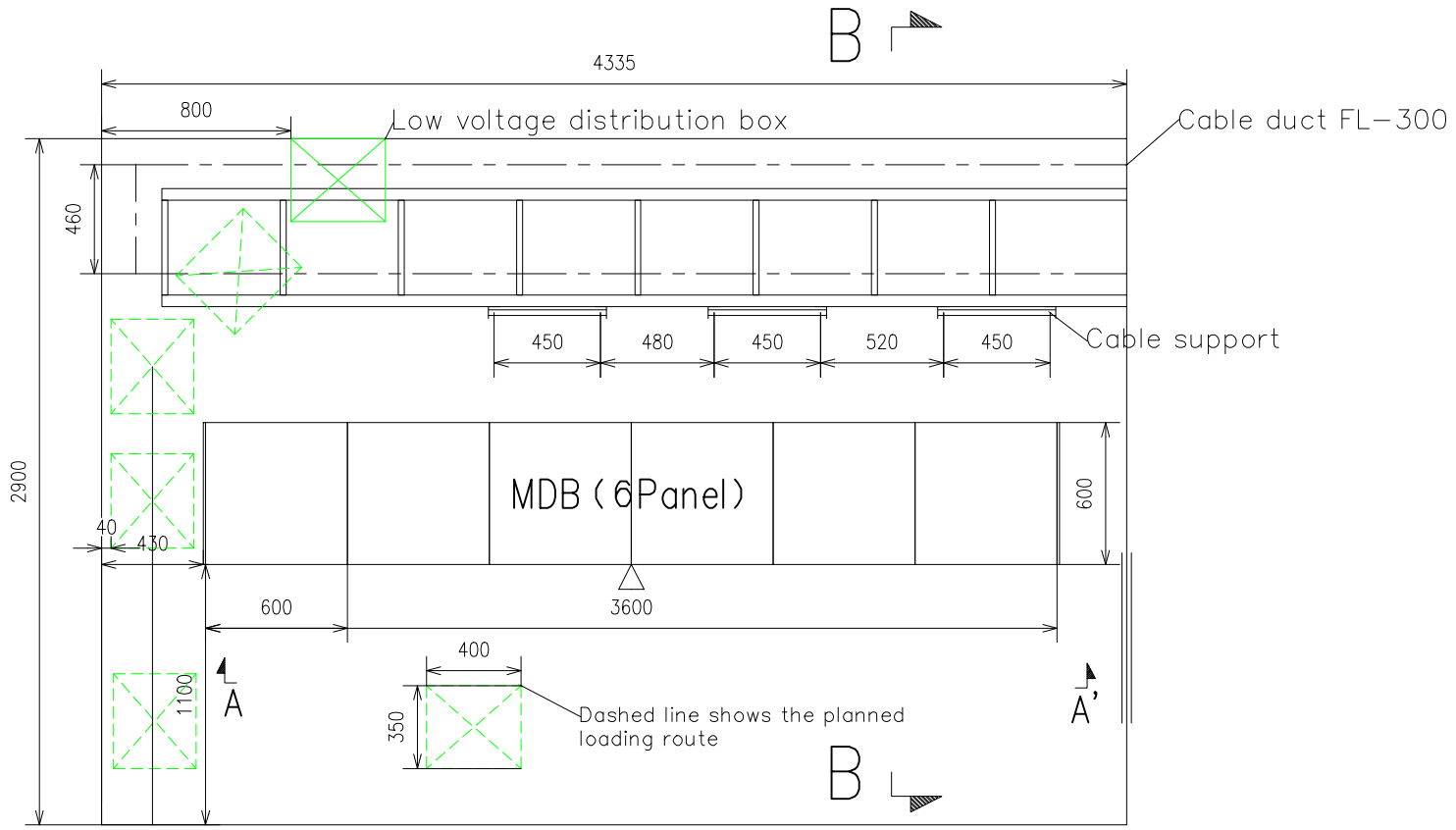


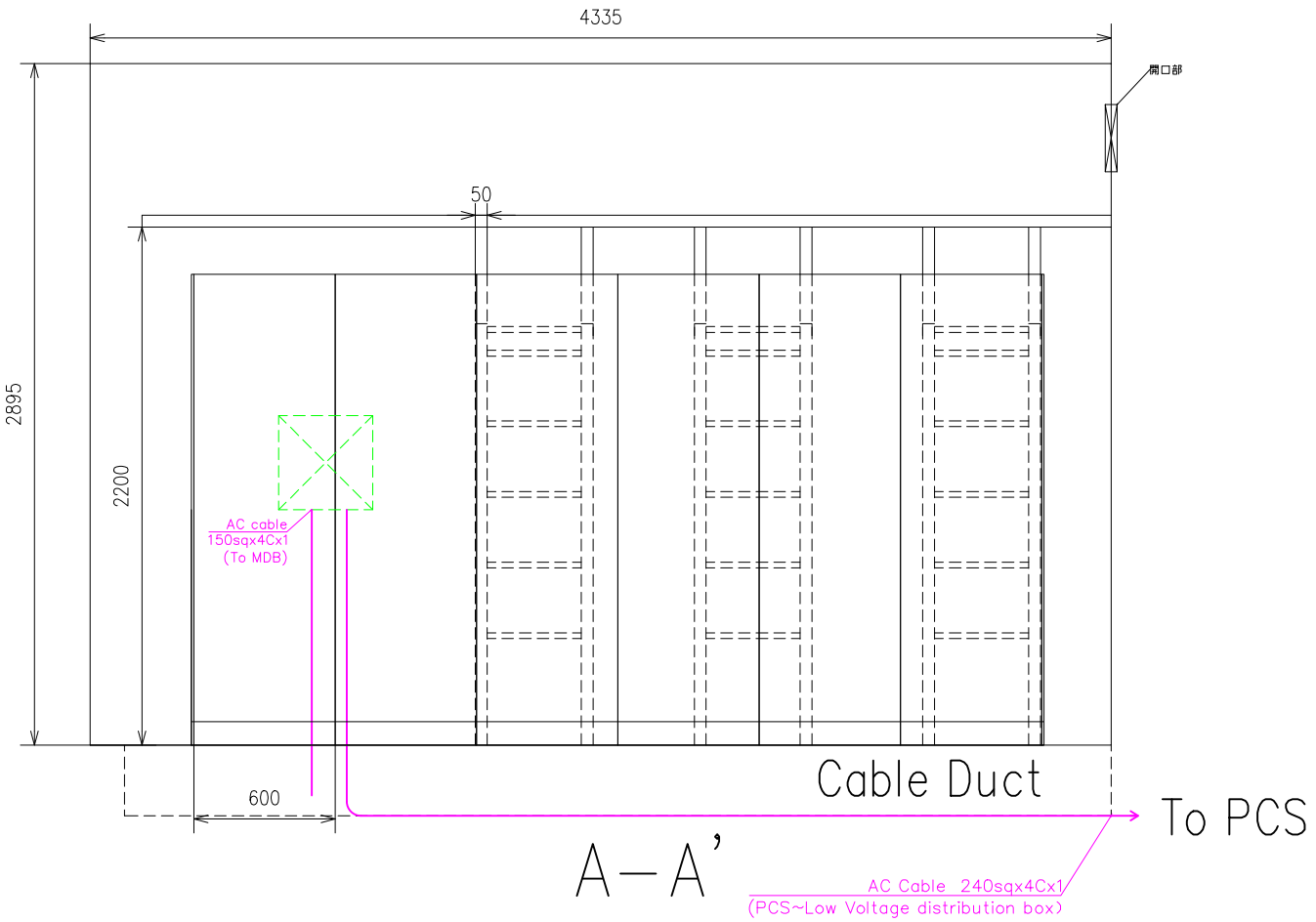
C—C

GRAPHIC SCALE
(IN METARS)
0 5 10 20 30 40 50

KE-6 Cable Route Plan

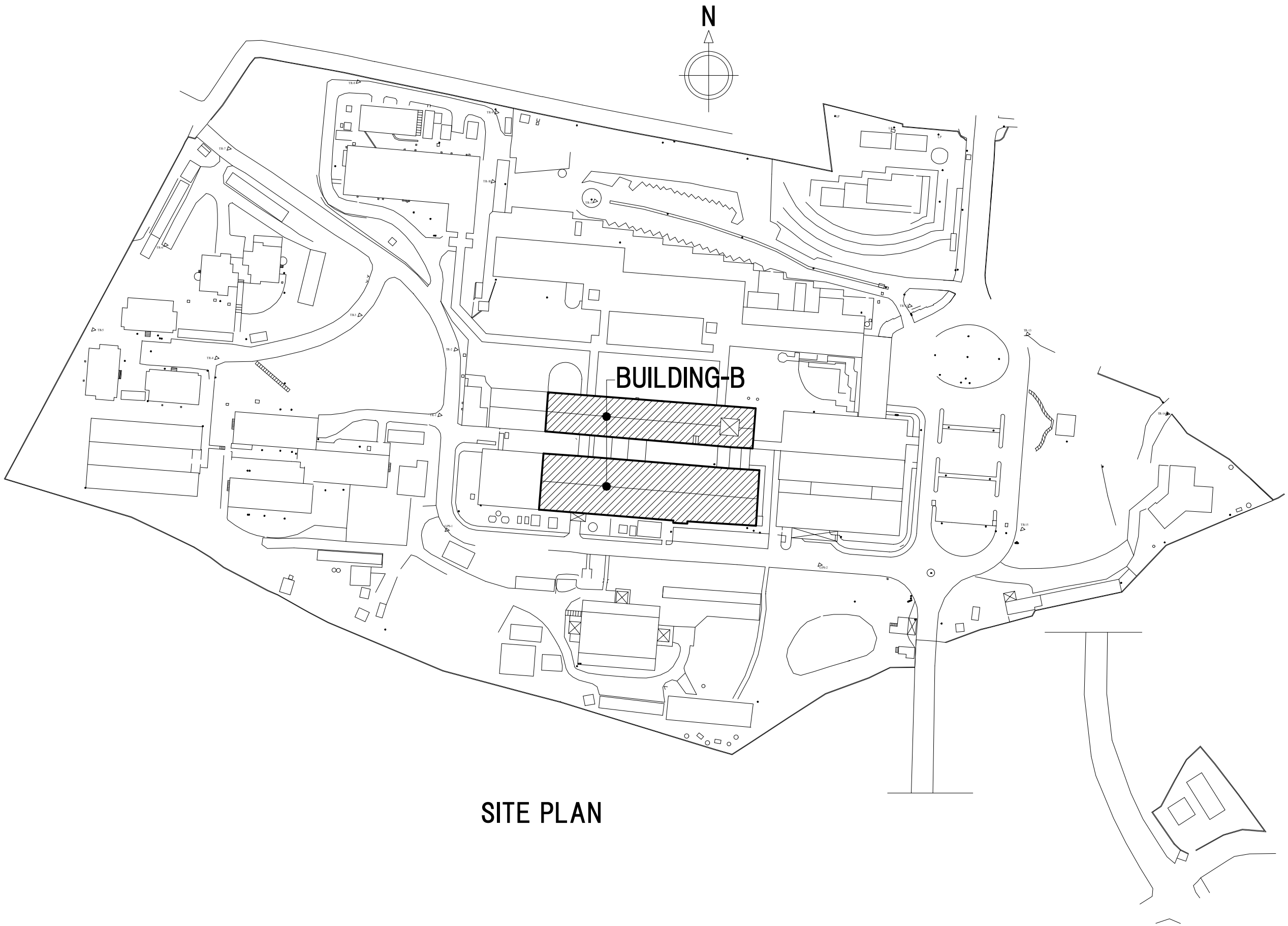
KE-7 layout plan for main distribution room





*The solid line shows the walls of the building

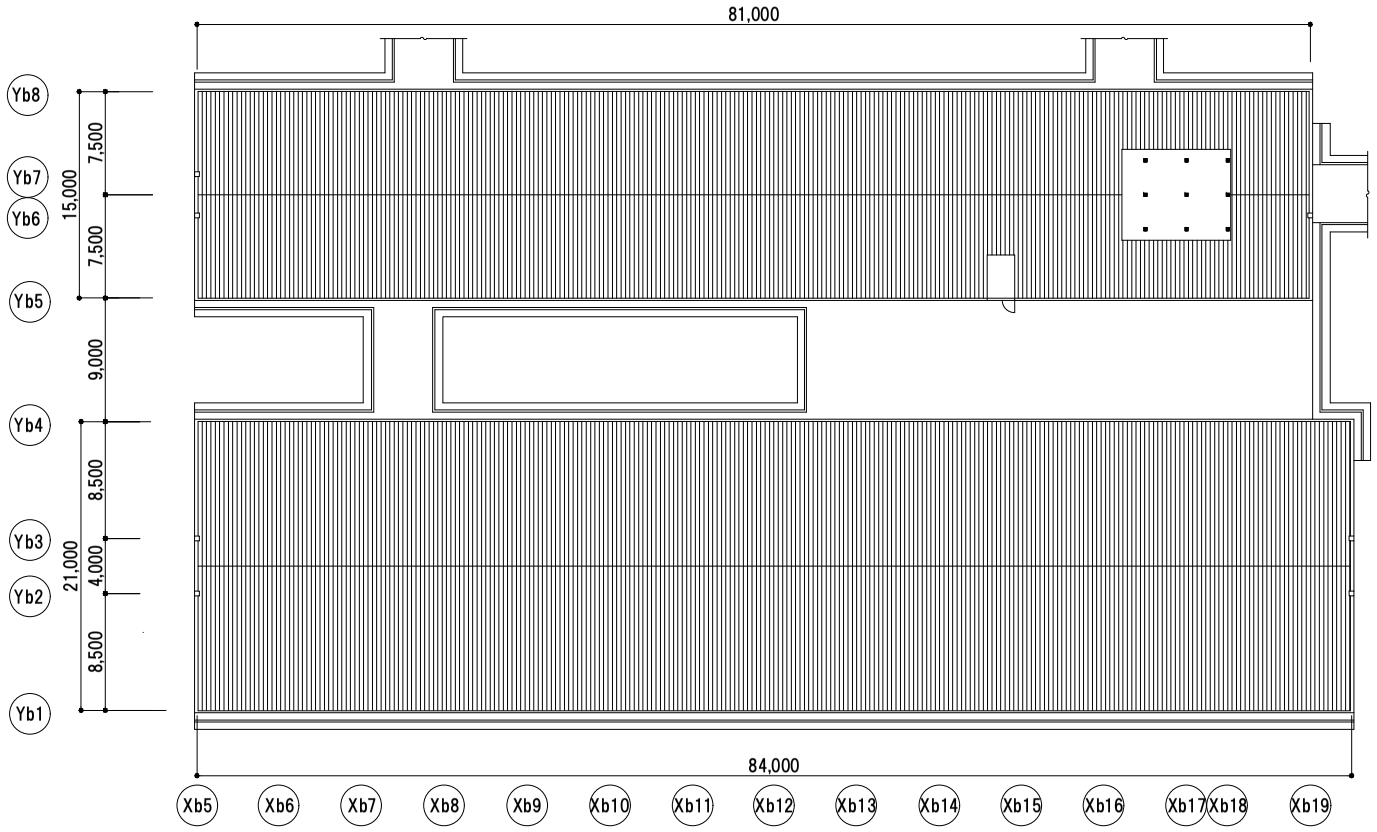
6-4. Facility drawings (SJGH)



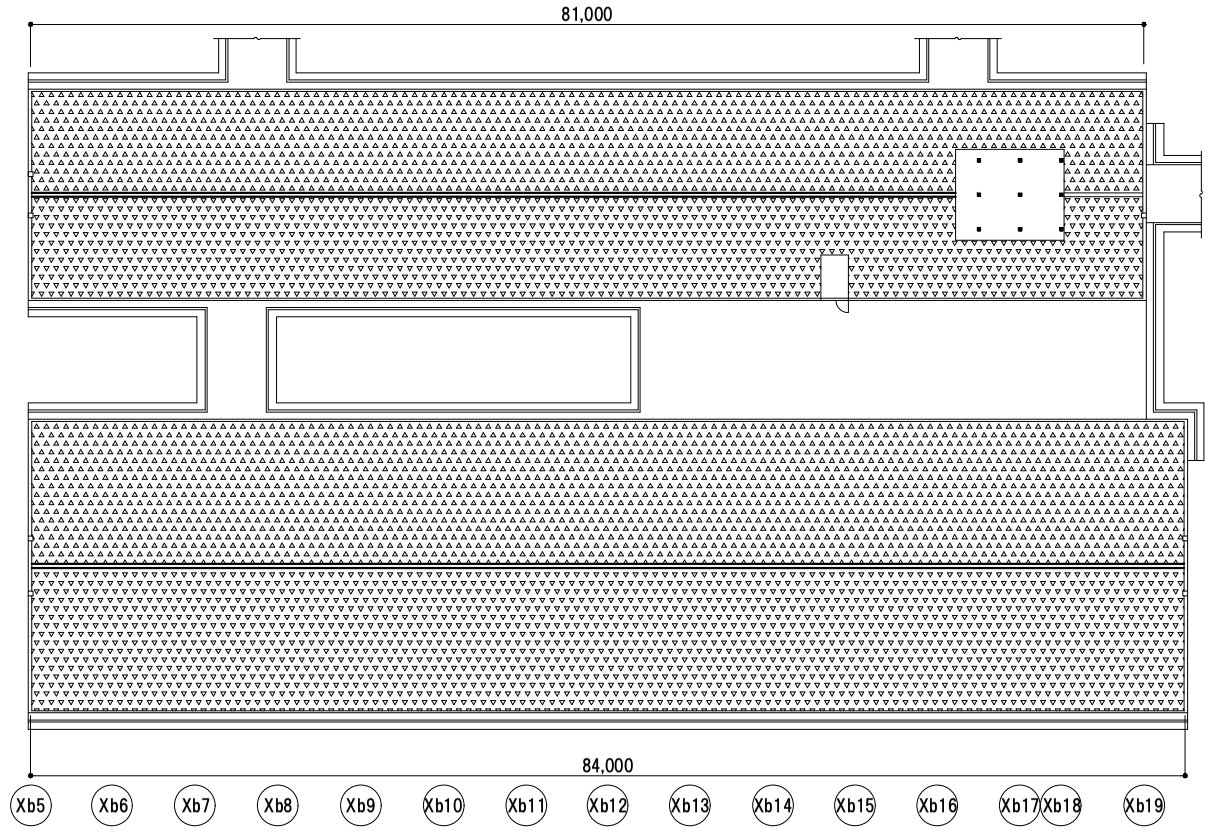
SITE PLAN

DWG No. SF-1

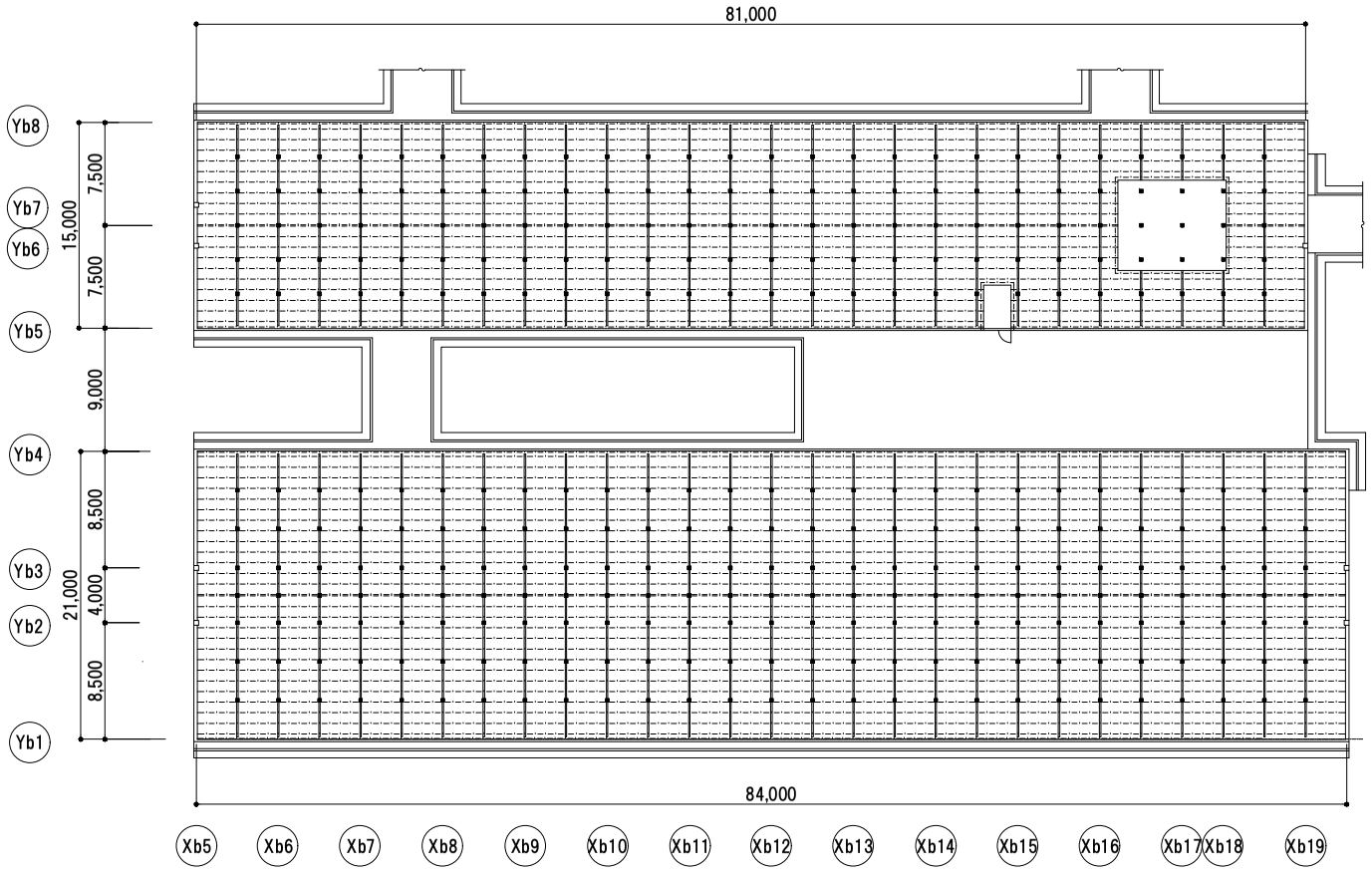
SRI JYAEWARDENEPURA HOSPITAL BUILDING-B
SITE PLAN



EXISTING CORRUGATED CEMENT SHEET ROOF PLAN

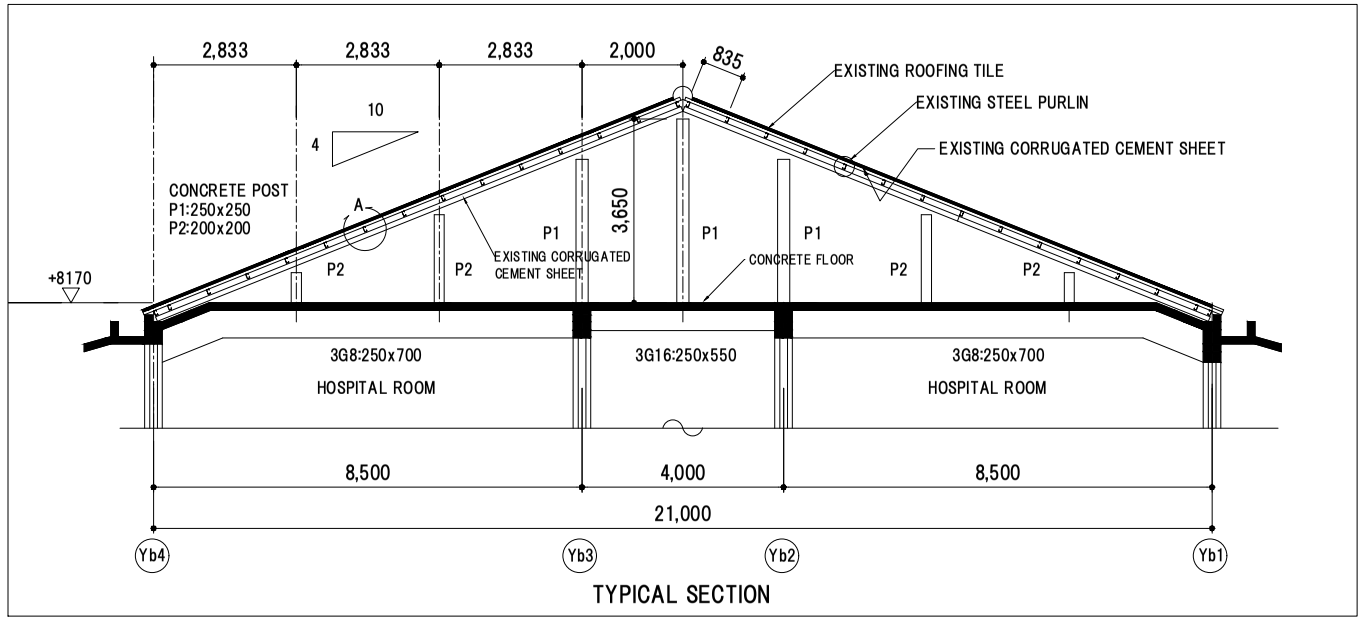


EXISTING ROOF TILE PLAN

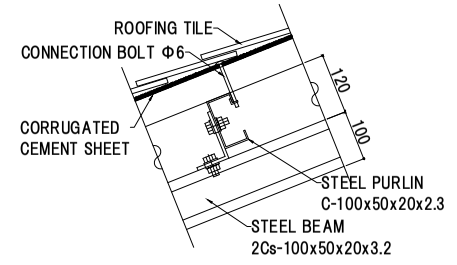


EXISTING ROOF FLOOR STEEL BEAM PLAN

2Cs-100 x 50 x 20 x 3.2
Cs-100 x 50 x 20 x 2.3



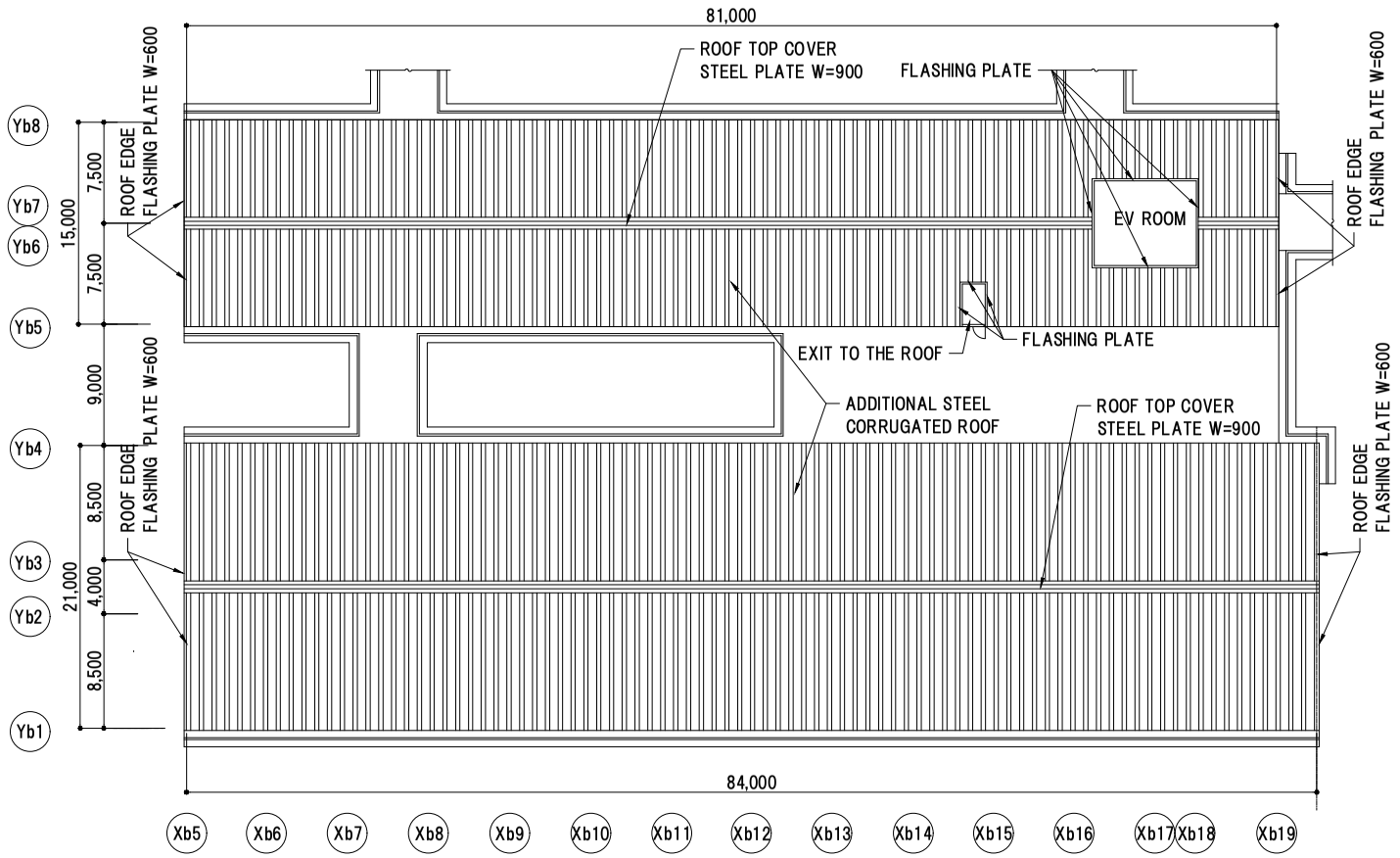
TYPICAL SECTION



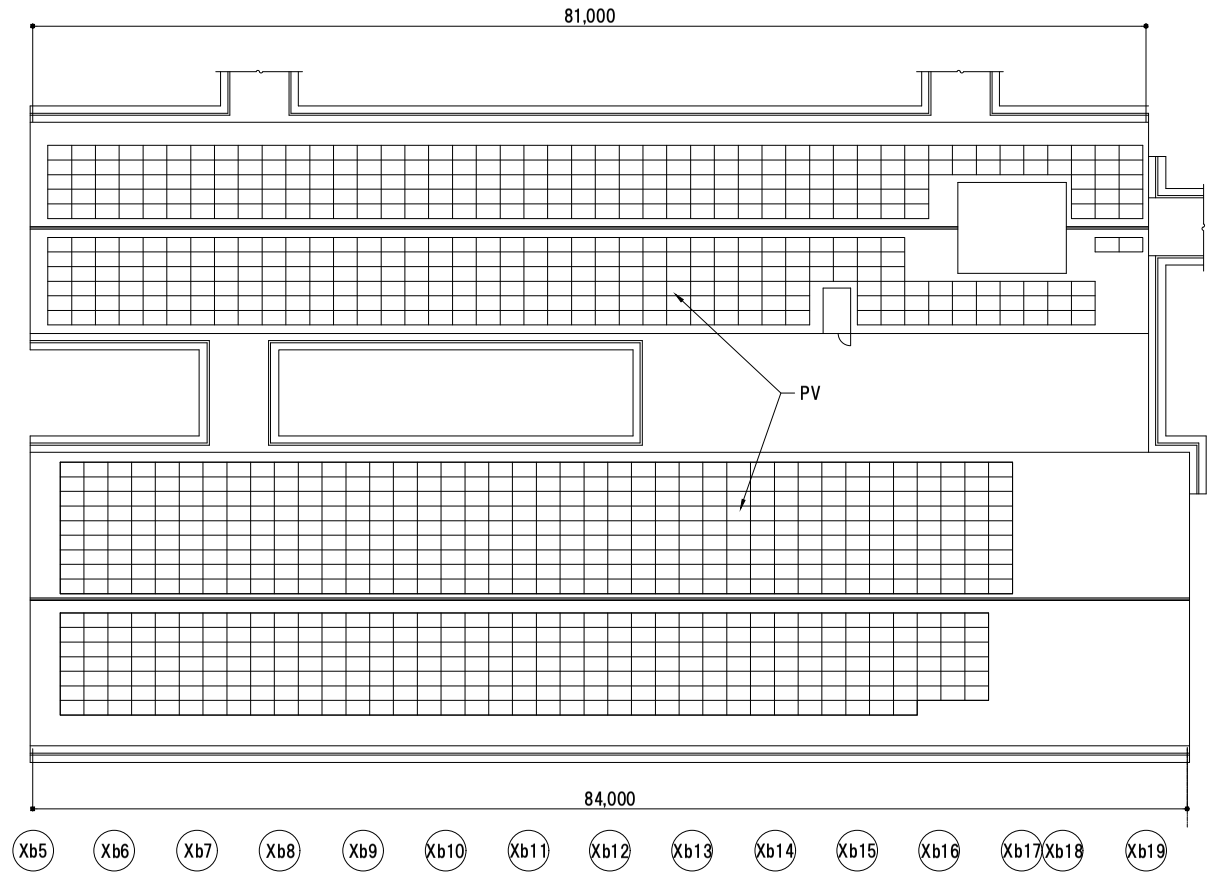
DETAIL-A

DWG No. SF-2

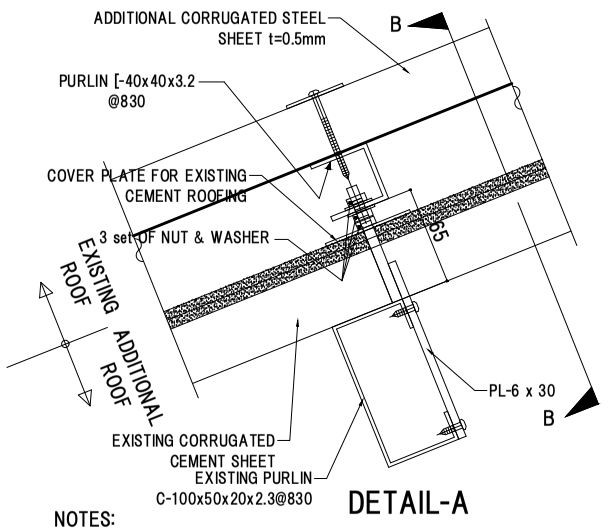
SRI JYAEWARDENEPURA HOSPITAL BUILDING-B/
EXISTING ROOFING PLAN



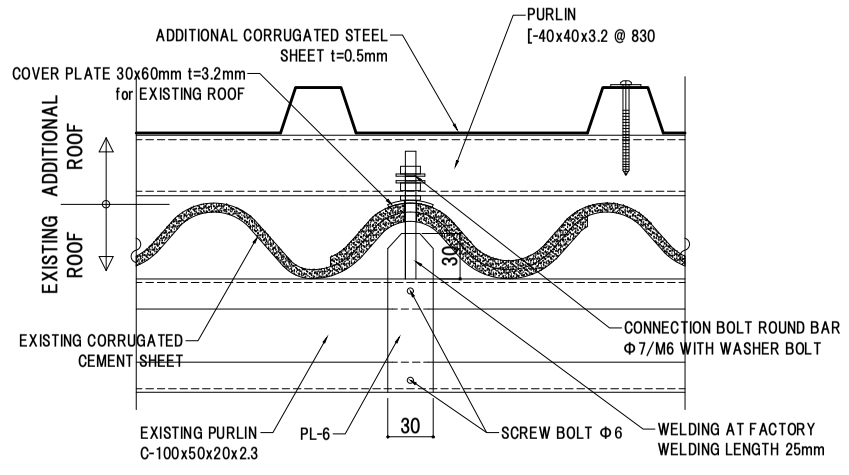
ADDITIONAL CORRUGATED STEEL ROOF PLAN



PV ALLOCATION PLAN



DETAIL-A



SECTION B-B

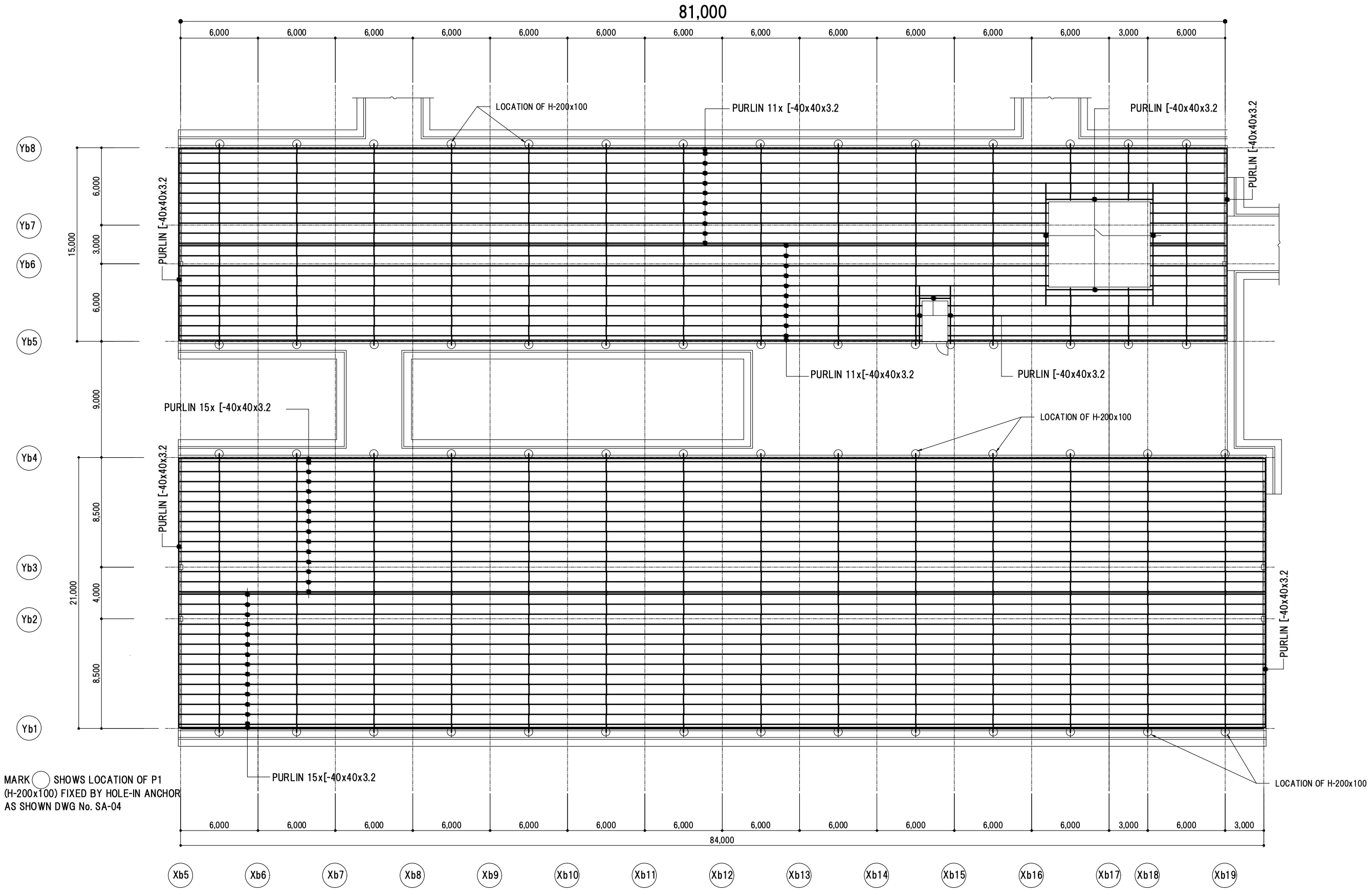
NOTES:

(1) THE MAIN ITEMS OF ROOFING WORKS ARE AS FOLLOWS:
1) ALL OF THE EXISTING ROOFING TILES SHALL BE REMOVED AND STOCK AT THE DESIGNATED PLACE IN THE HOSPITAL AREA
2) INSTALL ADDITIONAL ROOFING SHEET AND FLASHING PLATE

(2) METHOD AND ITEMS OF THE ADDITIONAL ROOFING WORKS ARE AS FOLLOWS:
1) EXISTING CONNECTION BOLT FIXING EXISTING CORRUGATED CEMENT SHEET AND EXISTING STEEL PURLIN SHALL BE REMOVED
2) NEW CONNECTION PLATE AND BOLT SHALL BE INSTALLED AT THE POSITION OF THE EXISTING CONNECTION BOLT HOLE
3) NEW CONNECTION PLATE AND BOLT SHALL BE FABRICATED AT THE FACTORY
4) NEW CONNECTION PLATE AND BOLT SHALL BE FIXED BY SCREW BOLT AT THE POSITION OF THE EXISTING CONNECTION BOLT HOLE
5) NEW PURLIN FOR ADDITIONAL STEEL ROOFING SHALL BE FIXED TO THE CONNECTION BOLT AS SHOWN DETAIL-A AND SECTION-B
6) THE INTERVAL OF THE EXISTING PURLIN OF ROOF SLOPE DIRECTION IS 835mm, AND EXISTING CORRUGATED CEMENT SHEET AND PURLIN IS CONNECTED BY BOLT Φ6 AT 1670mm INTERVALS, THEREFORE, THE NEW CONNECTION PLATE AND BOLT SHALL BE PROVIDED AT 1670mm INTERVAL TYPICALLY
7) THE HORIZONTAL INTERVAL OF THE EXISTING CONNECTION BOLT FOR EXISTING CORRUGATED CEMENT SHEET IS 520mm ～640mm
8) THE NEW COVER PLATE SHALL BE INSTALLED AT AS SHOWN SECTION B-B
9) INSTALL NEW PURLIN AND FIXING ADDITIONAL ROOFING

DWG No. SF-3

SRI JYAEWARDENEPURA HOSPITAL BUILDING-B/
ADDITIONAL ROOFING PLAN & DETAILS



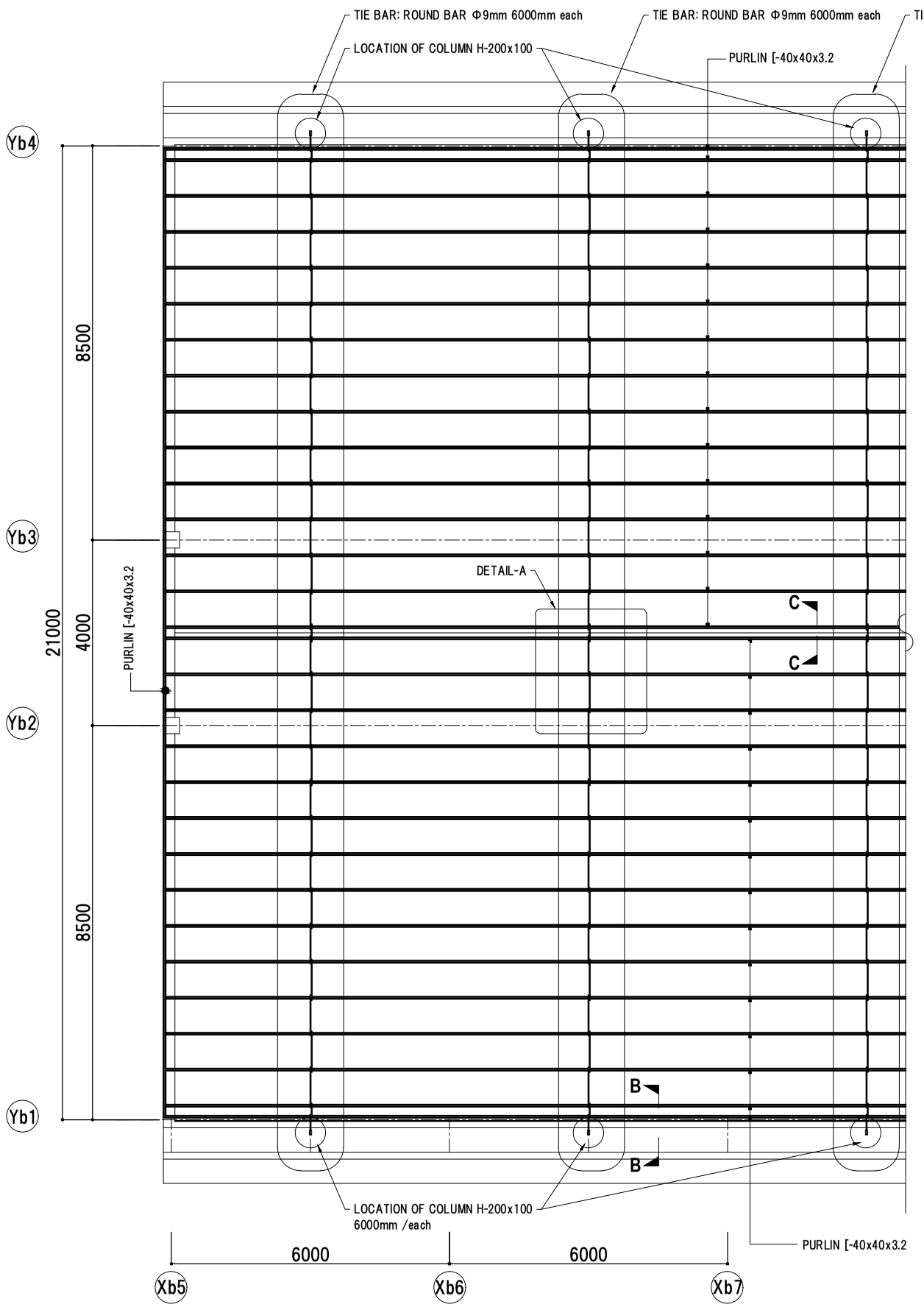
MARK ◯ SHOWS LOCATION OF P1
(H-200x100) FIXED BY HOLE-IN ANCHOR
AS SHOWN DWG No. SA-04

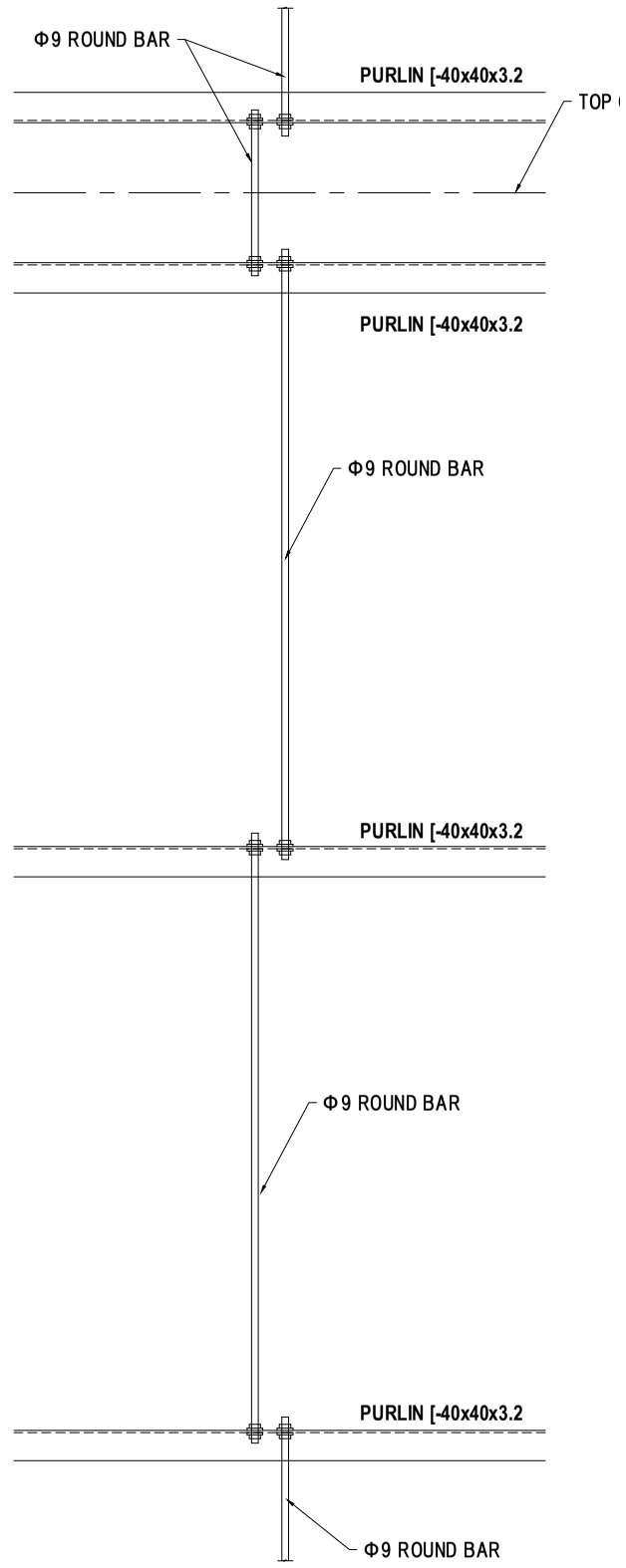
MATERIALS:
STRUCTURAL STEEL: SS400/SSC400 OR EQUIVALENT
ROUND BAR : SR235 OR EQUIVALENT

ADDITIONAL PURLIN PLAN

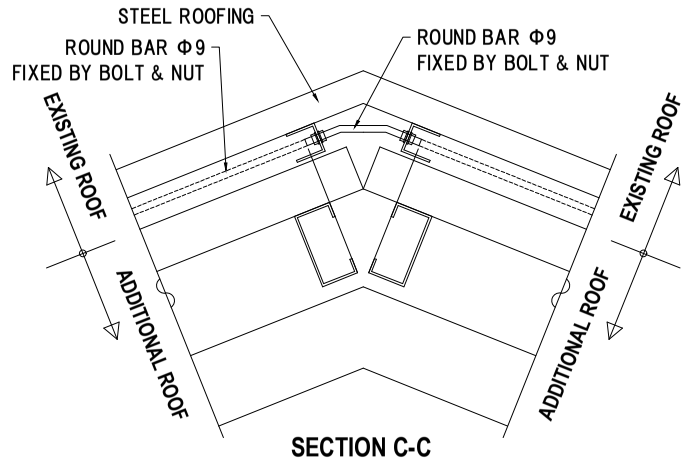
DWG No. SF-4

SRI JYAEWARDENEPURA HOSPITAL BUILDING-B/
ROOF PURLIN PLAN FOR ADDITIONAL ROOFING



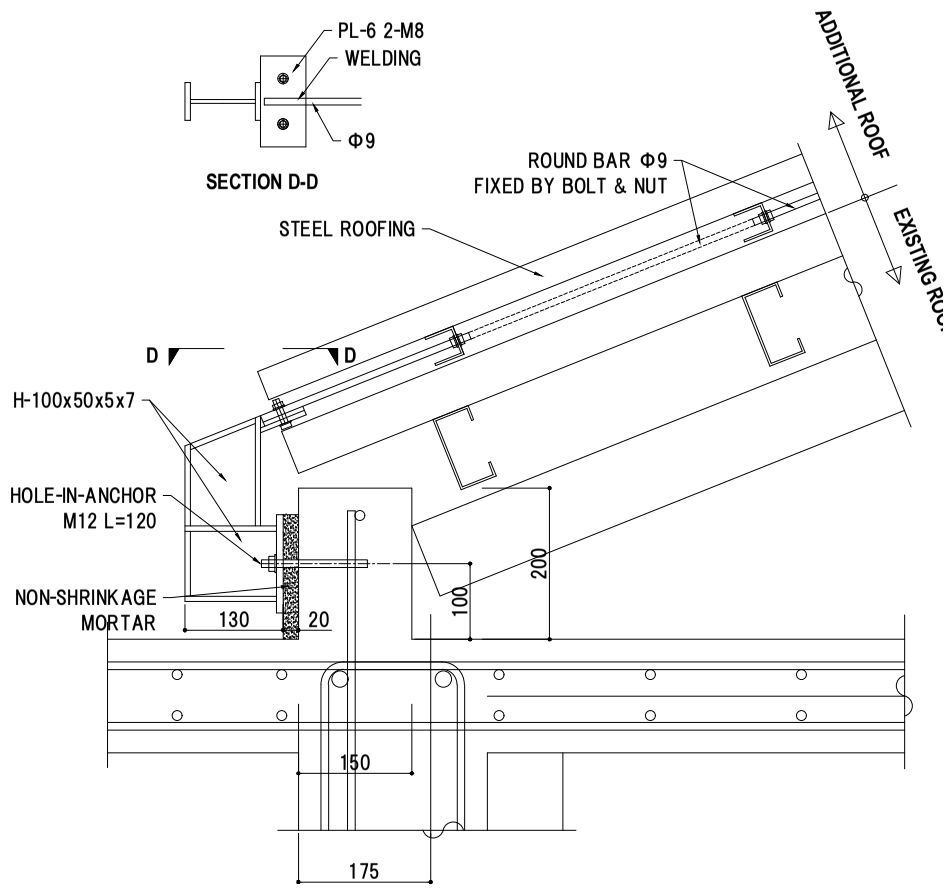


DETAIL - A DETAIL OF TIE BAR



SECTION C-C

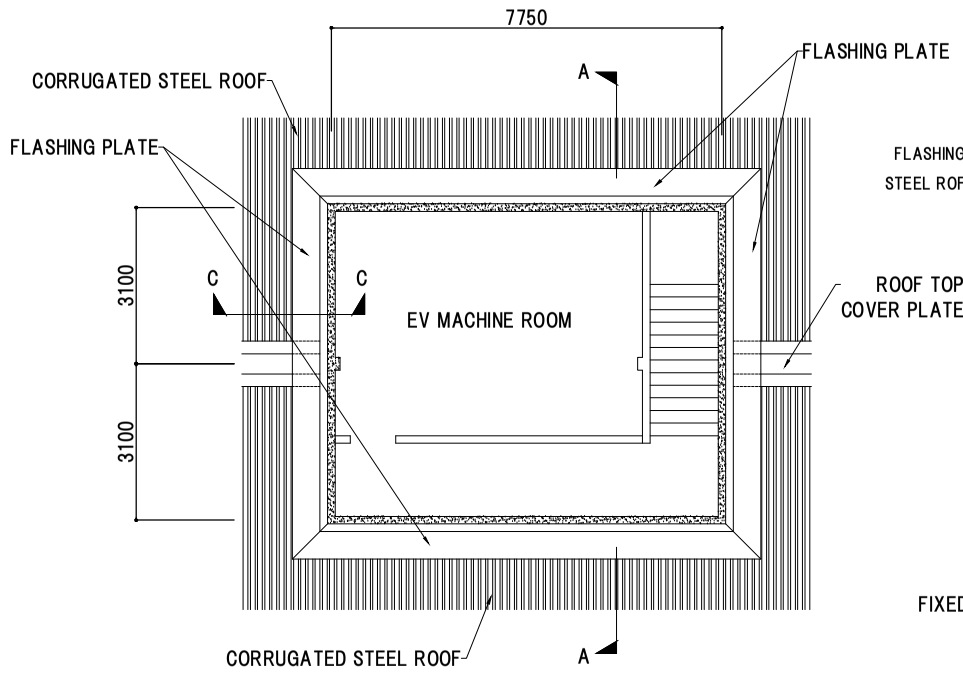
SECTION D-D



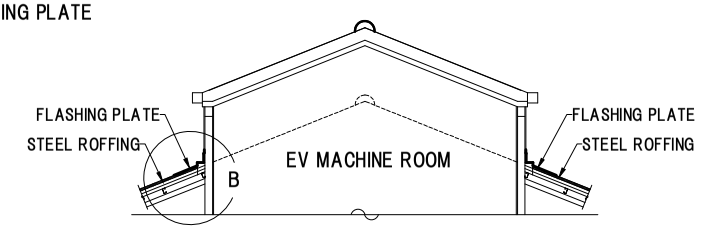
SECTION B-B

DWG No. SF-5

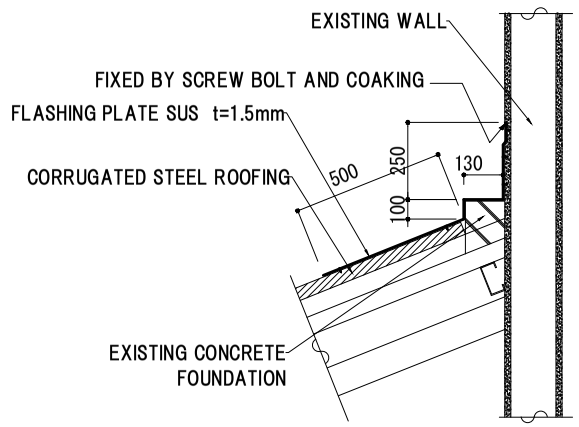
SRI JYAEWARDENEPURA HOSPITAL BUILDING-B/
DETAIL OF TIE BAR



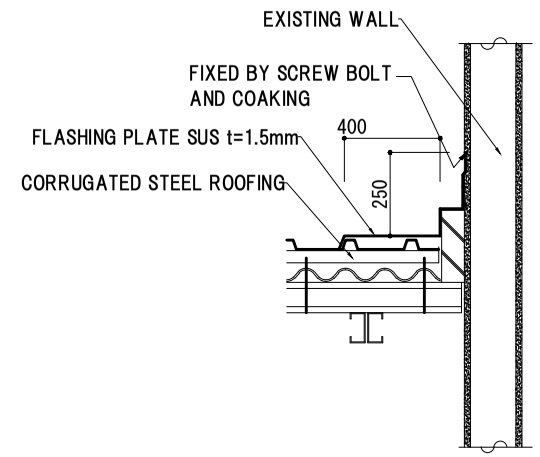
FLASHING PLATE PLAN OF THE EV MACHINE ROOM



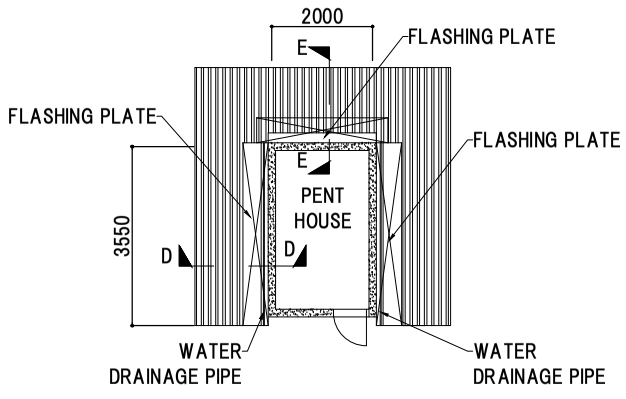
SECTION A-A



DETAIL-B

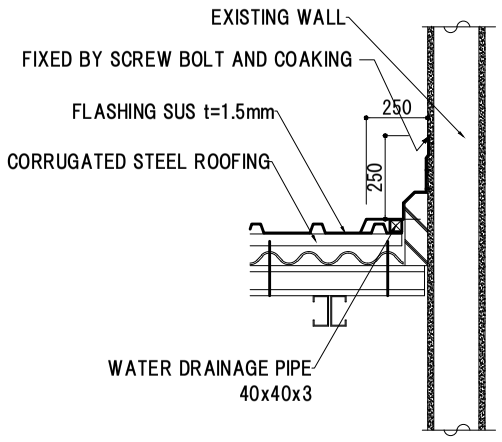


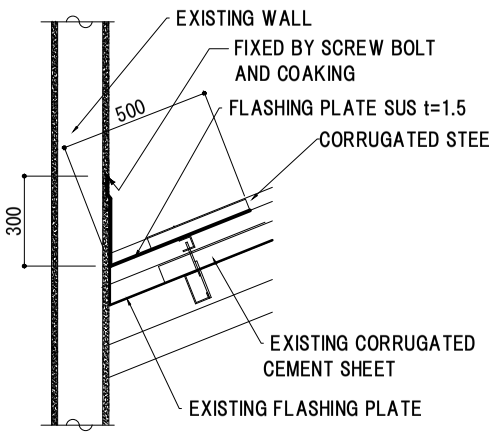
SECTION C-C

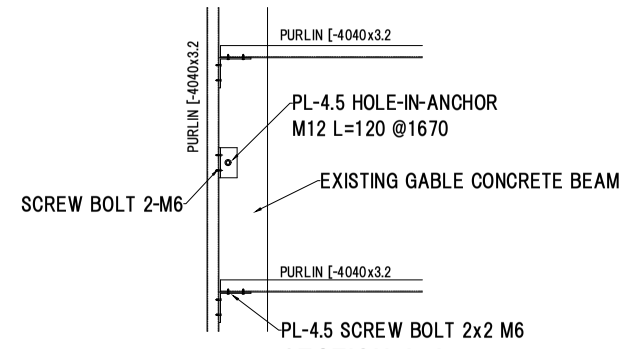


FLASHING PLATE PLAN OF THE PENT HOUSE

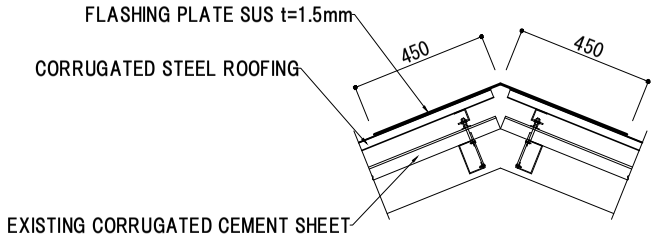
NOTE
DIMENSIONS FOR THE FLASHING PLATE ARE JUST FOR REFERENCE.
THE CONTRACTOR SHALL CARRY OUT SITE SURVEY, AND SHALL BE DECIDED THE ACCURATE DIMENSION BASE ON THE ACTUAL DIMENSION MEASURED ON SITE



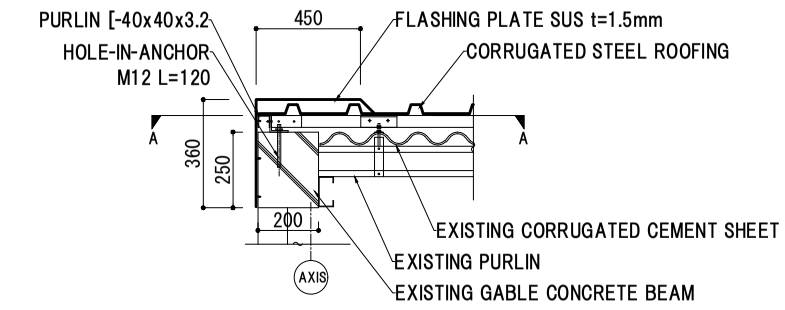




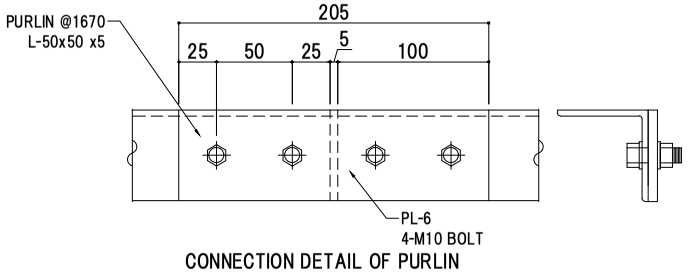
SECTION A-A



TYPICAL SECTION OF THE
FLASHING FOR THE ROOF TOP



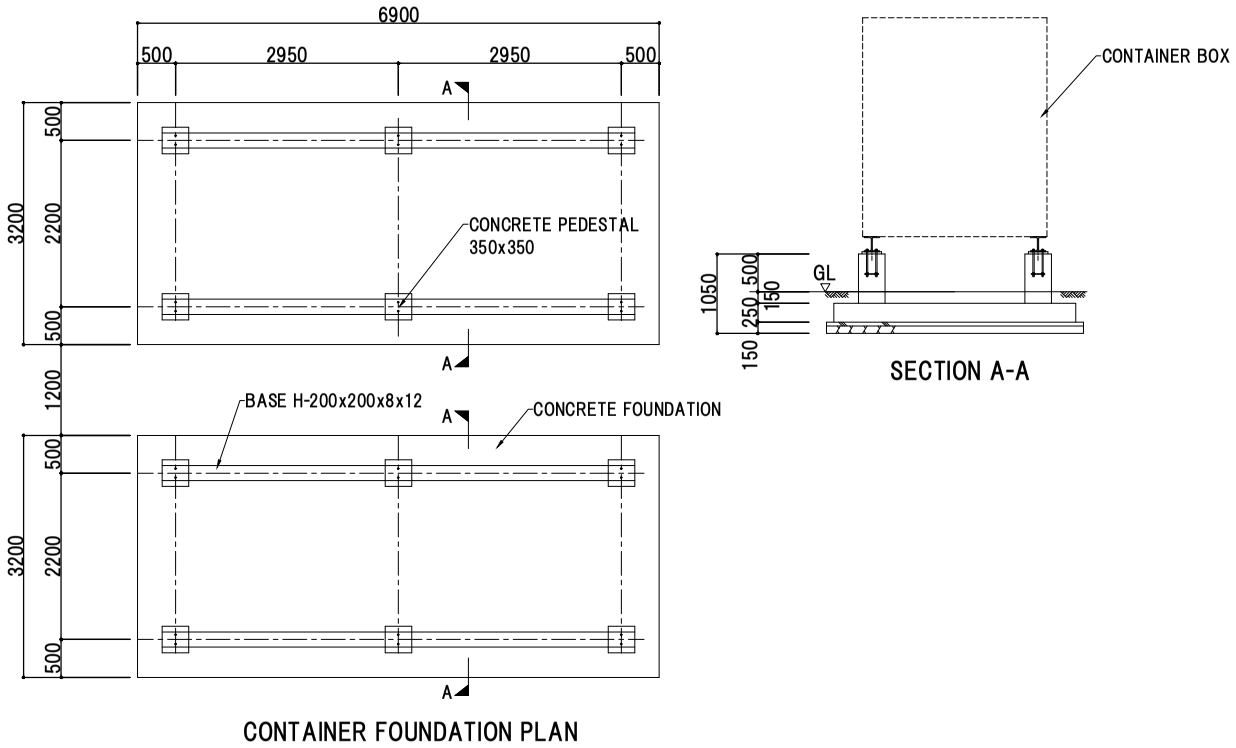
TYPICAL SECTION OF THE
FLASHING FOR THE ROOF EDGE



CONNECTION DETAIL OF PURLIN

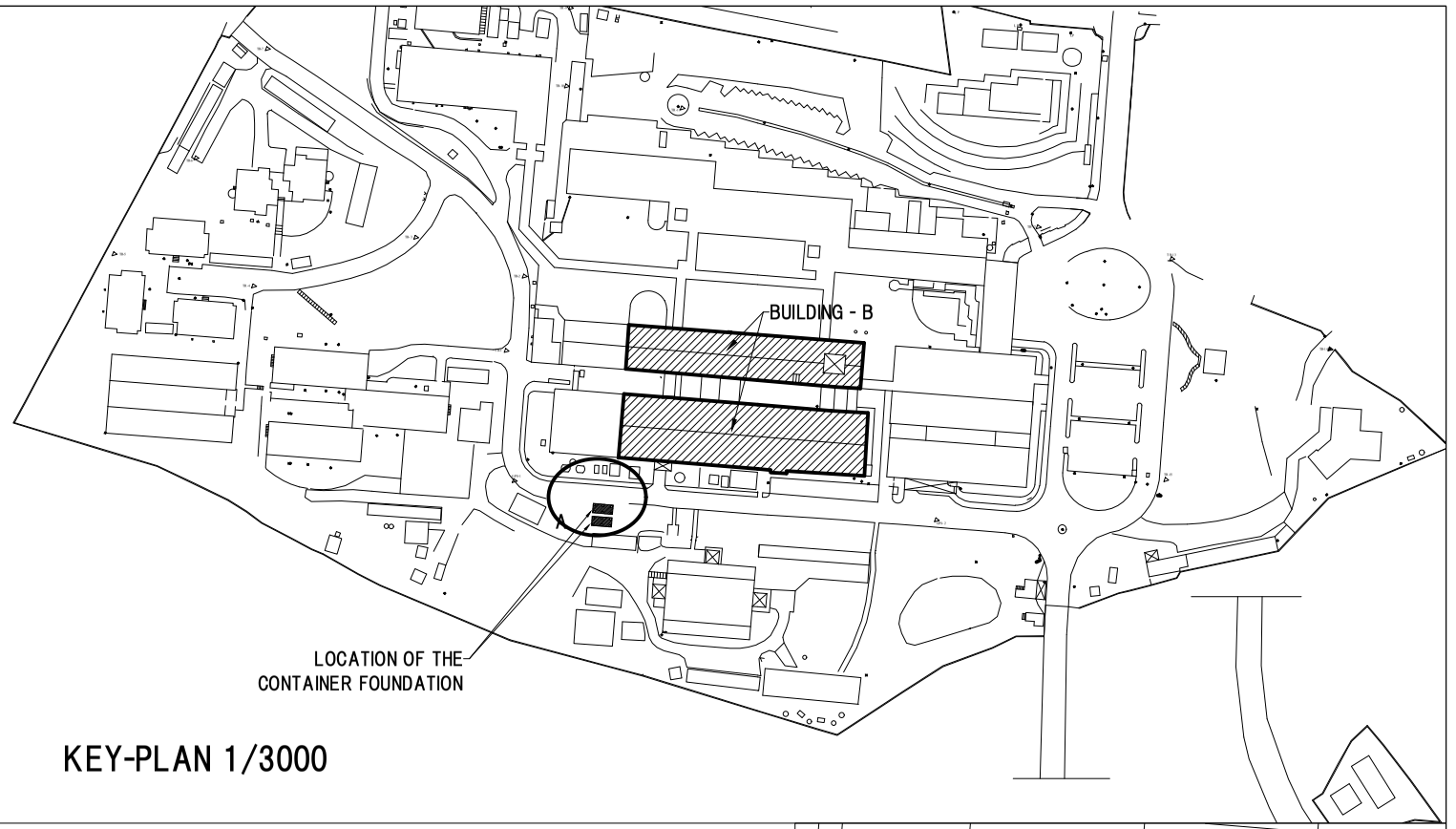
DWG No. SF-6

SRI JYAEWARDENEPURA HOSPITAL BUILDING-B/
DETAILS OF THE FLASHING PLATE

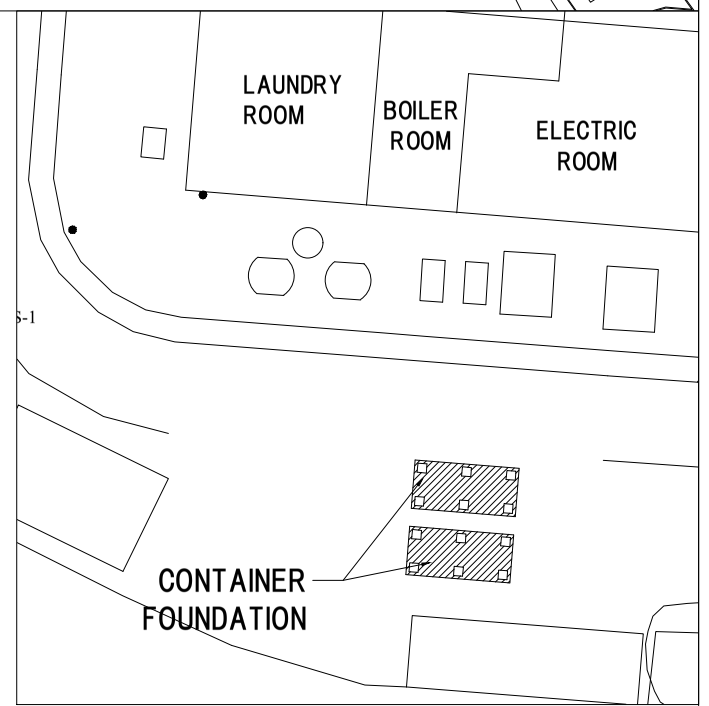


CONTAINER FOUNDATION PLAN

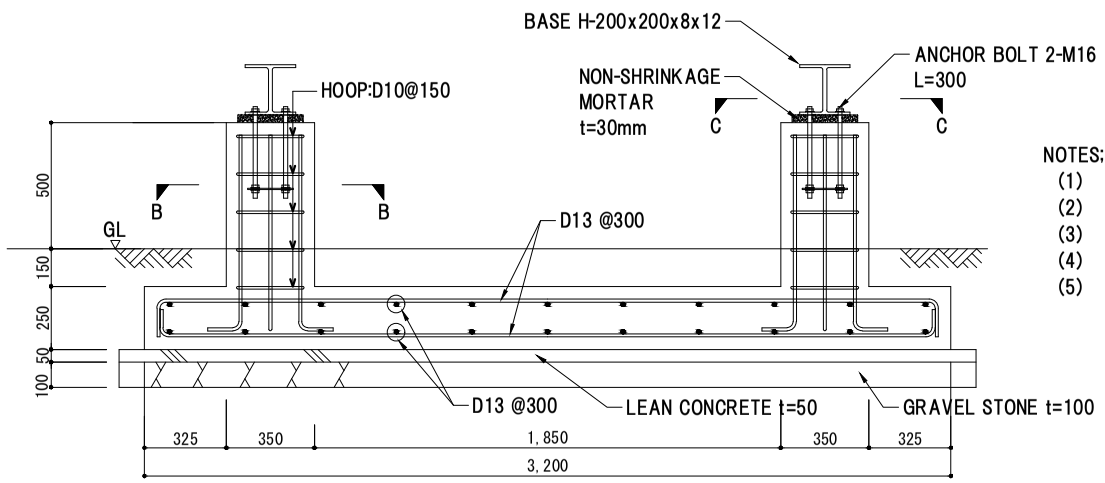
SECTION A-A



KEY-PLAN 1/3000

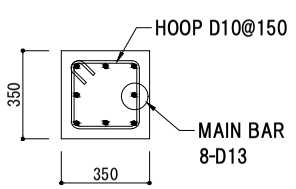


DETAIL-A 1/500

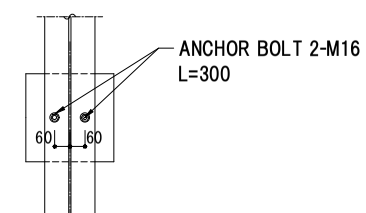


NOTES;

(1) FOUNDATION CONCRETE Fc28=21N/mm2
(2) LEAN CONCRETE Fc=18N/mm2
(3) REINFORCING BARS: SD295A /SD345 OR EQUIVALENT
(4) BASE STEEL : SS400 or EQUIVALENT
(5) ANCHOR BOLT: SR 235 OR EQUIVALENT



SECTION B-B

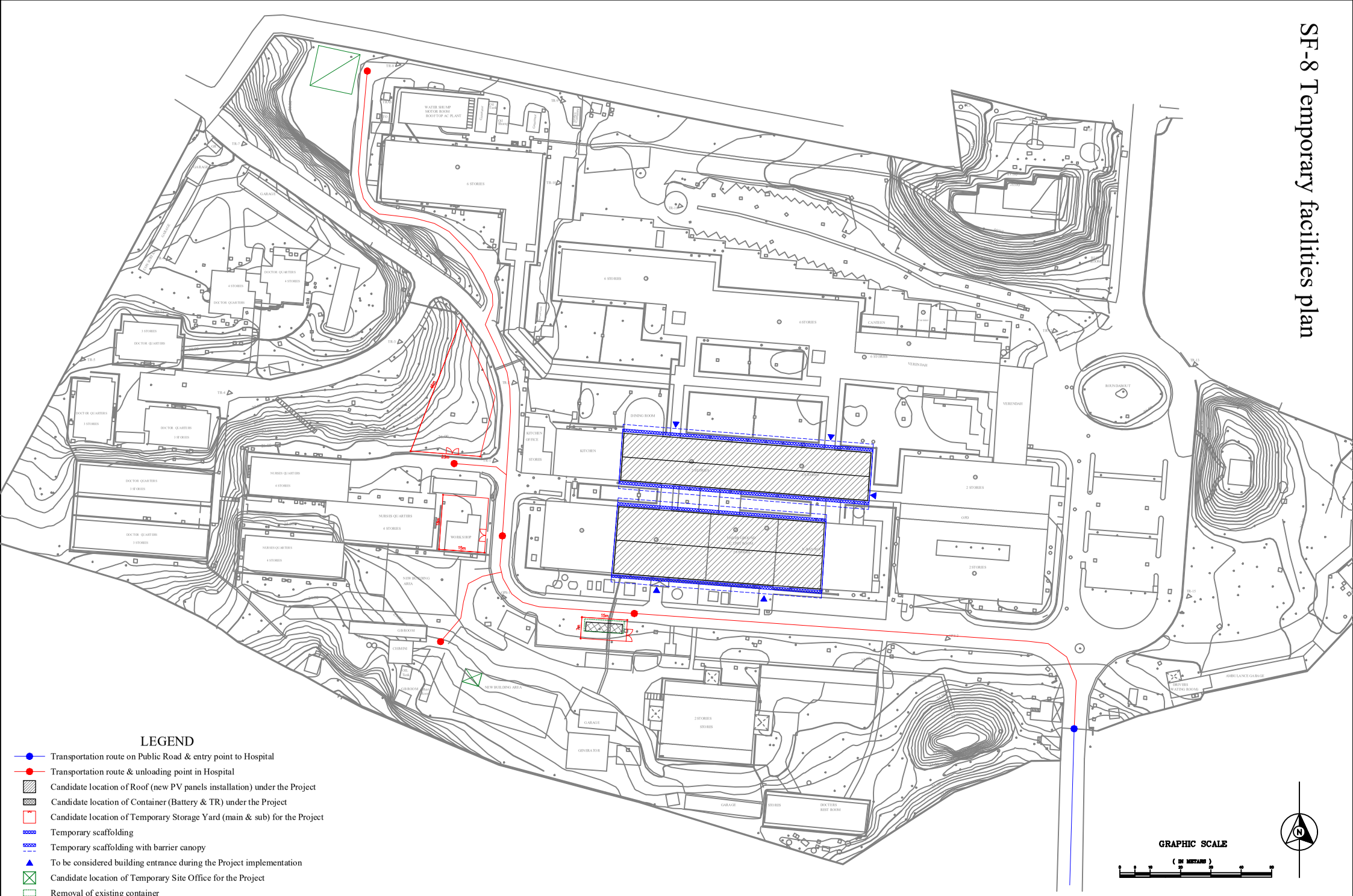


SECTION C-C

DWG No. SF-7

SRI JYAE WARDENEPURA / CONTAINER FOUNDATION

SF-8 Temporary facilities plan



ENGINEERING SURVEY OF GENERAL HOSPITAL SRI JAYAWARDANAPURA

B.R.L.BORALUWA
REGISPARED LICENSED SURVEYOR

DRAWING NO. JAY.03

SURVEYED ON JULY 2017

CONTAINING IN TOTAL EXTANT OF HOSPITAL PREMISES 8.1772 HECTARES (20 A. 0 R 33.03 P.)

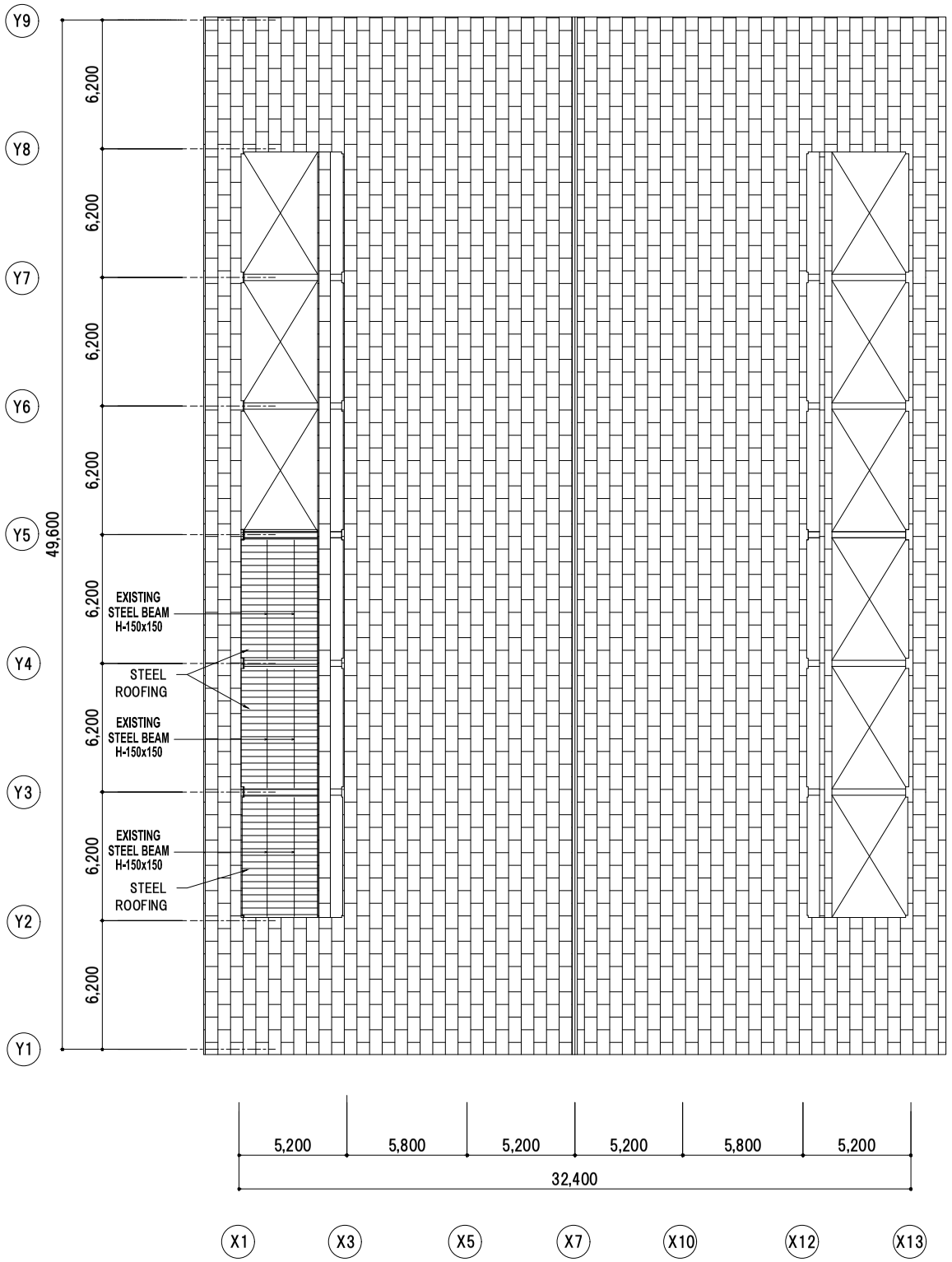
6-5. Facility drawings (TH Ratnapura)



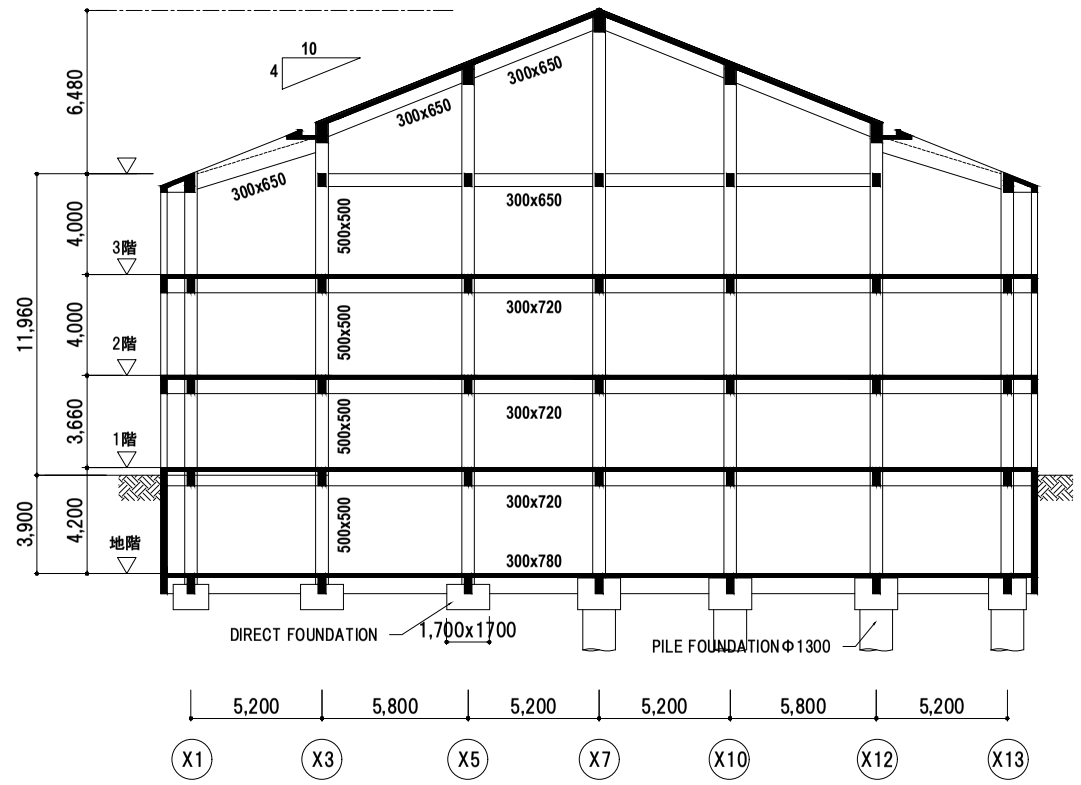
SITE PLAN

DWG No. RF-1

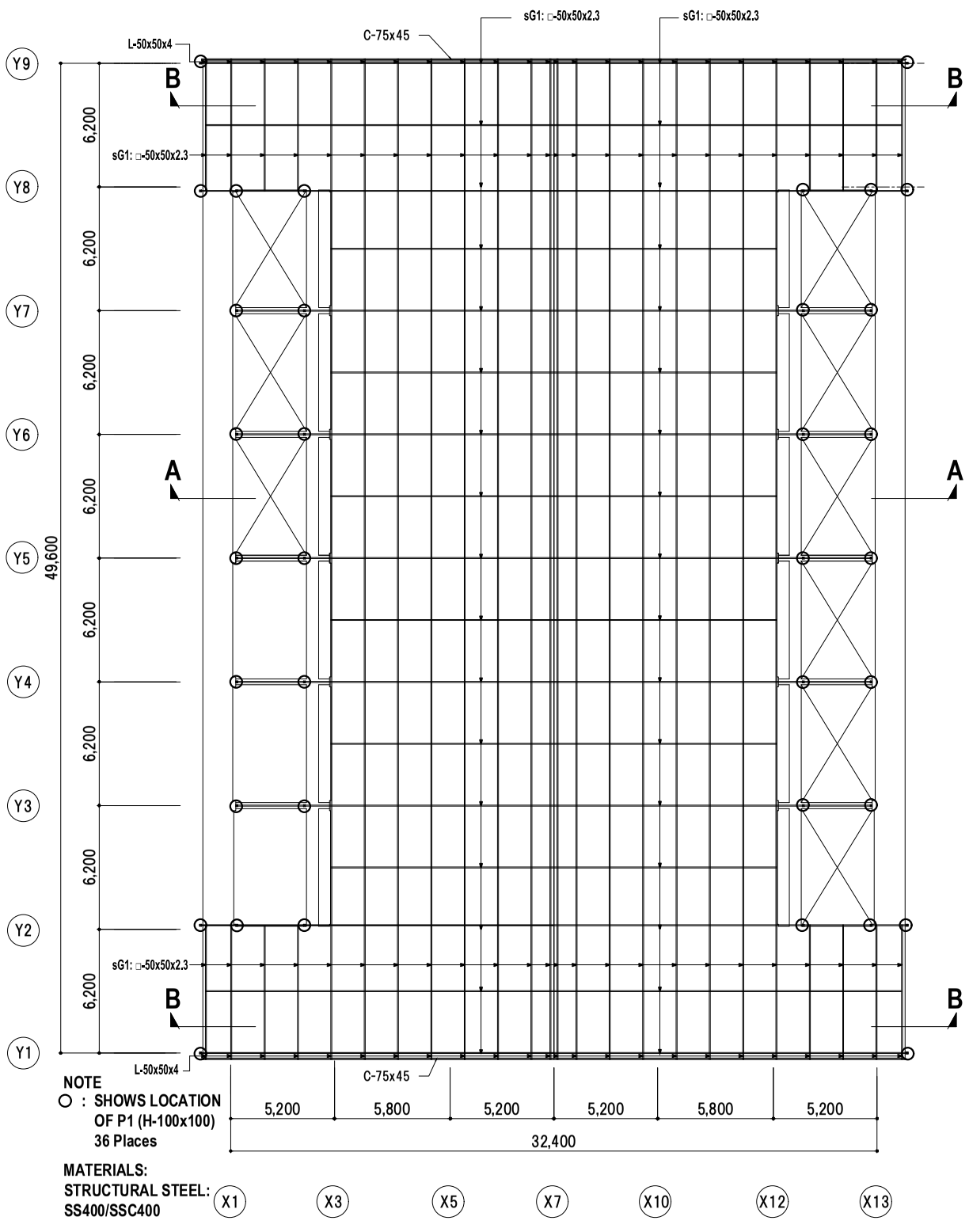
RATHUNAPURA HOSPITAL / SITE PLAN



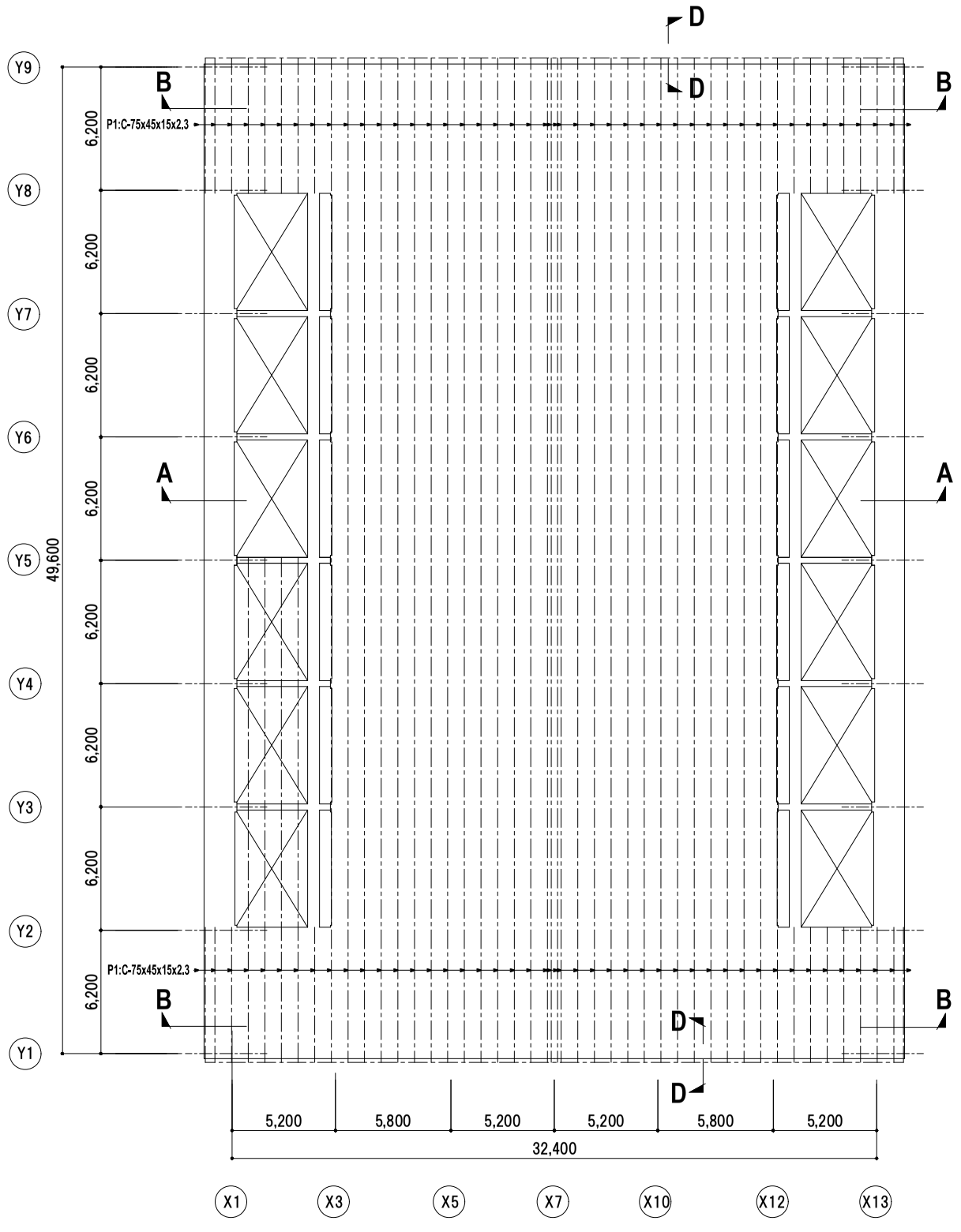
ROOF PLAN
EXISTING ROOF CONDITION



SECTION



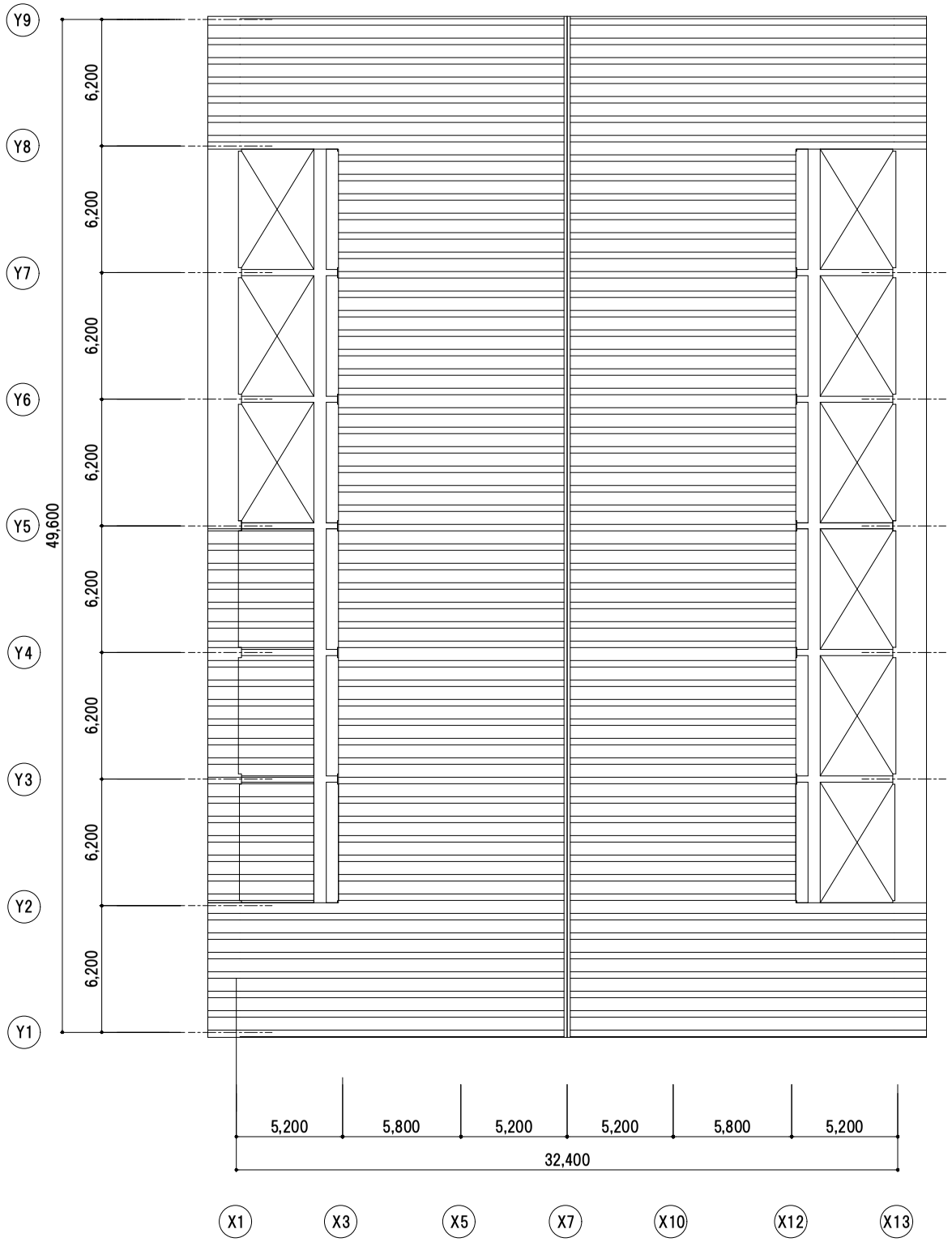
ROOF FLOOR STEEL FRAME PLAN FOR ADDITIONAL ROOFING



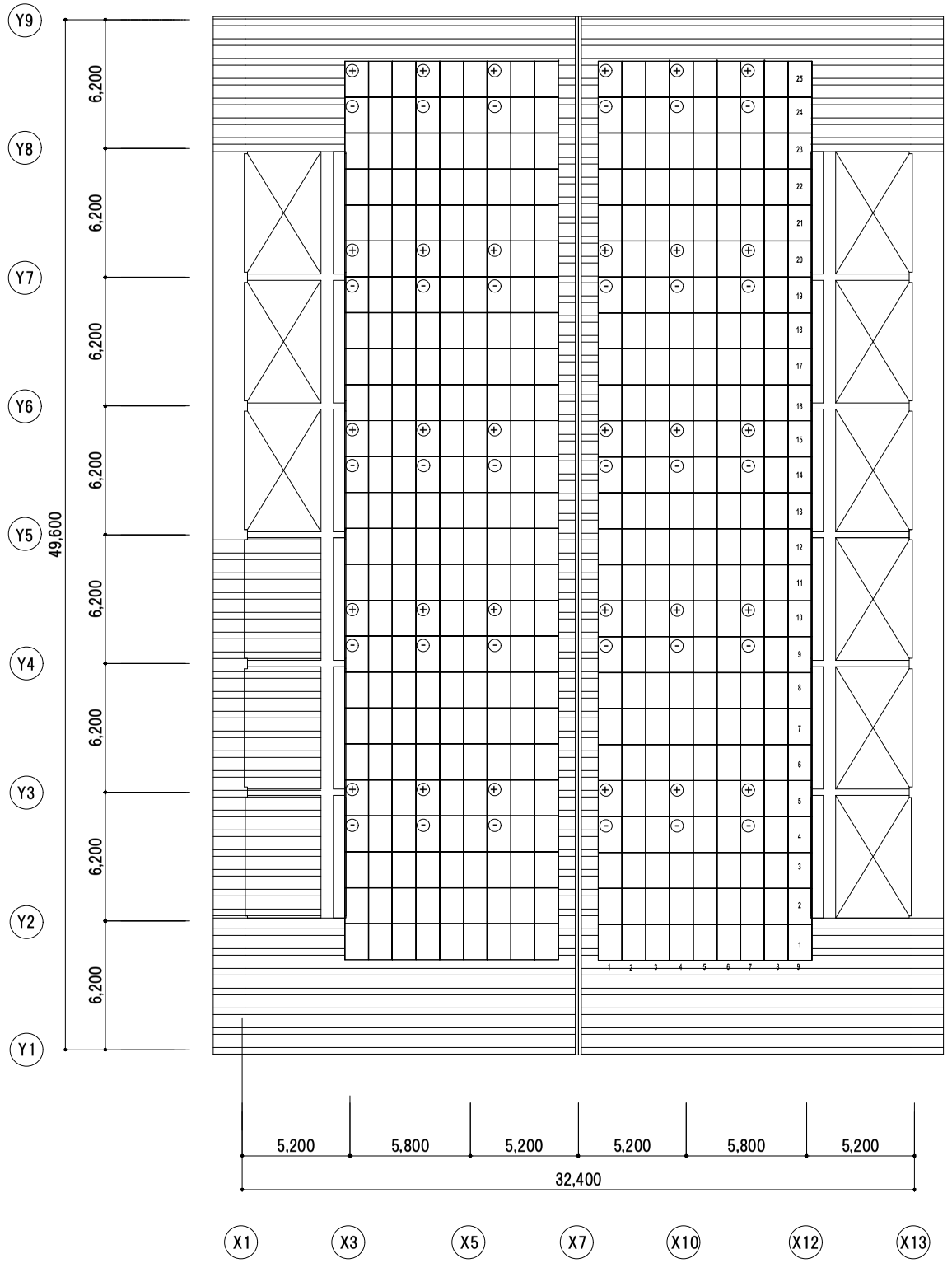
ROOF FLOOR PURLIN PLAN

DWG No. RF-3

RATHUNAPURA HOSPITAL JICA BUILDING
STEEL FRAMING PLAN FOR ADDITIONAL ROOFING



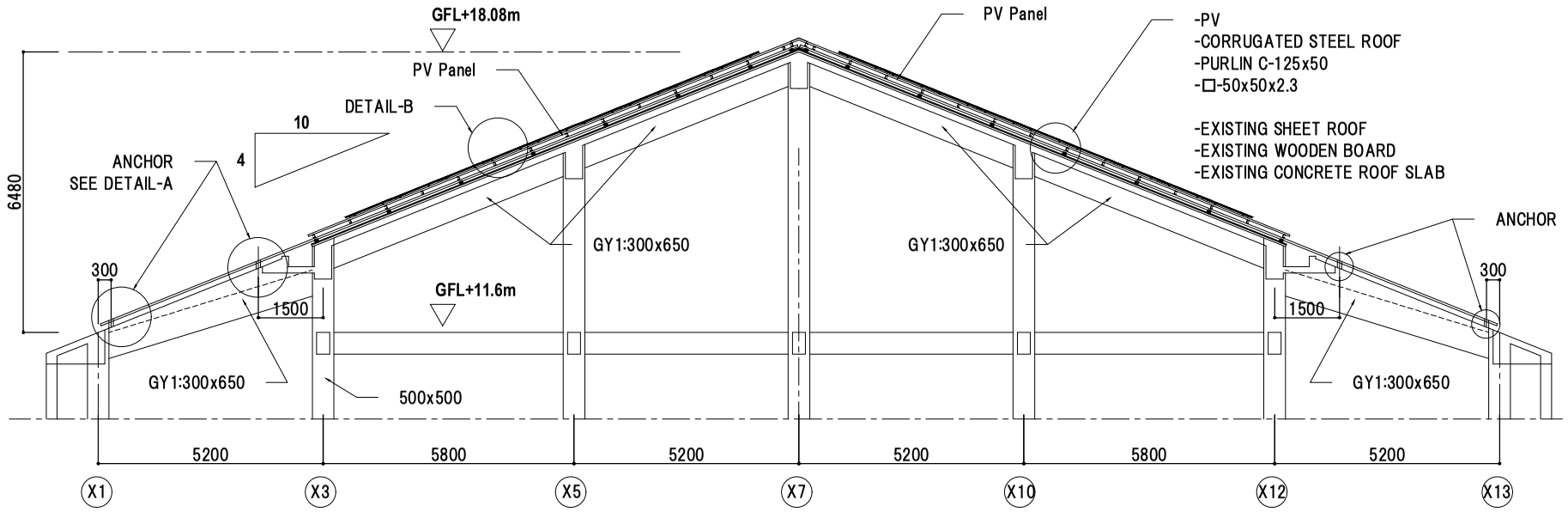
ADDITIONAL ROOF PLAN
(CORRUGATED STEEL ROOF)



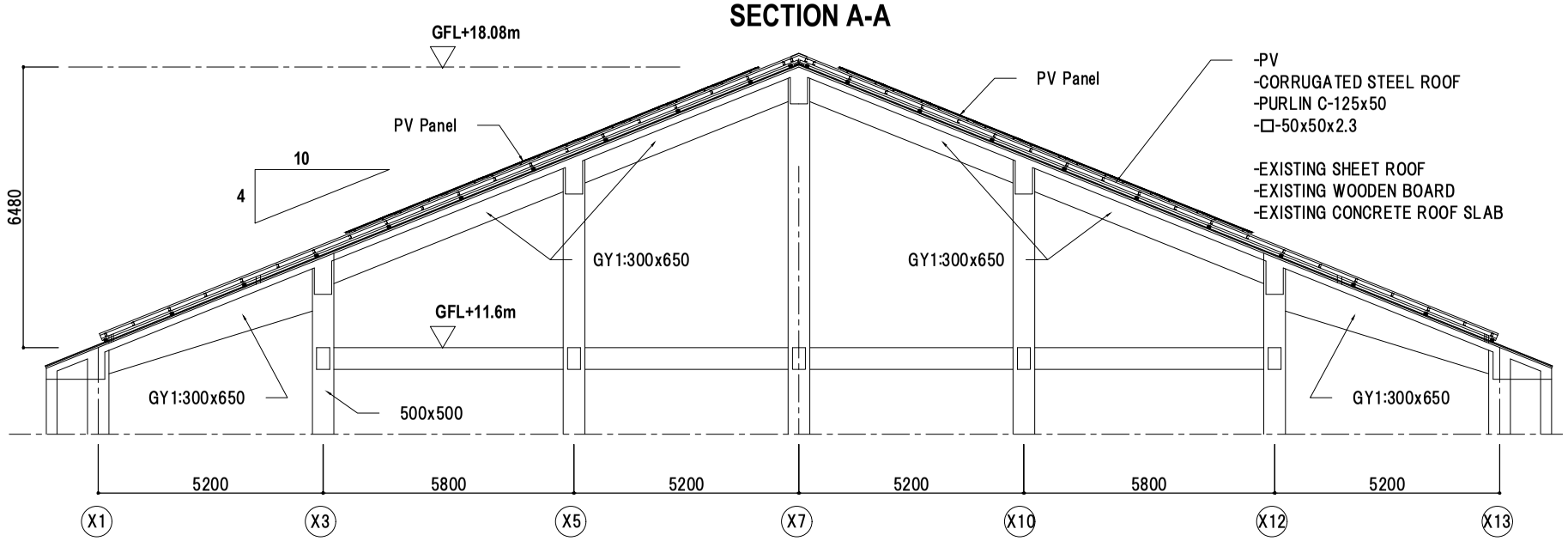
PV ARRANGEMENT PLAN

DWG No. RF-4

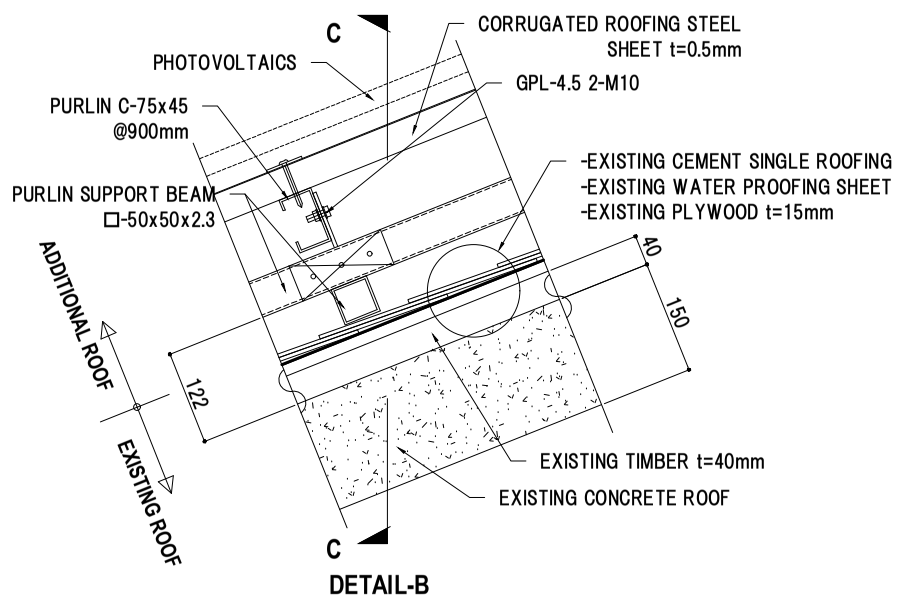
RATHUNAPURA HOSPITAL JICA BUILDING/
ADDITIONAL ROOFING PLAN



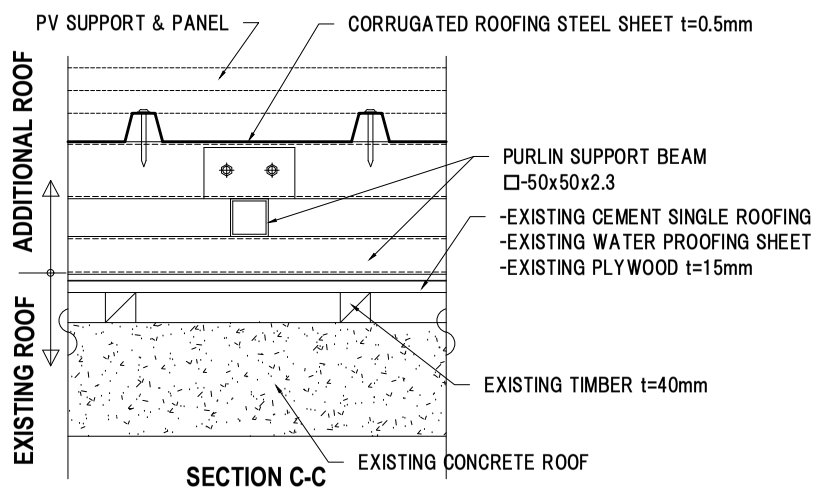
SECTION A-A



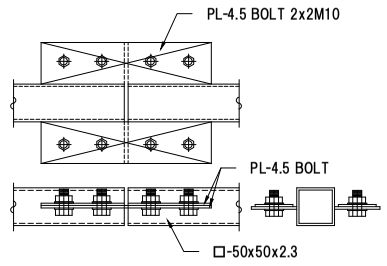
SECTION B-B



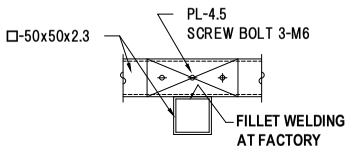
DETAIL-B



SECTION C-C

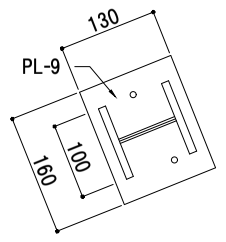


JOINT DETAIL OF □-50x50x2.3

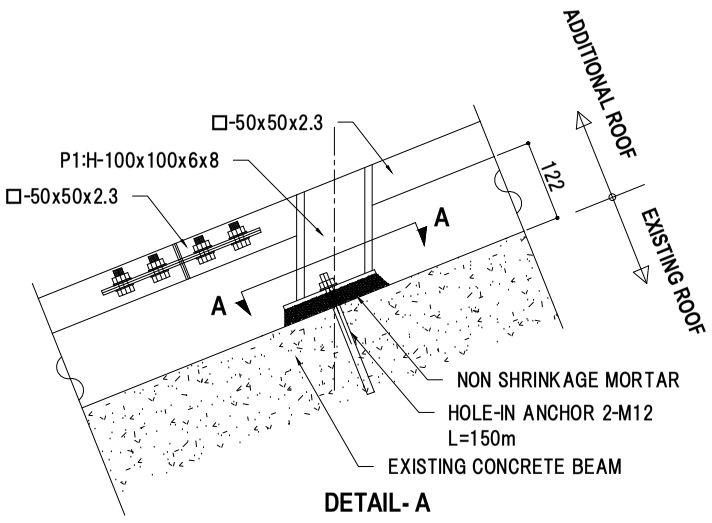


CROSSING PART

NOTES:
ALL OF THE CROSSING PART OF THE □-50x50x2.3 SHALL BE CONNECTED EACH OTHERS BY SCREW BOLT AS SHOWN ABOVE



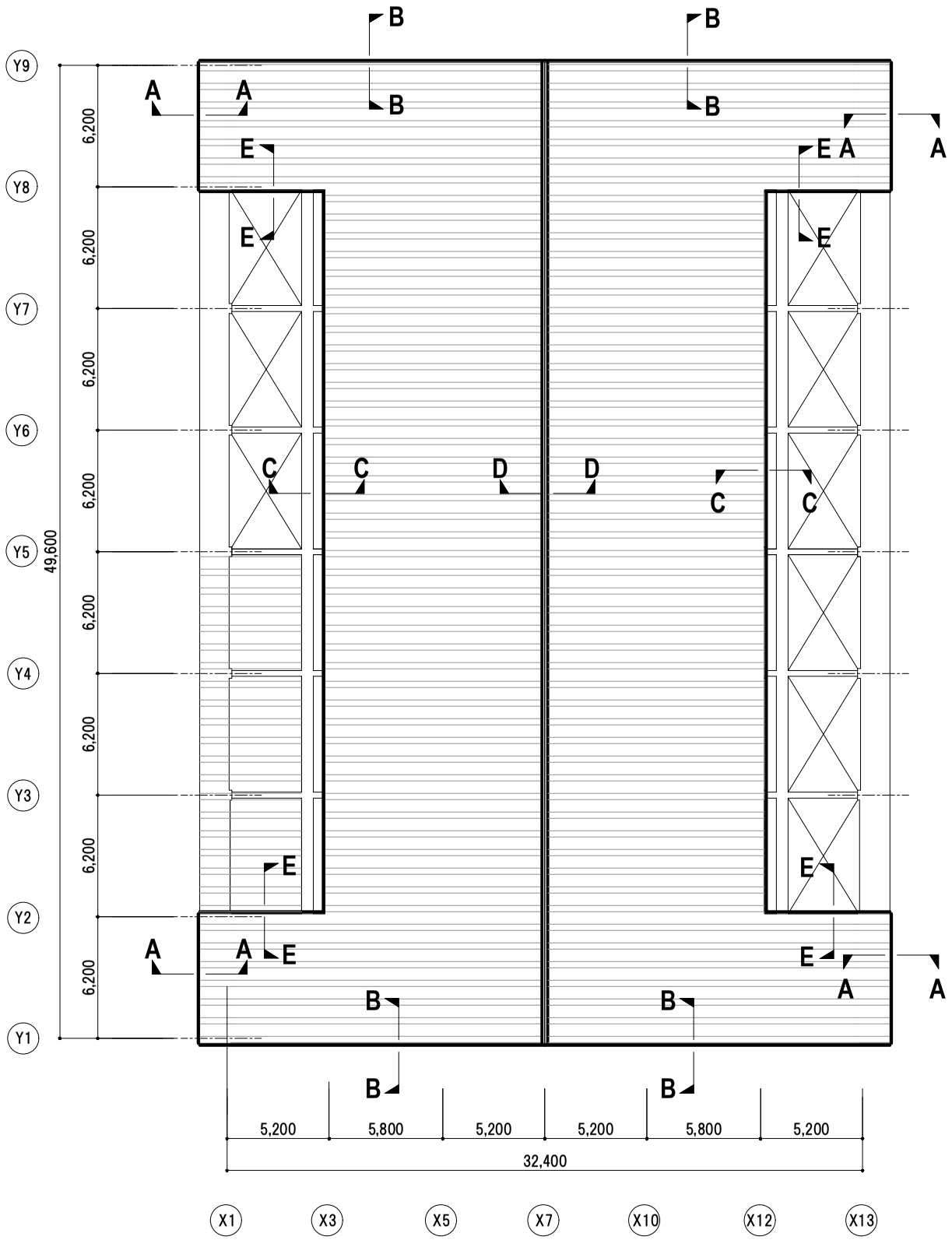
SECTION A-A



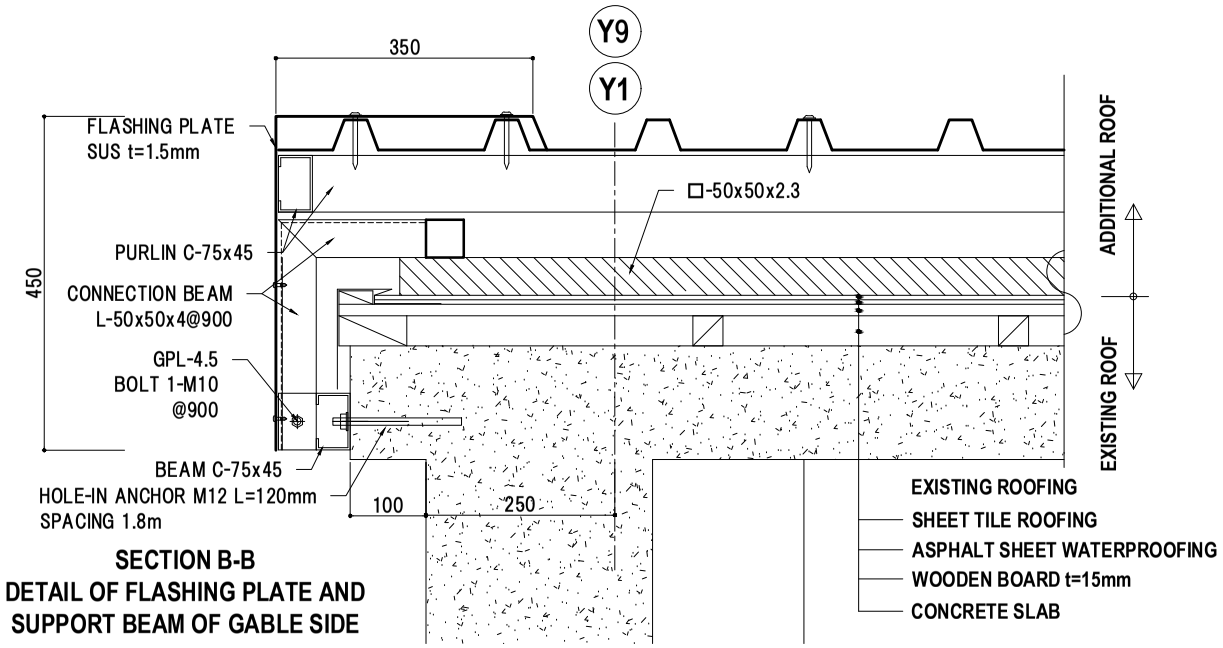
DETAIL- A

DWG No. RF-5

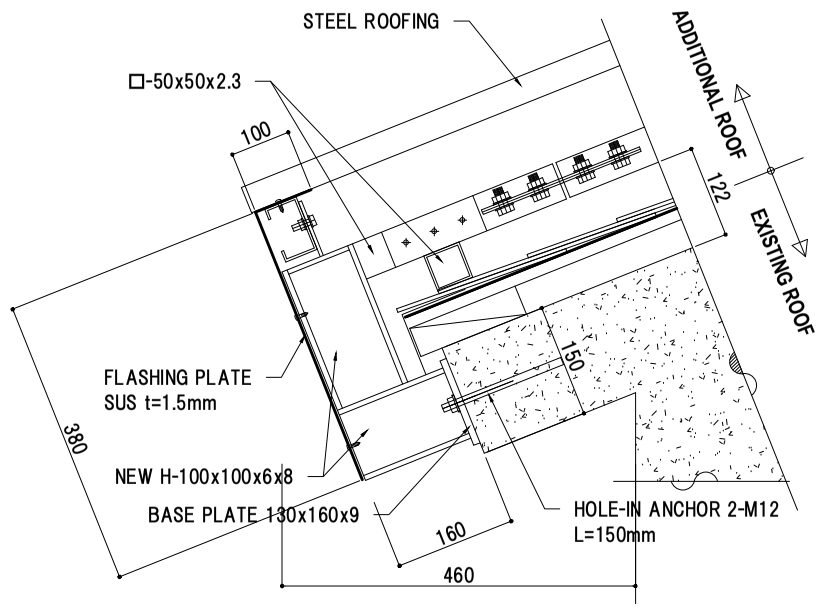
RATHUNAPURA HOSPITAL JICA BUILDING/
DETAILS OF THE STEEL FRAMING



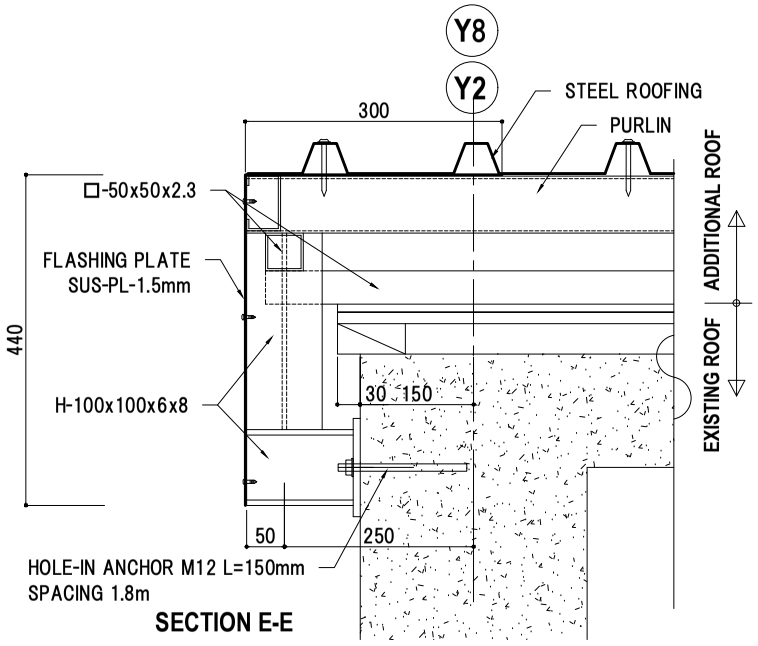
FLASHING PLATE LOCATION



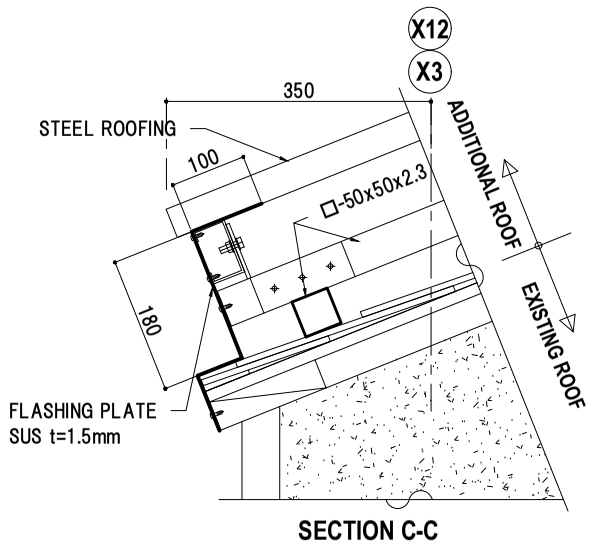
SECTION B-B
DETAIL OF FLASHING PLATE AND SUPPORT BEAM OF GABLE SIDE



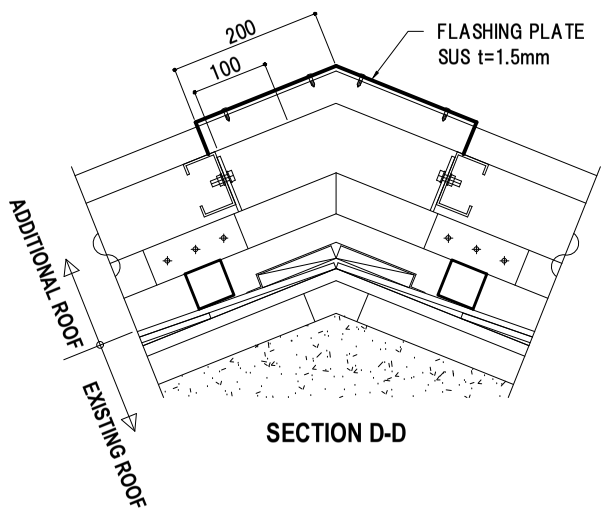
SECTION A-A



SECTION E-E



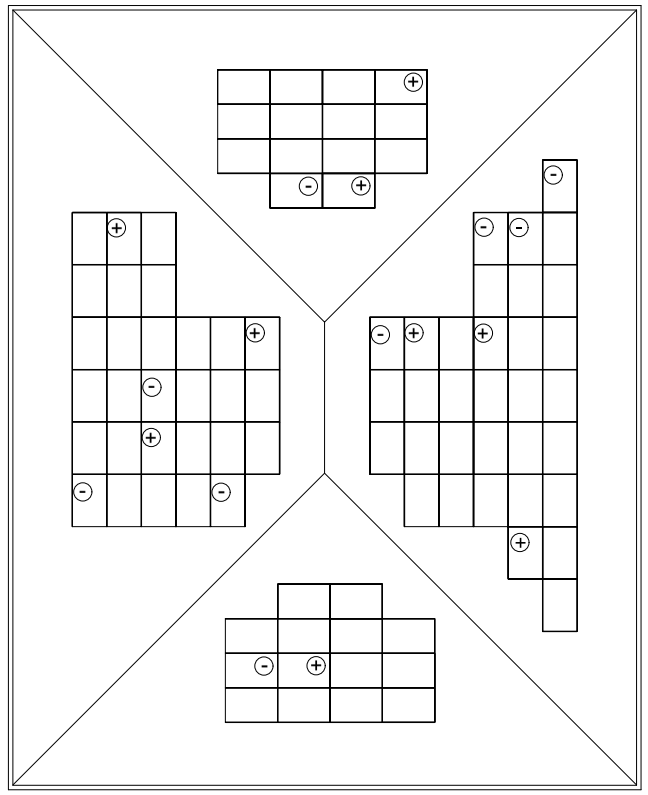
SECTION C-C



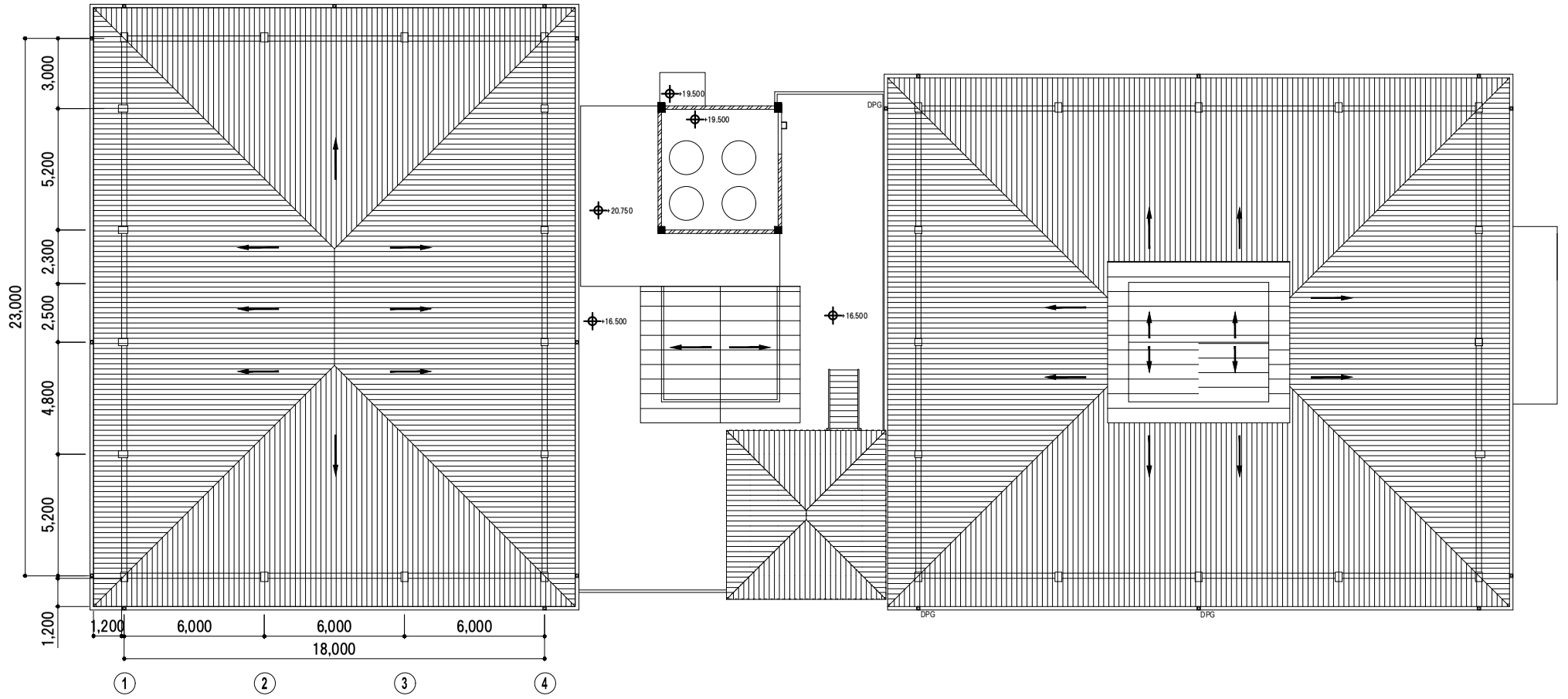
SECTION D-D

DWG No. RF-6

RATHUNAPURA HOSPITAL JICA BUILDING/
DETAILS OF THE FLASHING PLATE



PHOTOVOLTAICS ALLOCATION PLAN



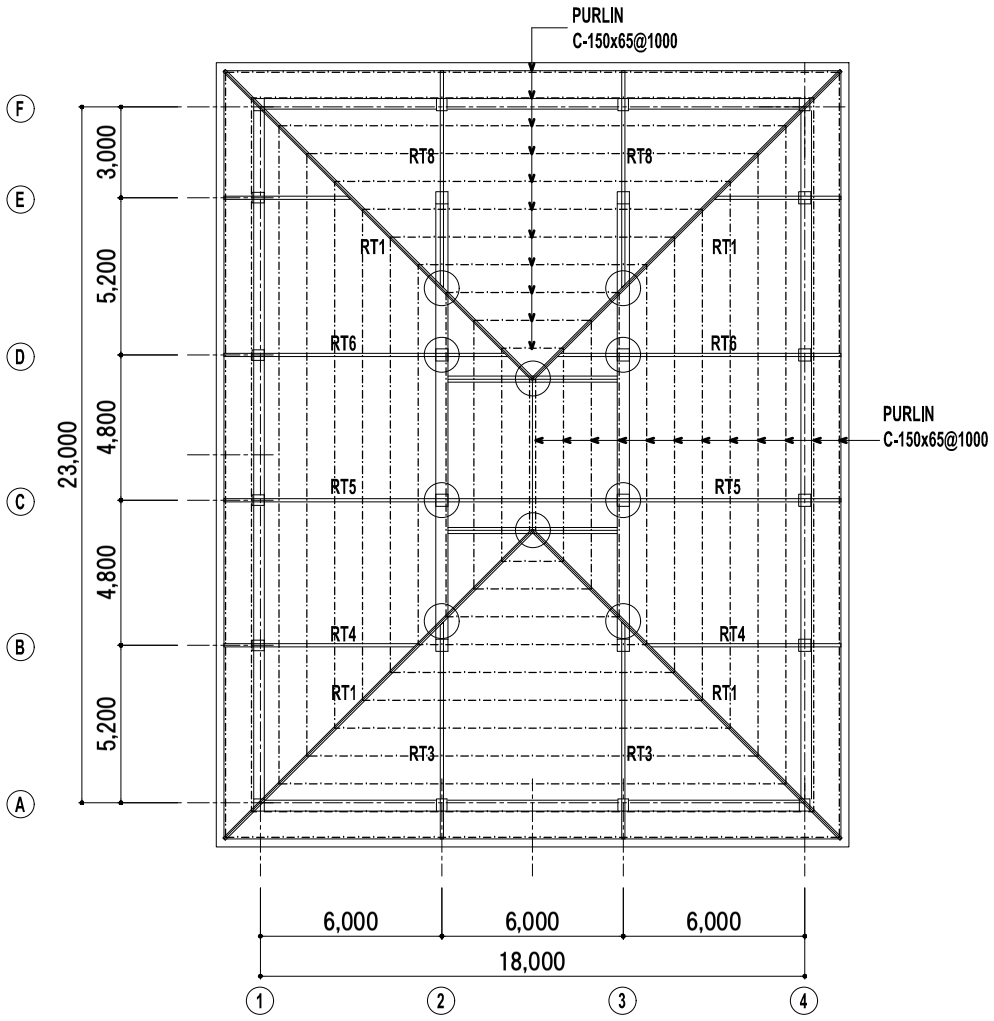
ROOF PLAN



FRONT ELEVATION

DWG No. RF-7

RATHUNAPURA HOSPITAL A&E BUILDING/
EXISTING ROOFING PLAN

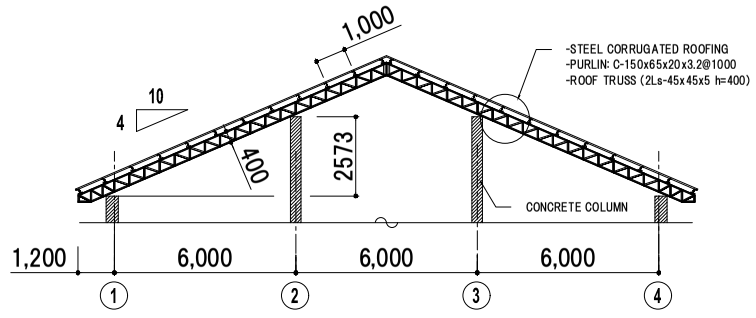


ROOF TRUSS PLAN

NOTES

(1) LOCATION MARKED BY ◯ SHOWS CONNECTION TO THE CONCRETE STRUCTURE

(2) Purlin C-150x65x20x3.2 @1000



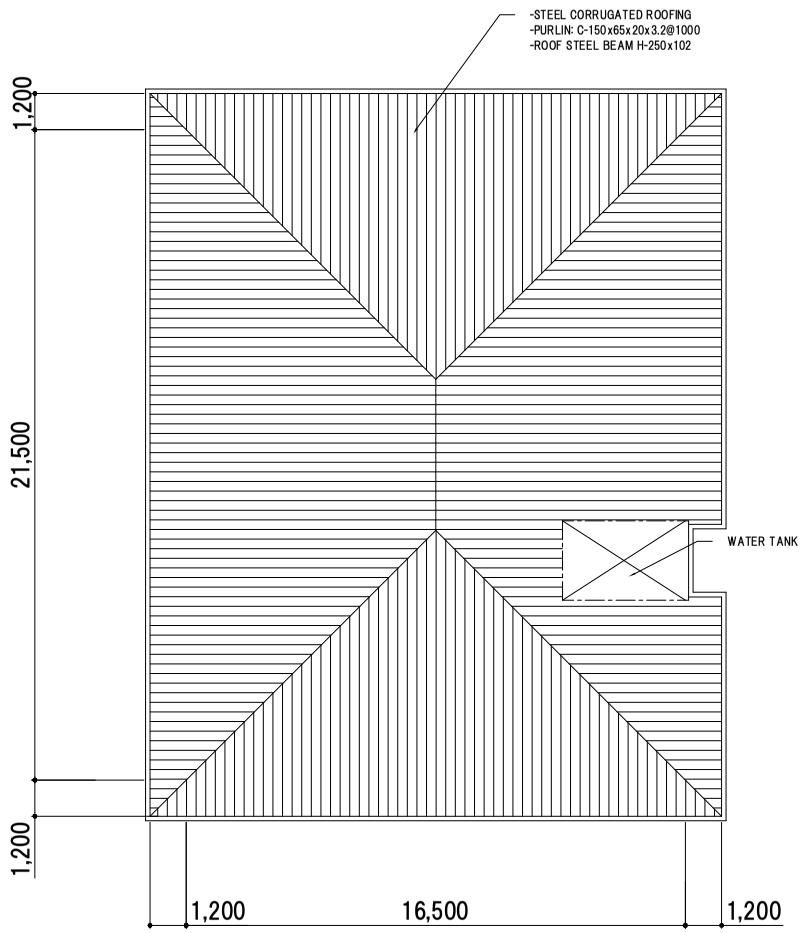
ROOF TRUSS RT5 SECTION

ITEMS OF THE ROOFING WORKS TO BE DONE BY THE PROJECT
FOLLOWING WORKS SHALL BE INCLUDED IN THE SCOPE OF WORKS OF THE CONTRACTOR BEFORE INSTALLATION OF THE PHOTOVOLTAICS

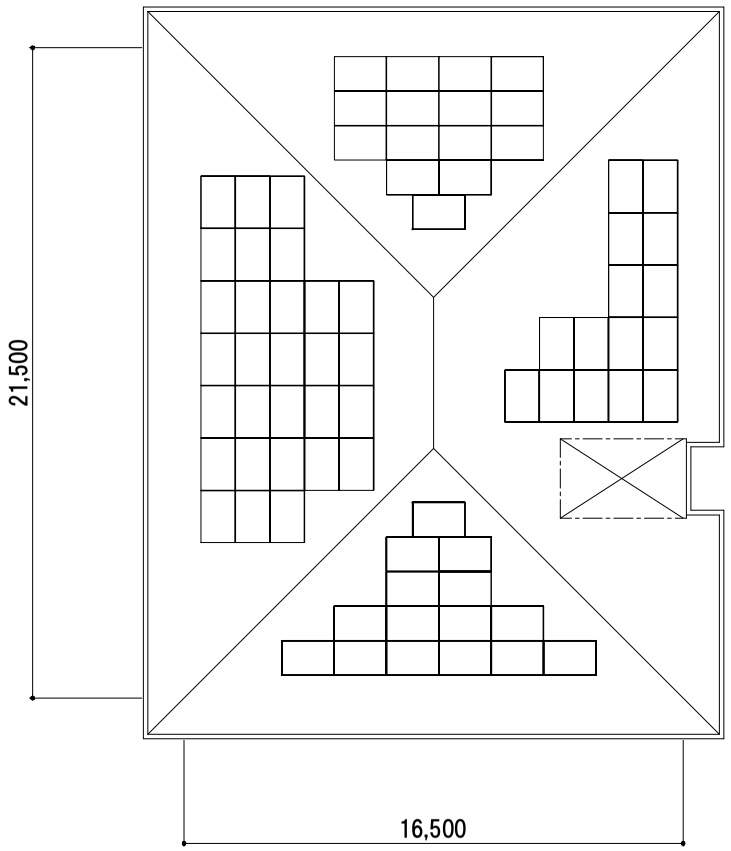
(1) CLEANING EXISTING STEEL ROOF BY HIGH PRESSURE WATER WASHING MACHINE
(2) REPLACE AND RETIGHTENS THE EXISTING SCREW WHEN THE SCREW CONNECTING ROOF STEEL AND STEEL PURLIN ARE LOOSE
(3) PAINTING EXISTING STEEL ROOF BY SILICONE RESIN PAINT

DWG NO. RF-8

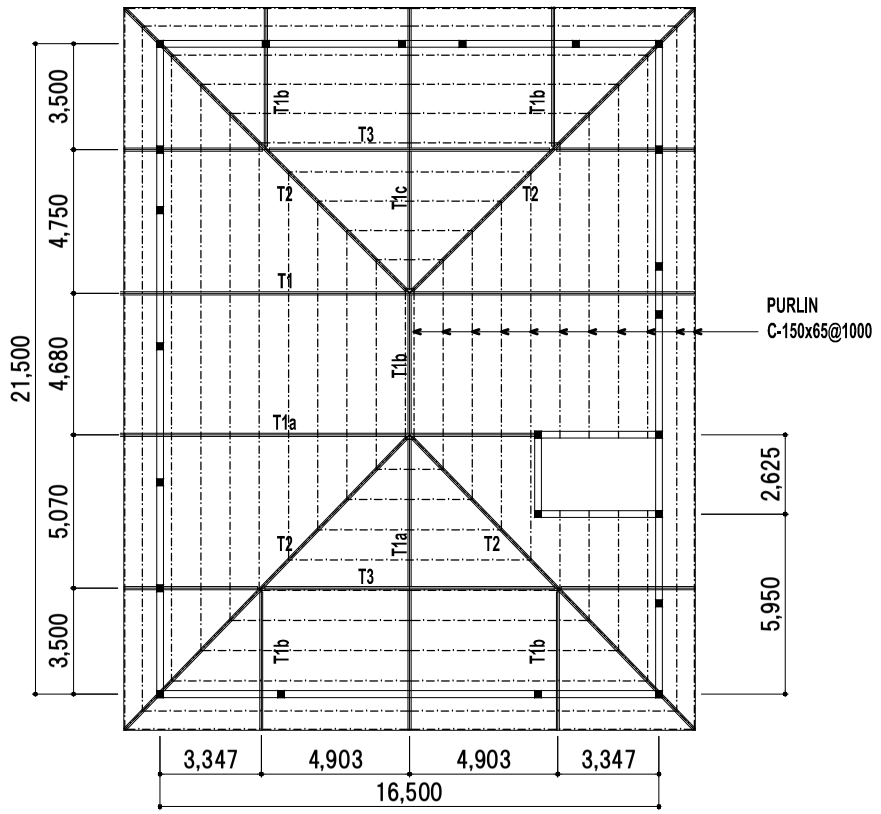
RATHUNAPURA HOSPITAL A&E BUILDING/
STEEL ROOF PLAN AND SECTION



ROOF PLAN



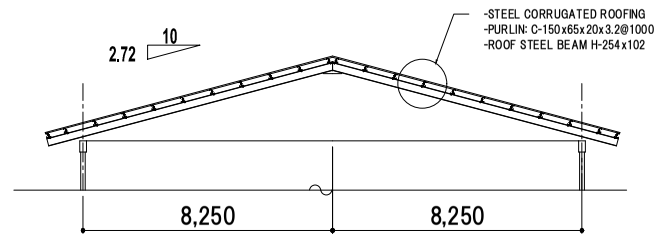
PHOTOVOLTAICS ALLOCATION PLAN



ROOF BEAM PLAN

ITEMS OF THE ROOFING WORKS TO BE DONE BY THE PROJECT
FOLLOWING WORKS SHALL BE INCLUDED IN THE SCOPE OF WORKS OF THE CONTRACTOR BEFORE INSTALLATION OF THE PHOTOVOLTAICS

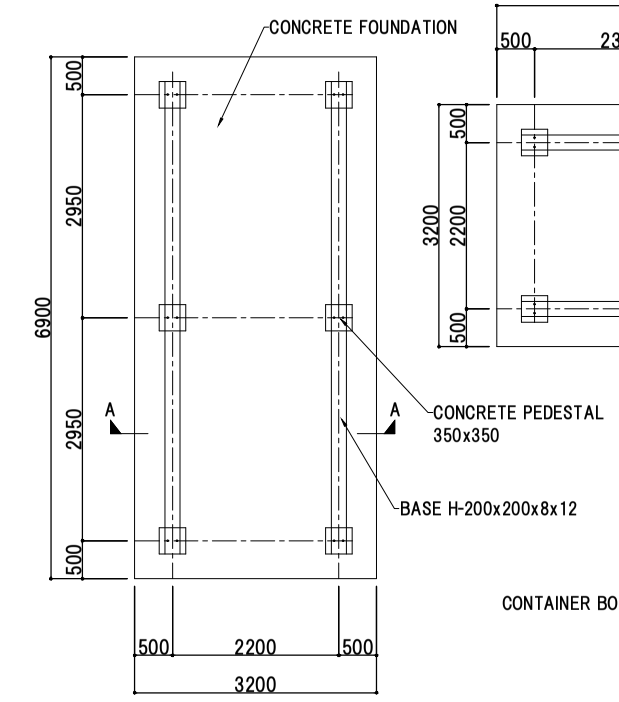
(1) CLEANING EXISTING STEEL ROOF BY HIGH PRESSURE WATER WASHING MACHINE
(2) REPLACE AND RETIGHTENS THE EXISTING SCREW WHEN THE SCREW CONNECTING ROOF STEEL AND STEEL PURLIN ARE LOOSE
(3) PAINTING EXISTING STEEL ROOF BY SILICONE RESIN PAINT



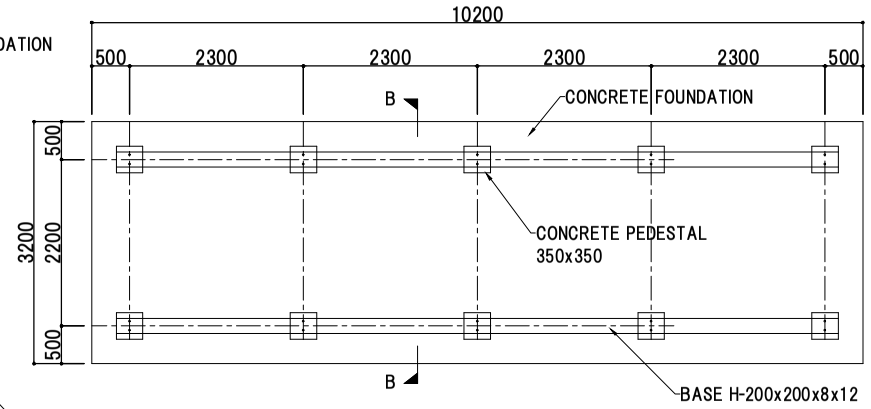
ROOF BEAM T1 SECTION

DWG NO. RF-9

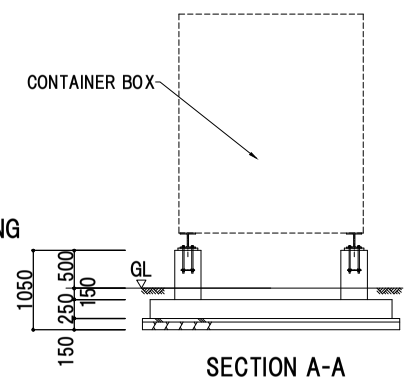
RATHUNAPURA HOSPITAL BLOOD BANK BUILDING /
EXISTING ROOFING PLAN



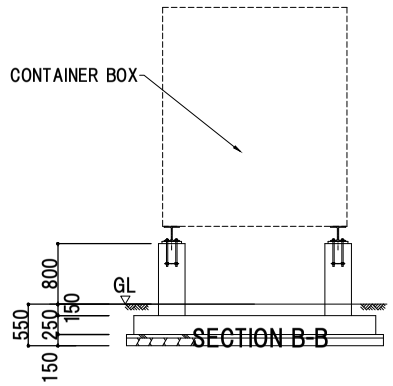
CONTAINER FOUNDATION
FOR A&E BUILDING & BLOOD BANK BUILDING



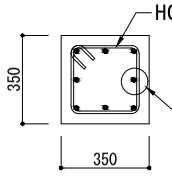
CONTAINER FOUNDATION
FOR JICA BUILDING



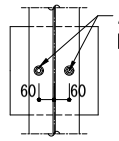
SECTION A-A



SECTION B-B

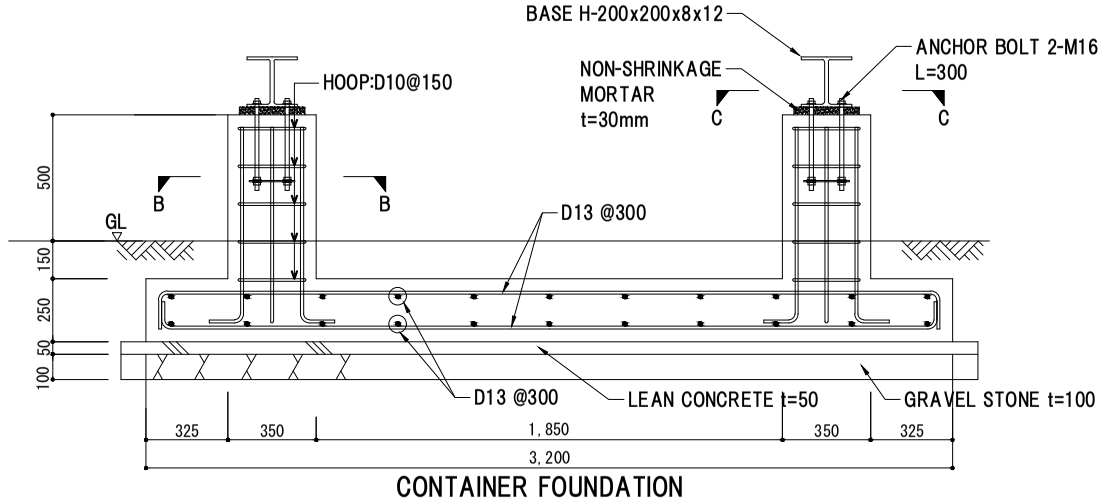


SECTION B-B

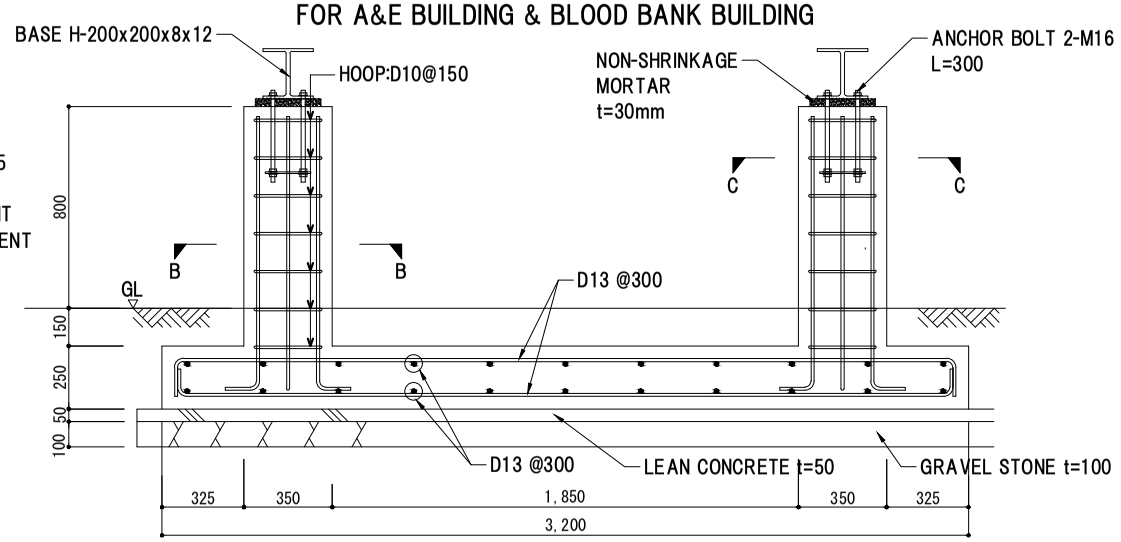


SECTION C-C

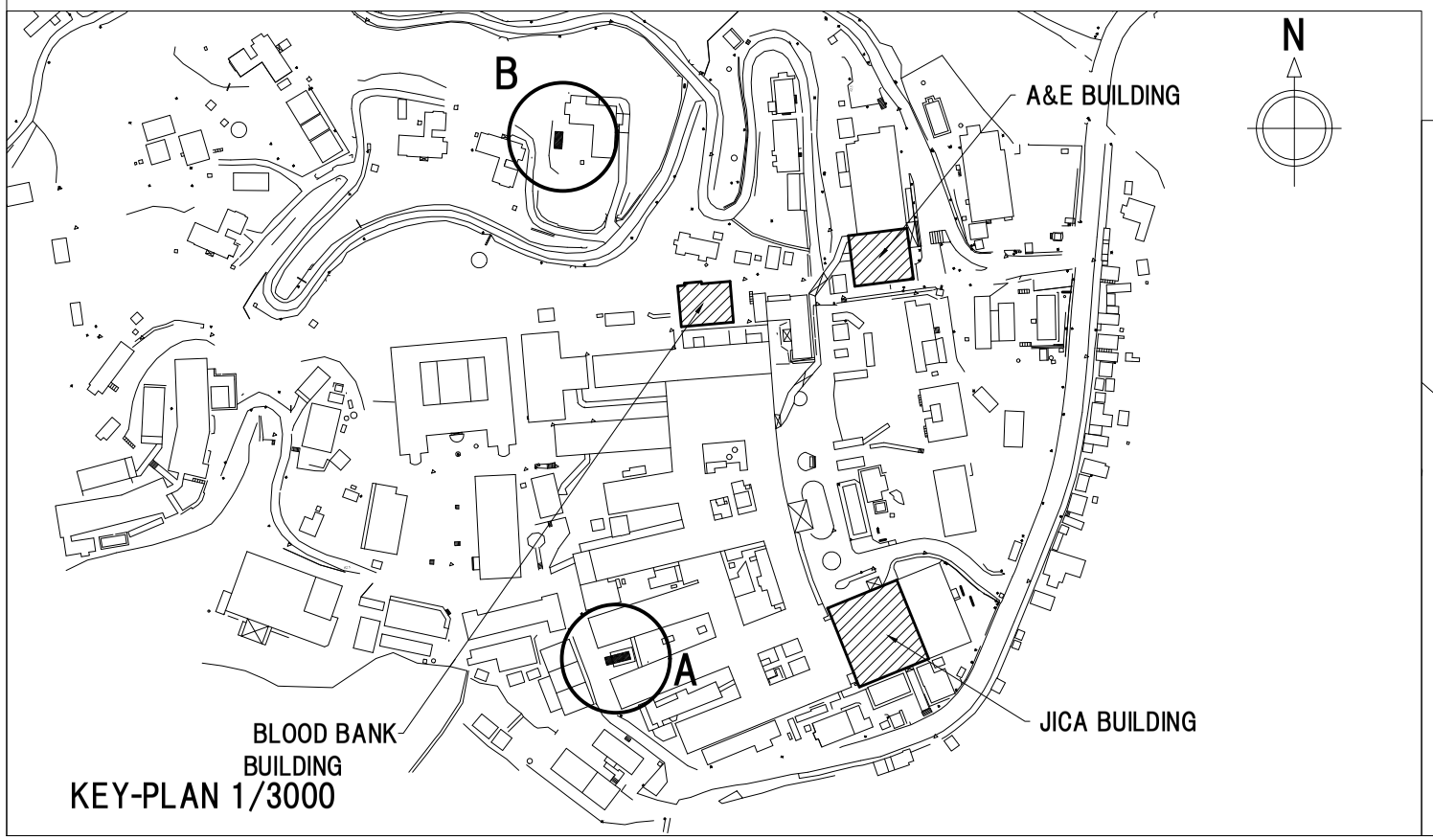
NOTES;
(1) FOUNDATION CONCRETE
Fc28=21N/mm2
(2) LEAN CONCRETE Fc=18N/mm2
(3) REINFORCING BARS: SD295A /SD345
OR EQUIVALENT
(4) BASE STEEL : SS400 or EQUIVALENT
(5) ANCHOR BOLT: SR 235 OR EQUIVALENT



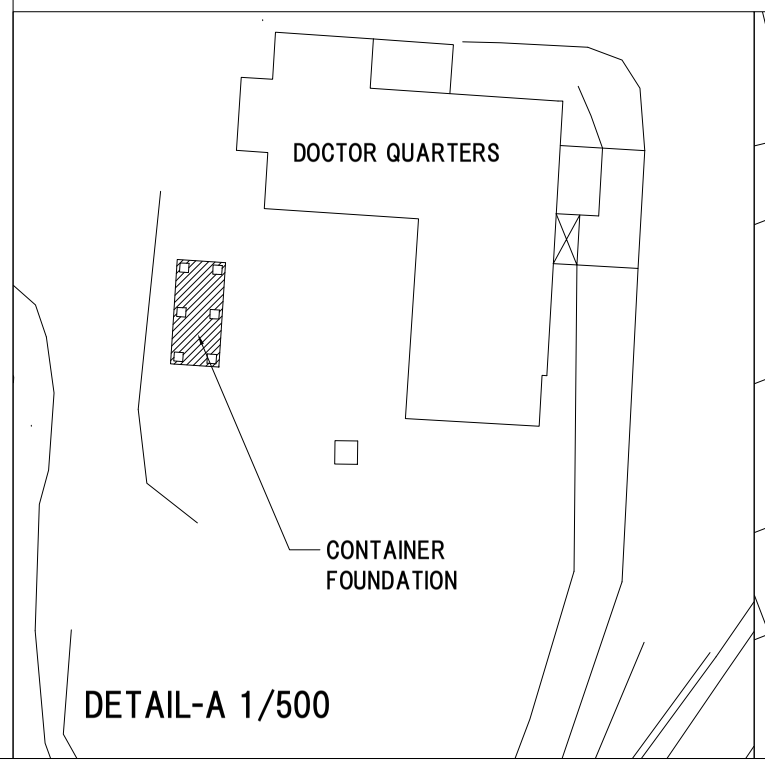
CONTAINER FOUNDATION
FOR A&E BUILDING & BLOOD BANK BUILDING



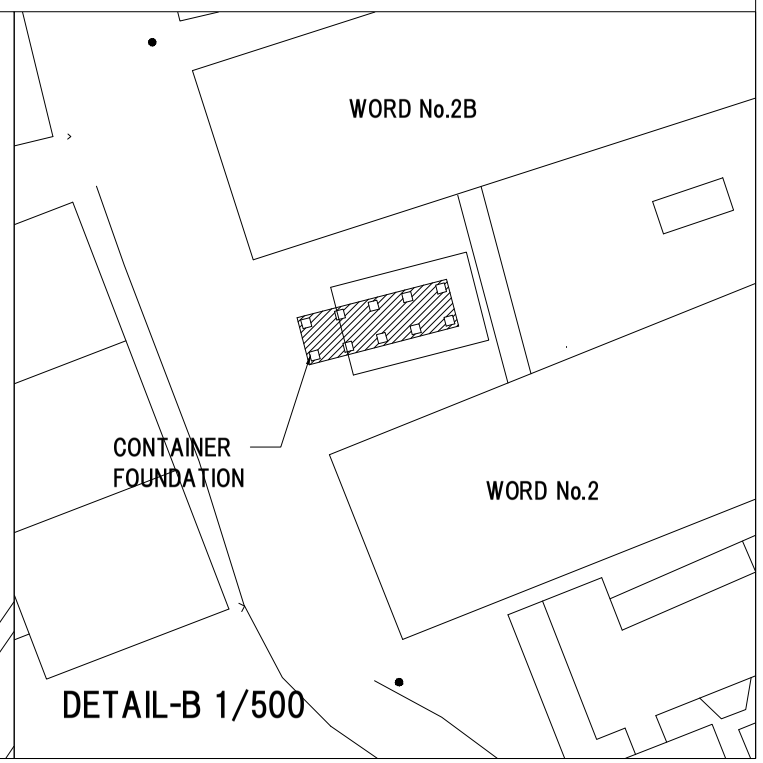
CONTAINER FOUNDATION FOR JICA BUILDING



KEY-PLAN 1/3000



DETAIL-A 1/500



DETAIL-B 1/500

DWG No. RF-10

RATHUNEPURA / CONTAINER FOUNDATION

RF-11 Temporary facilities plan



6-6. Facility drawings (TH Kurunegala)

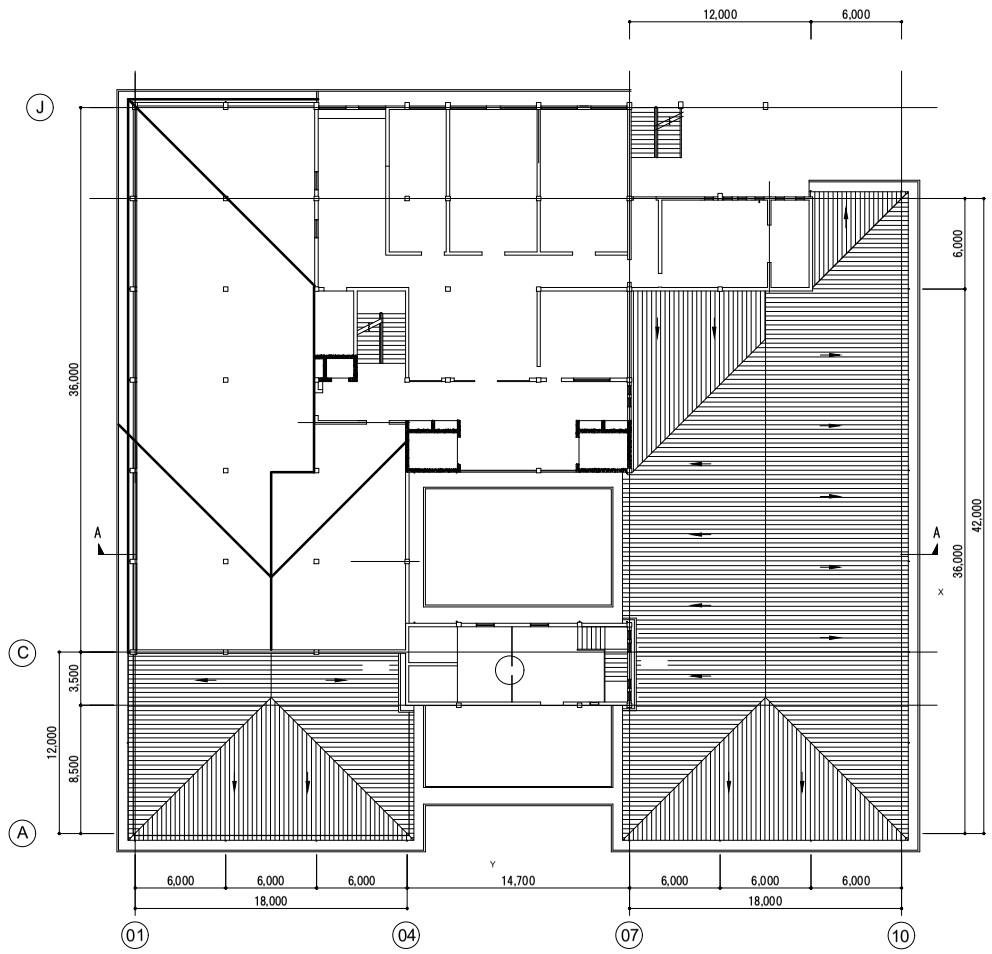
N

MATERNITY BUILDING

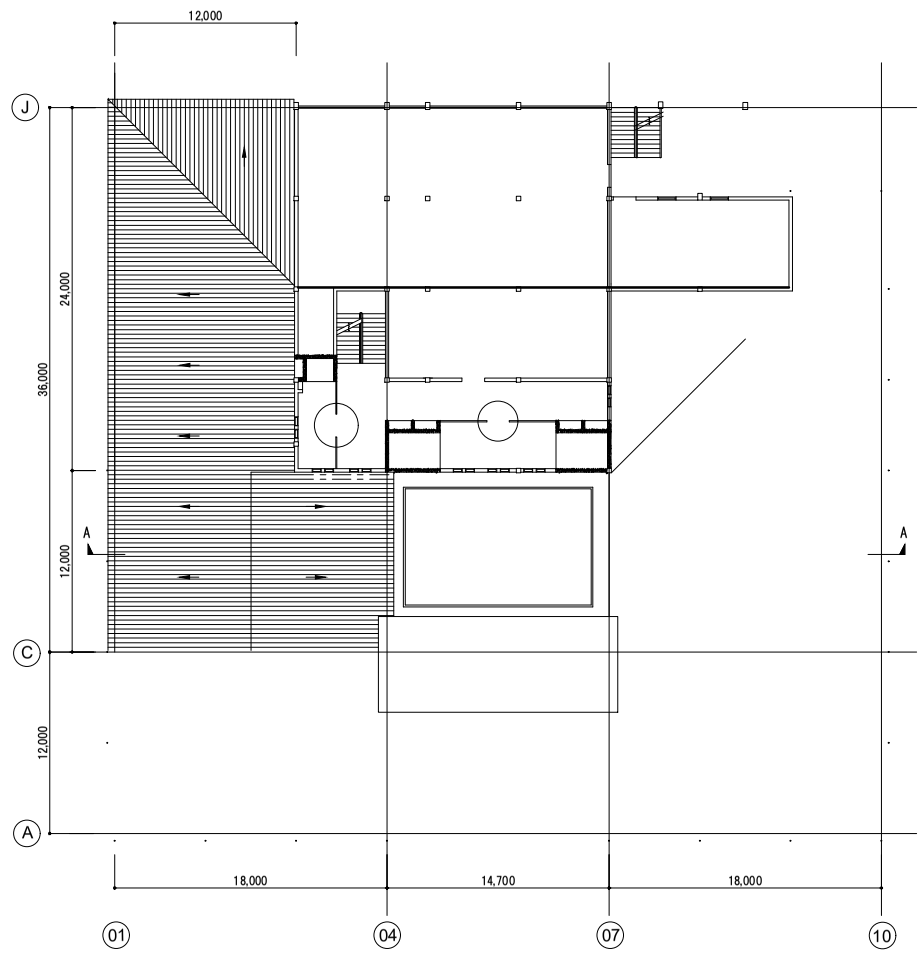
SITE PLAN

DWG No. KF-1

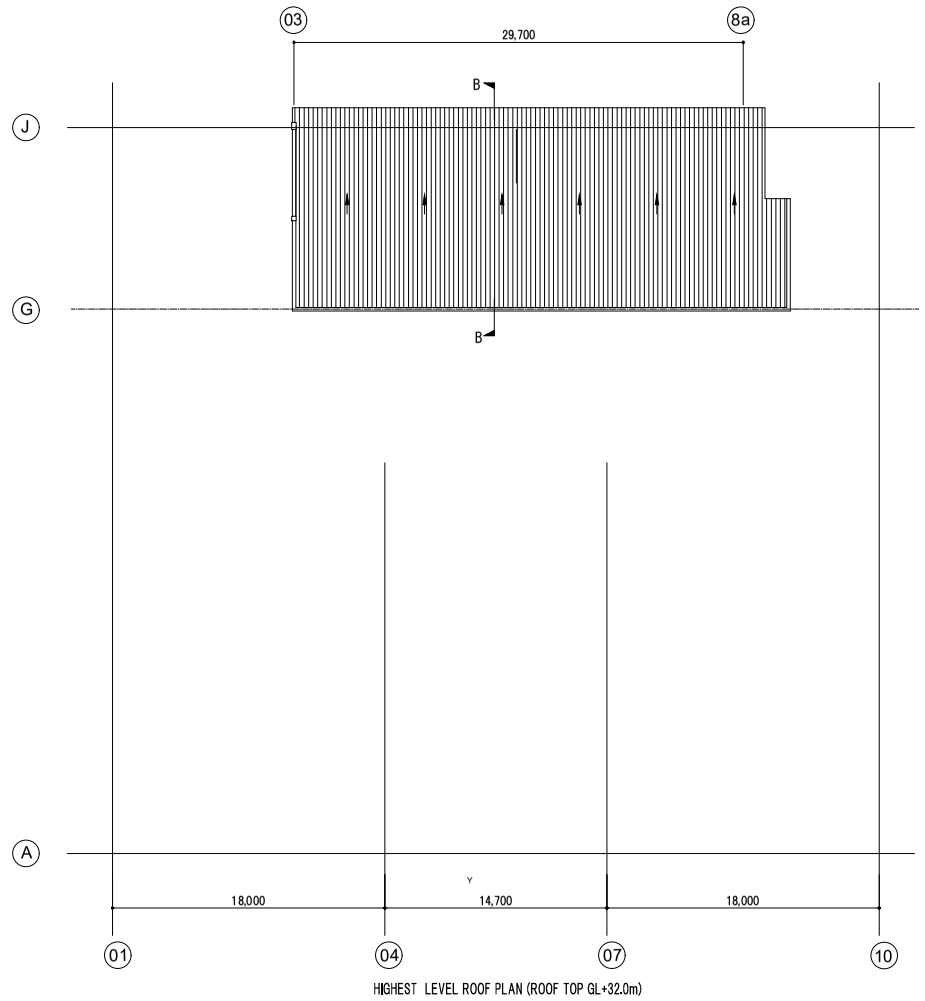
KURUNEGALA HOSPITAL/ SITE PLAN



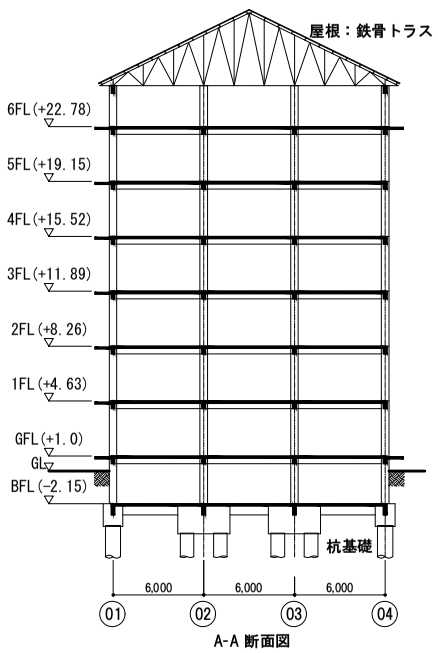
LOWEST LEVEL ROOF PLAN (ROOF TOP GL+27.0m)



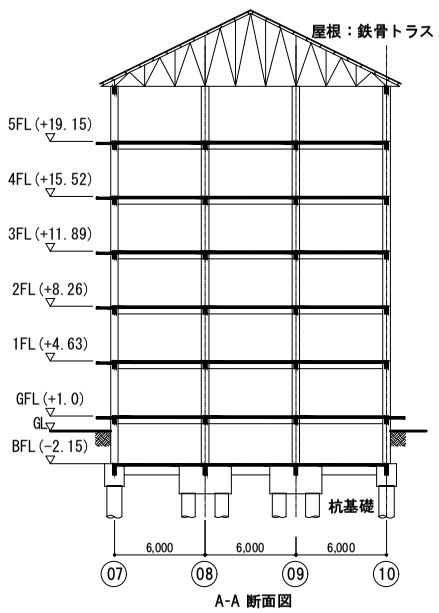
MIDDLE LEVEL ROOF PLAN (ROOF TOP GL+30.0m)



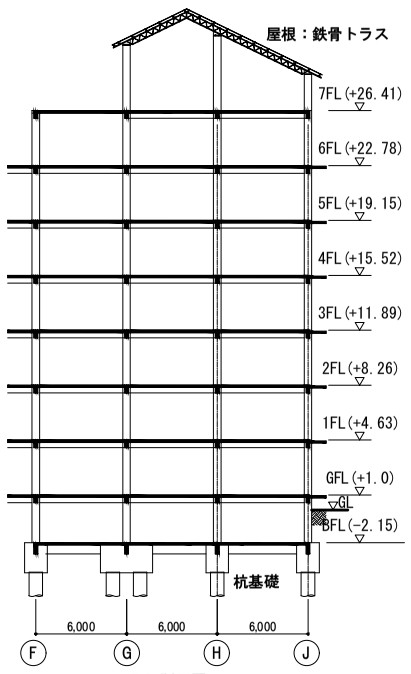
HIGHEST LEVEL ROOF PLAN (ROOF TOP GL+32.0m)



A-A 断面図



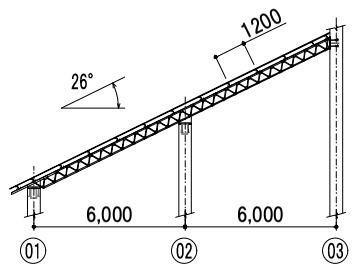
A-A 断面図

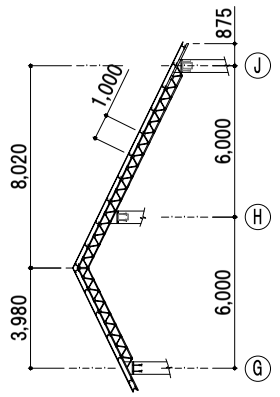


B-B 断面図

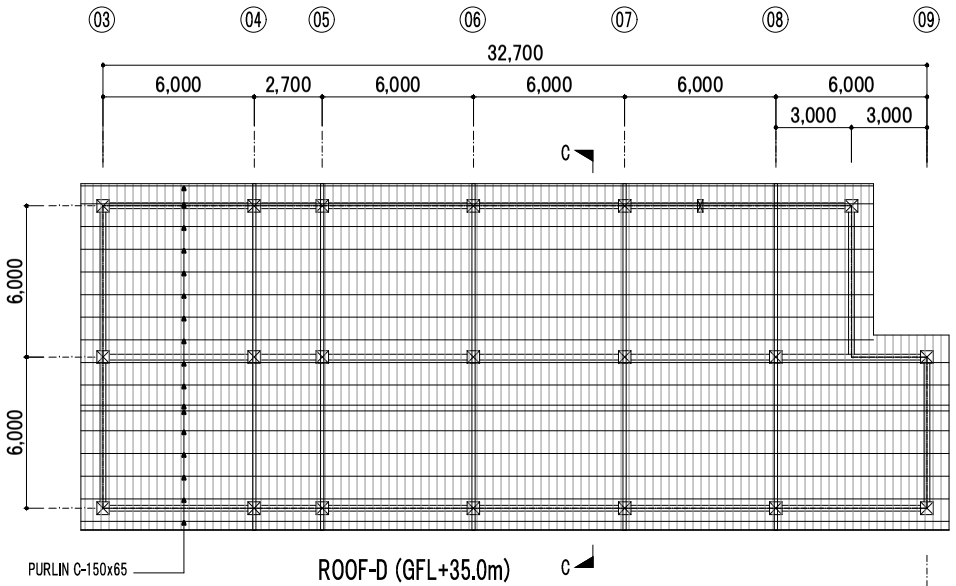
DWG No. K-02

KURUNEGALA HOSPITAL/ MATERNITY BUILDING
EXISTING ROOFING PLAN AND SECTION

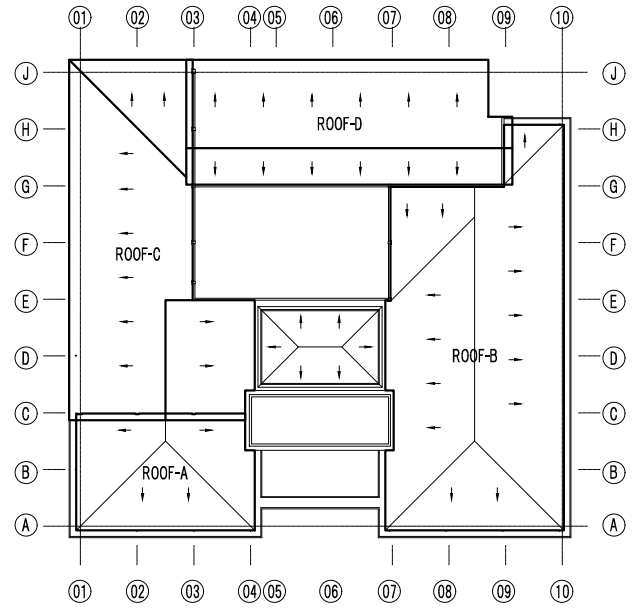




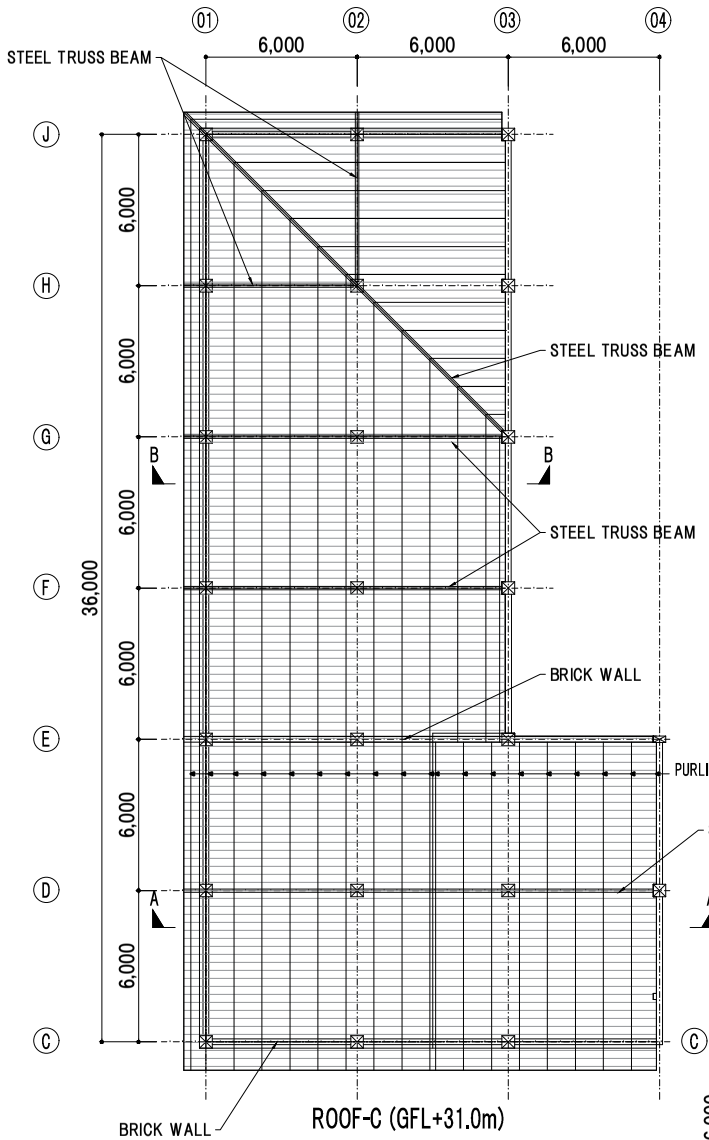
SECTION C-C



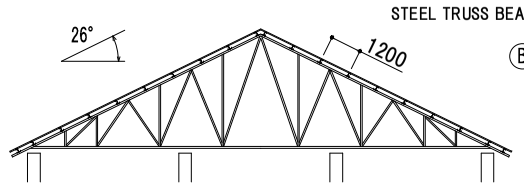
ROOF-D (GFL+35.0m)



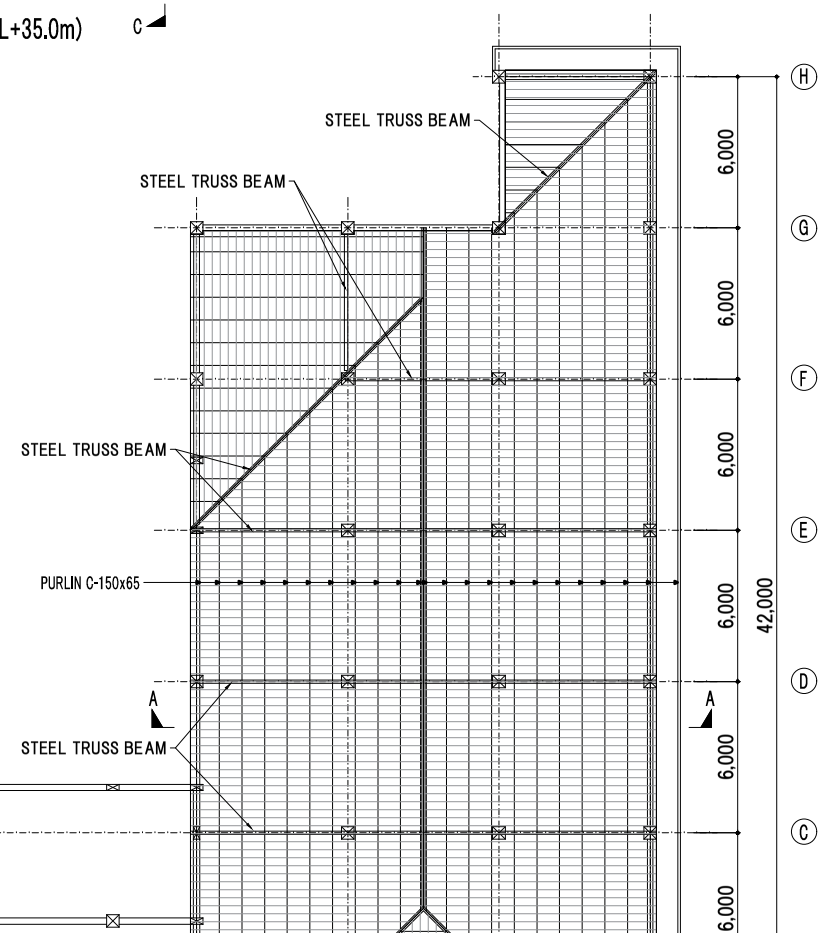
KEY-PLAN



ROOF-C (GFL+31.0m)

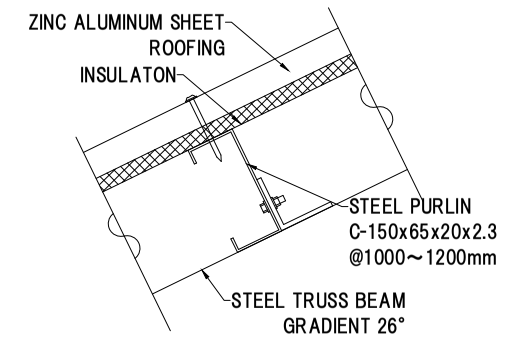


SECTION A-A



ROOF-A (GFL+27.0m)

ROOF-B (GFL+27.0m)



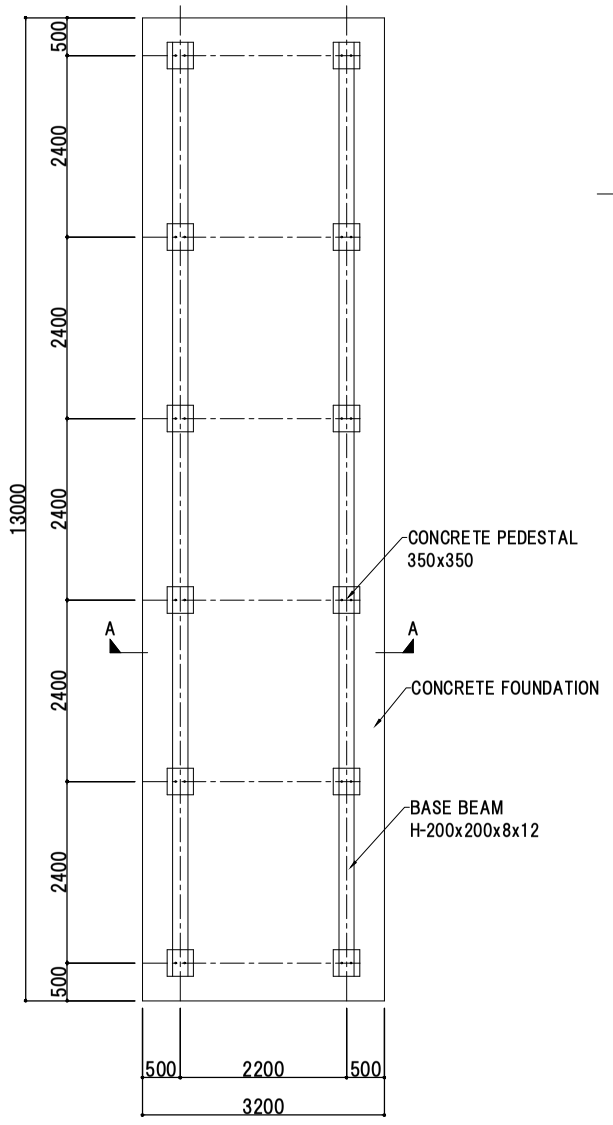
TYPICAL DETAIL OF PURLIN

NOTE:

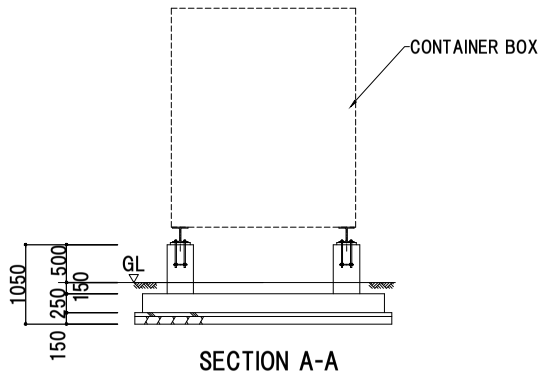
⊠ SHOWS CONCRETE COLUMN

DWG No. KF-3

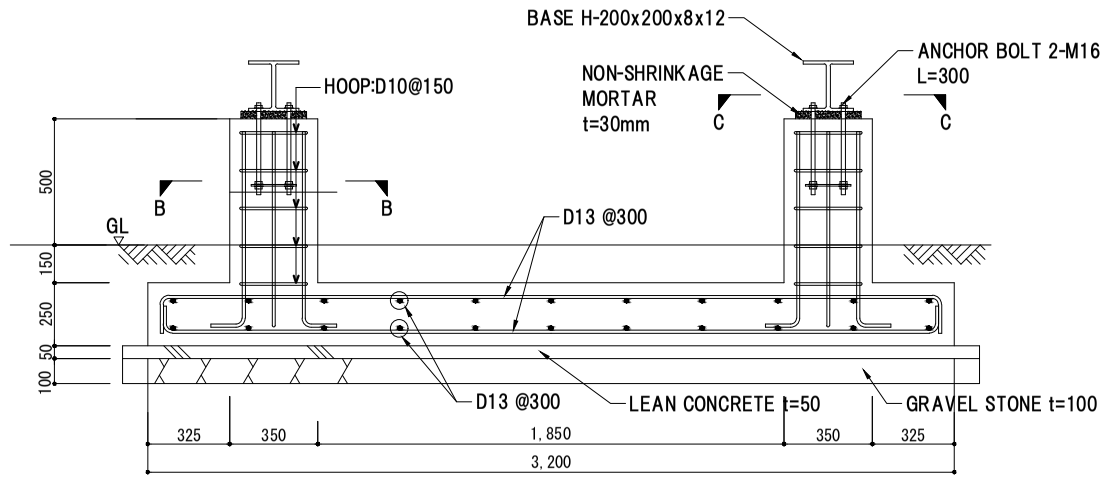
KURUNEGALA HOSPITAL/ MATERNITY BUILDING
EXISTING STEEL ROOFING PLAN

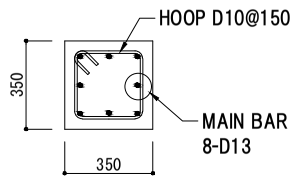


CONTAINER FOUNDATION

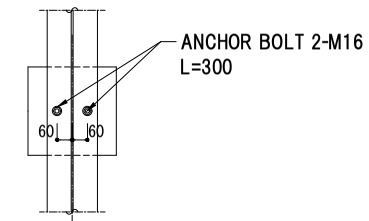


SECTION A-A





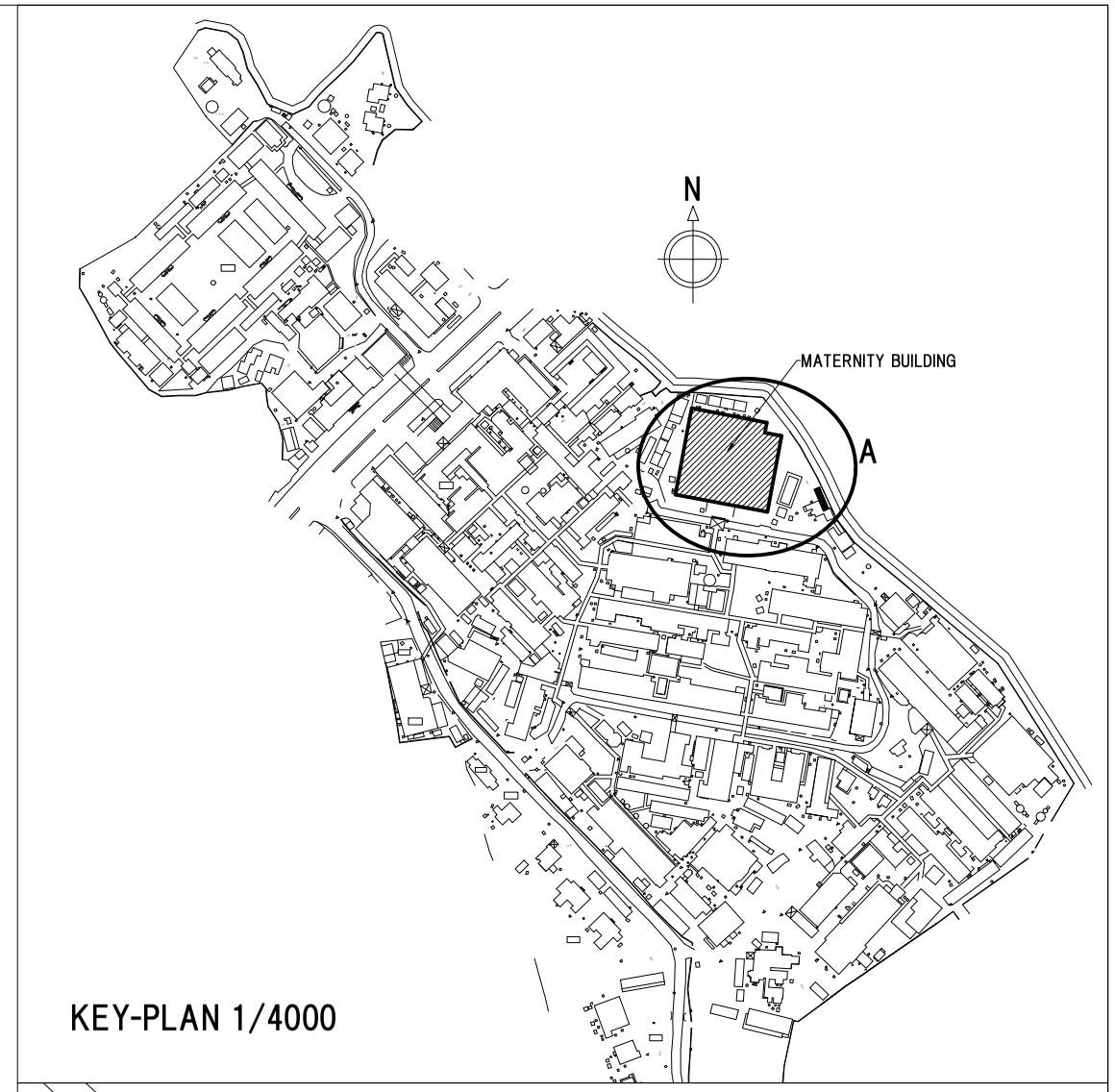
SECTION B-B



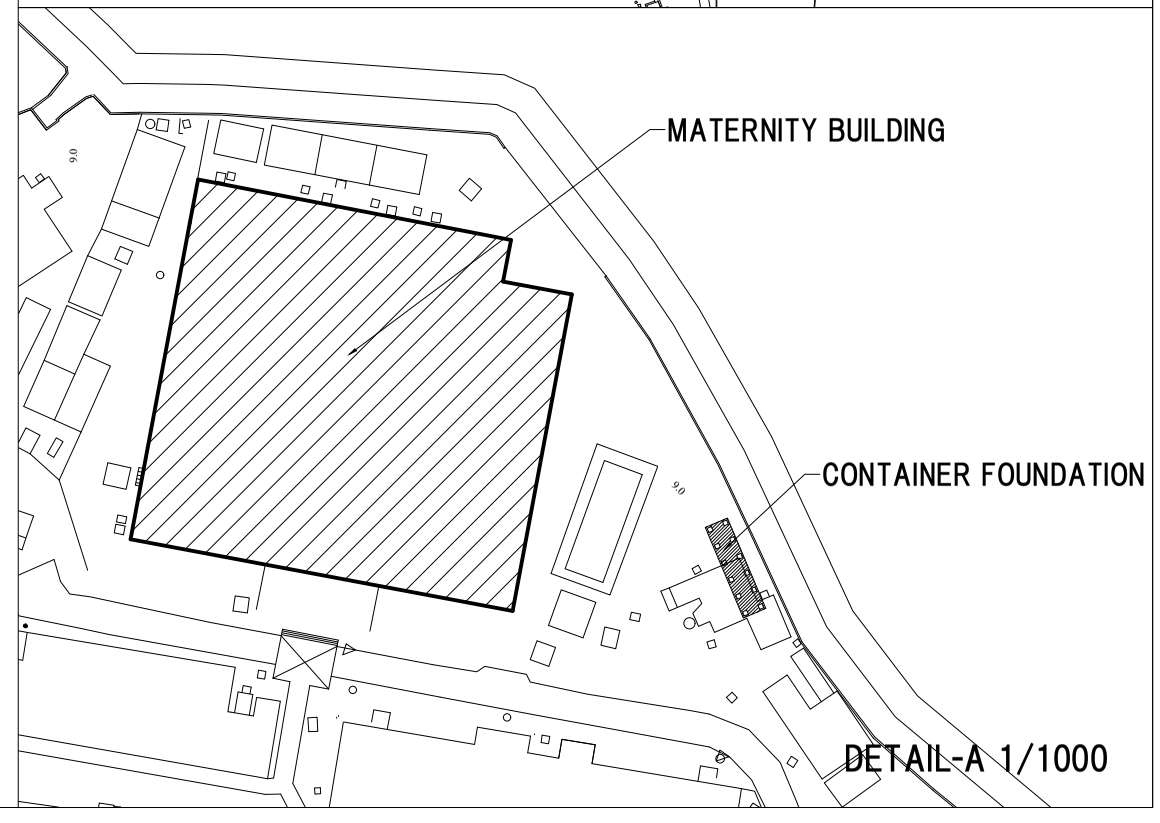
SECTION C-C

NOTES:

(1) FOUNDATION CONCRETE Fc28=21N/mm2
(2) LEAN CONCRETE Fc=18N/mm2
(3) REINFORCING BARS: SD295A /SD345 OR EQUIVALENT
(4) BASE STEEL : SS400 or EQUIVALENT
(5) ANCHOR BOLT: SR 235 OR EQUIVALENT



KEY-PLAN 1/4000

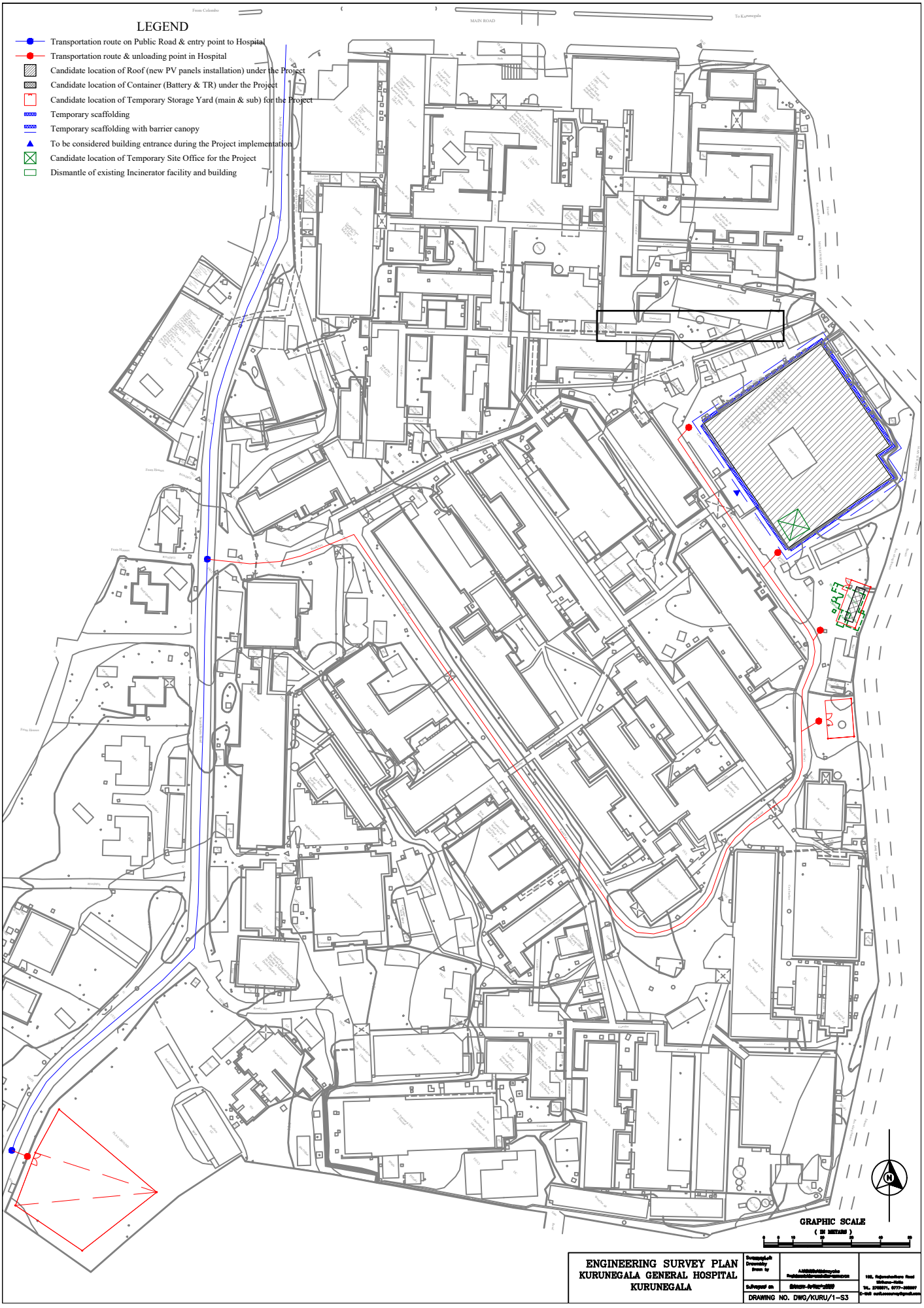


DETAIL-A 1/1000

DWG No. KF-4

KURUNEGALA / CONTAINER FOUNDATION

KF-5 Temporary facilities plan



7. Photos of present conditions of buildings

Photographs of the current condition of the survey site（1/4）



Sri Jayawardenapura General Hospital (Building B)
Condition of roof tiles on Building B. The roof tiles are cracked and peeling off due to age-related deterioration.



Sri Jayawardenapura General Hospital (Building B)
Condition of top floor beams and columns in Building B. No cracks or damage to concrete, no repairs or renovations required.



Sri Jayawardenapura General Hospital (Building B)
Shed condition in Building B. Concrete bundle posts are not cracked or damaged and do not require repair or renovation.



Sri Jayawardenapura General Hospital (Building B)
There was no rust on the steel members that served as the main building and no restoration or renovation was required. The slate was in good condition.



Ratnapura Teaching Hospital (JICA building)
Perimeter conditions. Installation of a large crane would be difficult. The structure is in good condition with no cracks.



Ratnapura Teaching Hospital (JICA building)
Condition of the top floor frame. The building is in good condition with no cracks, although there are some age-related stains.

Photographs of the current condition of the survey site（2/4）



Ratnapura Teaching Hospital (JICA building)
Condition of the frame at the back of the shed. No cracks and in good condition.



Ratnapura Teaching Hospital (A&E Building)
External frame condition. No cracks and in good condition.



Ratnapura Teaching Hospital (A&E Building)
Condition of the concrete post at the back of the shed. No cracks and in good condition.



Ratnapura Teaching Hospital (A&E Building)
Steel frame condition of the beams at the back of the shed. They are in good condition with no rust.



Ratnapura Teaching Hospital (A&E Building)
Existing metal folded plate roof condition. It has not been maintained and has rusted screws. Needs high-pressure cleaning and painting.

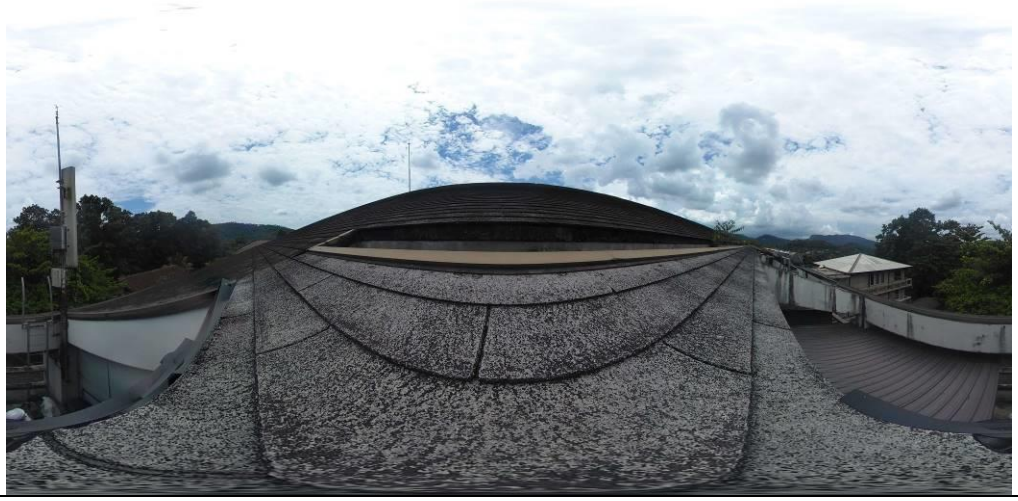


Ratnapura Teaching Hospital (Blood Bank Building)
External frame condition. No cracks and in good condition.

Photographs of the current condition of the survey site（3/4）

	
Ratnapura Teaching Hospital (Blood Bank Building) Bottom concrete condition of the water storage tank installed on the roof. No cracks were found and it was confirmed to be in good condition.	**Ratnapura Teaching Hospital (Blood Bank Building)** It is not maintained and needs to be pressure washed and painted. Solar panels will be installed avoiding the water storage tank.
	
Kurunegala Teaching Hospital (Maternity Ward) External frame condition. No cracks and in good condition.	**Kurunegala Teaching Hospital (Maternity Ward)** Status of main roof assembly at the back of the shed. Good condition was confirmed.
	
Kurunegala Teaching Hospital (Maternity Ward) The building is in good condition with no cracks in the post-and-beam frame and walls.	**Kurunegala Teaching Hospital (Maternity Ward)** The roof is in good condition and does not require painting. A frame will be installed on the existing roof and solar panels will be installed.

Photographs of the current condition of the survey site（4/4）



Ratnapura Teaching Hospital (360-degree camera)

Existing roof condition of the JICA Building. Areas not directly visible were confirmed with a 360-degree camera attached to a rod.



Ratnapura Teaching Hospital (360-degree camera)

Shed condition of the JICA Building. No deterioration damage or abnormalities were observed. The condition of the building frame was also good.



Ratnapura Teaching Hospital (360-degree camera)

A&E Building shed conditions. There were no leaks and no rust was observed on the main building steel frame.

8. Result of Schmidt Hammer Test

The compressive strength of the existing concrete on the roof and behind the shed for the solar panel installation was measured at Sri Jayawardhanapura General Hospital and TH Kurunegala using a Schmidt hammer. The following are the results of the testing.

The strength of the JICA Building at TH Ratnapura, where the same test was not conducted, was confirmed from the drawings in consideration of the effects of noise and vibration on hospitalized patients. The strength of the A&E Building and Blood Bank Building was confirmed from the drawings because the main frame of the structural shed frame is made of steel.

Table 8.1 Results of Compressive Strength Evaluation by Schmidt Hammer

1958 "Guidelines for Methods of Determining Compressive Strength of Concrete Implemented by Schmidt Hammer (Draft)".

Measurement Building Name		Sri Jayawardenapura Hospital Building B		Sri Jayawardenapura Hospital Building A (for reference)	Kurunegala Teaching Hospital Maternity Ward	Kurunegala Teaching Hospital Observation ward (For reference)
Measurement Area		Rooftop Bundle Columns	Bundle columns in the back of the shed	Bundle columns in the back of the shed	Top edge of bundle columns	Girder
Date of Measurement		27 April, 2023	27 April, 2023	18 April, 2023	26 April, 2023	26 April, 2023
Direction of Impact		0°	0°	-90°	-90°	0°
Rebound hardness	No.1	56	55	51	45	40
	No.2	56	46	40	42	40
	No.3	55	36	39	42	38
	No.4	58	41	44	42	39
	No.5	54	54	38	42	42
	No.6	54	54	34	42	46
	No.7	57	55	38	42	40
	No.8	61	51	28	47	44
	No.9	47	54	30	46	38
	No.10	45	45	39	47	36
	No.11	54	53	32	47	38
	No.12	58	52	33	46	34
	No.13	54	54	30	45	33
	No.14	53	52	40	41	42
	No.15	57	55	36	42	42
	No.16	55	46	28 *	42	44
	No.17	59	53	44	47	44
	No.18	50	48	30	44	42
	No.19	48	53	41	47	42
	No.20	55	46	45 *	46	40
	No.21		54		43	40
	No.22				39	41
	No.23				39	40
	No.24				46	43
	No.25				44	40
Average of measured values		54.30	50.33	37.00	43.80	40.32
Average of measured values ±20%		65.16 43.44	60.40 40.27	44.40 29.60	52.56 35.04	48.38 32.26
Total Adopted Value		1086	1057	667	1095	1008
Number of adopted values		20	21	18	25	25
Average of adopted values	R0	54.30	50.33	37.06	43.80	40.32
Moisture content correction (indentation black)	R1	2	0	0	2	0
strike direction correction factor	R2	0	0	3.1	2.7	0
Apparent Compressive Strength (The Society of Materials Science formula)	Fc	547.90	470.33	338.02	446.50	340.16
Apparent Compressive Strength (Architectural Institute of Japan formula)	Fc	510.99	467.43	393.14	454.05	394.34
Lumber Order Correction (1000 days or more)	α	0.60	0.60	0.60	0.60	0.60
Estimated Compressive Strength (The Society of Materials Science formula)	F	328.74 kg/cm2 32.2 N/mm2	282.20 kg/cm2 27.7 N/mm2	202.81 kg/cm2 19.9 N/mm2	267.90 kg/cm2 26.3 N/mm2	204.10 kg/cm2 20.0 N/mm2
Estimated Compressive Strength (Architectural Institute of Japan formula)	F	306.59 kg/cm2 30.0 N/mm2	280.46 kg/cm2 27.5 N/mm2	235.88 kg/cm2 23.1 N/mm2	272.43 kg/cm2 26.7 N/mm2	236.60 kg/cm2 23.2 N/mm2

Note: The following equation is used to calculate the estimated strength.

1) Estimated Compressive Strength F=α*Fc — F: Estimated final strength after adjusting for lumber age

2) Apparent compressive strength Fc＝13R-184(The Society of Materials Science formula — α: Lumber Order Correction Value

Fc＝7.3R＋100(Architectural Institute of Japan formula — Fc: Apparent compressive strength

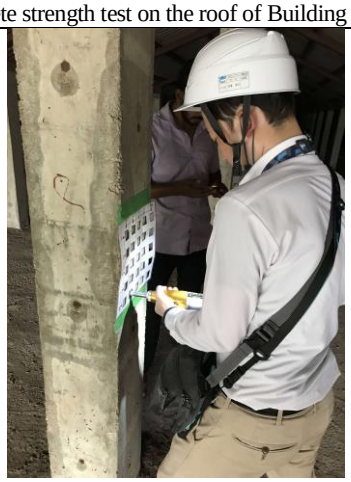
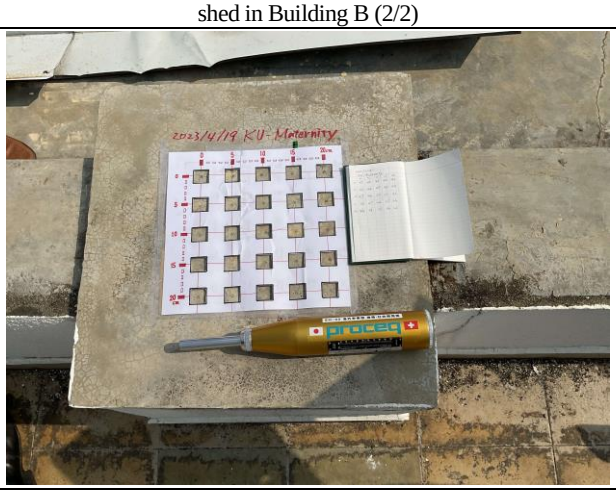
3) Standard Strength R=R0+(R1+R2) — R0 ＝ Schmidt hammer resilience (R-value)

SI unit conversion kg/cm2 x 0.098 = N/mm2 — R1 ＝ Correction value for moisture content

R2 ＝ Correction value for strike angle

Those marked with an asterisk (*) in the table indicate rejected data (those exceeding the mean ±20% of the adopted value).

Photograph of existing concrete strength test (Schmidt hammer test) status

	
Sri Jayawardenapura General Hospital Concrete strength test on the roof of Building B (1/2)	**Sri Jayawardenapura General Hospital** Concrete strength test on the rooftop of Building B (2/2)
	
Sri Jayawardenapura General Hospital Concrete strength test of the bundle columns at the back of the shed in Building B (1/2)	**Sri Jayawardenapura General Hospital** Concrete strength test of the bundle columns at the back of the shed in Building B (2/2)
	
TH Kurunegala Concrete strength test on the rooftop of the maternity ward (1/2)	**TH Kurunegala** Concrete strength test on the rooftop of the maternity ward (2/2)

9. Result of JICA Climate-FIT-Mitigation

15. Renewable Energy / Solar, Wind and Others

Project Name

Project for Strengthening Electricity Resilience in Hospitals Using Renewable Energy

Country

The Democratic Socialist Republic of Sri Lanka

Emission Reduction

		Value	Unit
ER_y	Emission reduction	820	tCO_2/year
BE_y	Baseline emission	820	tCO_2/year
PE_y	Project emission	0	tCO_2/year

Inputs

1) Electricity generation projects (Grid connected system or standalone or mini-grid syst *Input only orange cell

Parameter	Description		Value	Unit
-	The project is a development of geothermal power plant		No	
-	The project is a development of hydro power plant and CH_4 emission from reservoirs of hydro power plants is		No	
EG_y	Total electricity produced by the project activity in year y		1,269	MWh/year
EF_{elec}	CO_2 emission factor of the electricity		0.646	tCO_2/MWh
EF_{res}	Default emission factor for emissions from reservoirs of hydro power plants		0	$kgCO_{2\text{-}eq}$/MWh
$w_{Main,CO2}$	Average mass fraction of carbon dioxide in the produced steam			tCO_2/t
$w_{Main,CH4}$	Average mass fraction of methane in the produced steam			tCH_4/t
GWP_{CH4}	Global warming potential of methane			tCO_2/tCH_4
$M_{S,y}$	Quantity of steam produced in year y			t/year
$FC_{i,y}$	Consumption of fossil fuel i at the power plant in year y			t/year
NCV_i	Net calorific value of the fossil fuel i			TJ/Gg
$EF_{fuel,i}$	CO_2 emission factor of the fossil fuel i			$kgCO_2$/TJ

2) Solar water system *Input only orange cell

Parameter	Description		Value	Unit
-	The project is installation of solar water systems		No	
$EF_{fuel,i}$	CO_2 emission factor of the fossil fuel i			$kgCO_2$/TJ
ε_{BL}	Efficiency of baseline heating system			-
F_y	Amount of hot water supplied by the solar water heating system in year y			m^3
ΔT	Temperature rise of water (or hear carrier) by the solar water heating system			K
C	Specific heat of water (or hear carrier)			GJ/t.K
ρ	Density of water (or heat carrier)			t/m^3

15. Renewable Energy / Solar, Wind and Others

Project Name

Project for Strengthening Electricity Resilience in Hospitals Using Renewable Energy

Country

The Democratic Socialist Republic of Sri Lanka

Calculations

			Value	Unit
Emission reduction			820	tCO_2/year
Baseline emission			820	tCO_2/year
Baseline emission (Electricity generation projects (Grid connected system or standalone or mini-grid system))			820	tCO_2/year
	Total electricity produced by the project activity in year y		1269.4	MWh/year
	CO2 emission factor of the electricity		0.646	tCO_2/MWh
Baseline emission (Solar water system)			0	tCO_2/year
	0		0	$kgCO_2$/TJ
	Efficiency of baseline heating system		0	-
	Amount of hot water supplied by the solar water heating system in year y		0	m^3
	Temperature rise of water (or hear carrier) by the solar water heating system		0	K
	Specific heat of water (or hear carrier)		0	GJ/t.K
	Density of water (or heat carrier)		0	t/m^3
Project emission			0	tCO_2/year
	Default emission factor for emissions from reservoirs of hydro power plants		0	$kgCO_2$-eq/MWh
	Average mass fraction of carbon dioxide in the produced steam		0	tCO_2/t
	Average mass fraction of methane in the produced steam		0	tCH_4/t
	Global warming potential of methane		0	tCO_2/tCH_4
	Quantity of steam produced in year y		0	t/year
	Consumption of fossil fuel i at the power plant in year y		0	t/year
	Net calorific value of the fossil fuel i		0	TJ/Gg
	CO_2 emission factor of the fossil fuel i		0	$kgCO_2$/TJ

10. Presentation regarding the analysis on the addition of Battery System

Confidential

PREPARATORY SURVEY REPORT
on
the Project for
Strengthening Electricity Resilience in Hospitals Using Renewable Energy

Analysis on the addition of Battery System

AUGUST 2023
JICA SURVEY TEAM

© YACHIYO Engineering Co., Ltd.

八千代エンジニヤリング株式会社

REASON FOR EXCLUDING BATTERIES FROM THE SCOPE

The installation of **battery energy storage system** is determined to be **excluded** from the scope due to following reasons:

(1) Improvement of power supply situation from Ceylon Electricity Board (CEB) to each hospitals

Table Annual operating hours of emergency diesel generator

Year	SJGH	TH Ratnapura	TH Kurunegala
2018	49:41	-	-
2019	37:16	-	32:00
2020	37:16	45:17	84:00
2021	37:16	55:10	56:00
2022	49:42	35:25	27:00
2023	24:30	31:09	0:21

(Jan-Apr)x3 times

(2) Availability of Uninterruptible Power Supply (UPS)
Important medical treatment facilities which directly affect lives such as operation rooms, ICU, etc. are equipped with UPS (BESS).

(3) Requirements of backup power supply system
Due to the requirements of “Electrical safety guidelines for hospitals”, solar and battery system cannot supply power to important medical facilities such as ICU, Operation theatre, etc.

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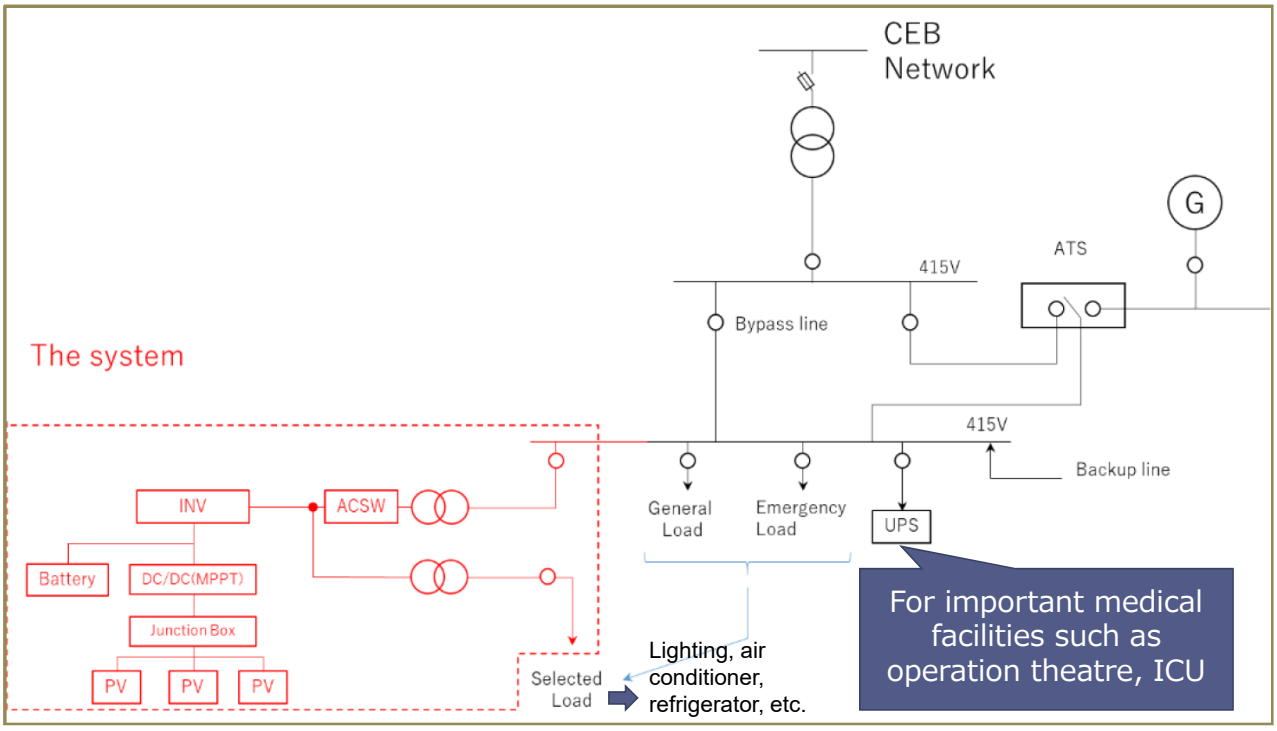
Medical locations and requirements of backup power supply

Classification	Medical Locations	Backup Power Supply
Group 0: Emergency care and diagnostics	Massage room	Allowable interruption **From 0.5 to 15 seconds**
Group 1: Patients in special medical locations	Bedrooms, Delivery room ECG, EEG, EHG room Endoscopic room, Examination or treatment room Urology room Radiological diagnostic and therapy room Hydrotherapy room, Physiotherapy room Haemodialysis room Magnetic resonance imaging (MRI) room Nuclear medicine	Allowable interruption **From 0.5 to 15 seconds**
Group 2: Life support or complex surgery	Anaesthetic room Operating theatre Operating preparation room Operating plaster room Operating recovery room Heart catheterization room Intensive care room Angiographic examination room Premature Baby Room	Allowable interruption **Less than 0.5 seconds** UPS (uninterruptible power supply) system needs to be equipped Solar and battery system cannot meet this requirement

Source: Public utilities commission of Sri Lanka, "Electrical safety guidelines for hospitals"

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Power supply system for hospital with solar and battery



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Power interruption records in Sri Lanka

Indicator	Area	2017	2018	2019	2020	2021
SAIDI (System Average Interruption Duration Index) Hours/Customer/Year	DD-1 Colombo Kurunegala	66h13m/y (5.52h/mo) (10.9m/d)	75h32m/y (6.29h/mo) (12.4m/d)	99h25m/y (8.28h/mo) (16.3m/d)	78h25m/y (6.53h/mo) (12.9m/d)	53h35m/y (4.47h/mo) (8.8m/d)
	DD-3 Ratnapra	79h06m/y (6.59h/mo) (13.0m/d)	81h25m/y (6.78h/mo) (13.4m/d)	108h23m/y (9.03h/mo) (17.8m/d)	78h31m/y (6.54h/mo) (12.9m/d)	84h01m/y (7.00h/mo) (13.8m/d)
SAIFI (System Average Interruption Frequency Index) Numbers/Customer/Year	DD-1 Colombo Kurunegala	16.5/y (1.4/mo)	15.1 (1.3/mo)	109 (9.1/mo)	25.9 (2.2/mo)	17 (1.4/mo)
	DD-3 Ratnapra	49.1 (4.1/mo)	56.8 (4.7/mo)	69 (5.8/mo)	44.5 (3.7/mo)	48.6 (4.1/mo)
Hydro power generation (GWh/year)		3,061	5,172	3,784	3,911	5,640

Source: Ceylon Electricity Board, Annual report 2017-2021

Even in a dry year like 2019, average power interruption is 16 to 18 minutes per day or 8 to 9 hours per month. Since hospitals have exclusive distribution feeders, power supply reliability is higher than ordinary customers.

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COST BENEFIT ANALYSIS ON THE ADDITION OF BATTERIES (1)

The following is the estimation of batteries with a capacity of 3 hours of electricity supply during power outage for selected loads.

Site	Selected Load [kW]	Battery Capacity [kWh]	Battery Cost [USD]
SJGH	140	540	**$369,863**
TH Ratnapura	65	360	**$246,575**
TH Kurunegala	75	360	**$246,575**
		TOTAL	**$863,013**

Cost of adding batteries

In order to allocate the budget of batteries within the same project budget, the capacity of Solar (PV) panels needs to be reduced.
The following is a comparison of the Solar capacity [kW] with and without batteries.

Site	Capacity of Solar panels (Current Plan) [kW]	Capacity of Solar panels to be reduced [kW]	Capacity of Solar panels (with Batteries) [kW]
SJGH	443	-73	**370**
TH Ratnapura			
- JICA Building	184	-19	**165**
- Blood Bank Building	37	-37	**0**
- A&E Building	30	-30	**0**
TH Kurunegala	240	-25	**215**
Total	**934**	**-184**	**750**

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COST BENEFIT ANALYSIS ON THE ADDITION OF BATTERIES (2)

Comparison of effects with/without batteries - 1

Site	Power Generation by Solar panels [MWH/year]			Saved electricity bills for CEB [Thousand SLR/year]		
	Without Batteries (Current Plan) [A]	With Batteries [B]	[B-A]	Without Batteries (Current Plan) [A]	With Batteries [B]	[B-A]
SJGH	604.7	505.1	-99.6	10,401	8,687	-1,714
TH Ratnapura						
- JICA Building	254.2	228.0	-26.2	4,395	3,941	-454
- Blood Bank Building	43.5	0	-43.5	884	0	-884
- A&E Building	50.9	0	-50.9	717	0	717
TH Kurunegala	316.1	283.2	-32.9	5437	4,871	-566
TOTAL	**1,269.4**	**1,016.3**	**-253.1**	**21,834 ($67,100)**	**17,499 ($53,780)**	**-4,335 (-$13,320)**

* 1SLR = $325.4

"With Batteries" can save the electricity bills of 17,499 thousand SLR, although the electricity bill savings are smaller than "without batteries (Current Plan)" by 4,335 thousand SLR.

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COST BENEFIT ANALYSIS ON THE ADDITION OF BATTERIES (3)

Comparison of effects with/without batteries - 2

Conditions for estimating diesel fuel reduction:

a. Annual Power Outage Hours

Case 1: 30 hours / year

Case 2: 60 hours / year

(Assumed from the SAIDI of the CEB and the generator operating hours of each hospital.)

b. Selected Load for battery power supply

140 kW (SJGJ) + 65 kW (THR) + 75 kW (THK) = 280 kW

c. Unit cost of diesel oil

1.37 USD / L

Expected fuel savings

Case1: **1,964 USD / year**

Case2: **3,928 USD / year**

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COST BENEFIT ANALYSIS ON THE ADDITION OF BATTERIES (4)

Evaluation of installation of batteries in the project

"With batteries" case

Pros.

1. Capable of supplying power from the batteries to the selected loads during a power outage.
2. Possible to reduce the fuel consumption of diesel generators during a power outage
3. Less environmental impact with less use of diesel fuel

Cons.

1. The electricity demand of the hospitals is far greater than the amount of electricity generated by the Solar power system, so there is no electricity surplus to be stored in batteries.
2. The annual power outage hours are limited, so power supplied from the batteries is not much, and the diesel fuel reduction effect is also small.
3. Batteries need to be replaced every 10 years, so it is necessary to secure the **budget for the replacement ($863,013)**. This is more expensive than the benefits from saved electricity bills and reduced diesel fuel.

(1) Saving of electricity bills:
$53,780 x 10 years = **$537,800**
(2) Fuel savings (For diesel generators):
$3,928/year (Case 2) x 10 years = **$39,280**
Battery replacement
(3) Savings over 10 years (1)+(2): $577,080 (< $863,013)

"Without batteries" case can save $13,320 more electricity bills per year with larger capacity of Solar panels and avoid battery replacement cost of $863,013 after 10years

[Conclusion]
Installation of batteries is not recommended.

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CEB's Long Term Generation Expansion Plan 2023-2042

1. Achieve 70% of electricity generation in the country using renewable energy (RE) sources by 2030
2. Achieve carbon neutrality in power generation by 2050
3. Cease building of new coal-fired power plants
4. New addition of firm capacity will be from clean energy sources such as re-gasified liquefied natural gas (RLNG)

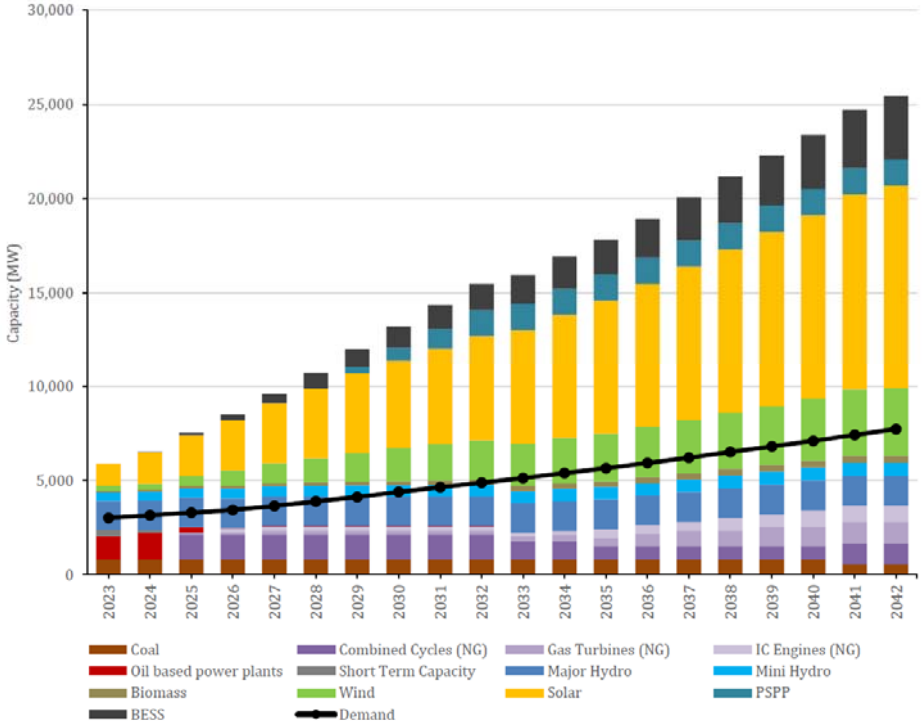
To achieve the policy targets, a significant level of RE capacity additions (especially wind and solar PV) is proposed in this plan throughout the planning horizon with 5,646 MW of Other Renewable Energy capacity additions envisaged during 2023-2030 period and 8,180 MW during 2031-2042 period.

With this accelerated development of RE capacities, this plan proposes timely implementation of enabling grid support technologies and measures such as Utility Scale Battery Energy Storage Systems (BESS), Pumped Storage Power Plants (PSPP) and Renewable Energy Desk at National System Control Center. These measures are imperative to maintain a secure, reliable, economical, and sustainable power system.

Long Term Generation Expansion Plan 2023-2042 was Submitted to Public Utilities Commission of Sri Lanka for approval on 14th September 2022 and PUCSL approval granted on 10th February 2023.

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CEB's Long Term Generation Expansion Plan 2023-2042
Cumulative Capacity by Plant Type in Base Case



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