4-4 Architecture

4-4-1 Plan and Elevation Designs

The buildings are designed as described below.

(1) Short-Circuit Generator Building

The building accommodates the short-circuit generator. It has a hall 3 stories high and a low wing. The low wing contains the control room and other facilities.

(2) Short-Circuit Testing Building

This building has 3 rooms for the short-circuit test and one room for preparation and maintenance works. The height of the building corresponds to 2 storied office building.

(3) Administration Building (Containing Short-Circuit Testing Measurement and Control Room)

The administration office building will be designed to accommodate 20 personnel plus a few secretary/typists and guardmen.

In order to make efficient use of the premise, the building will be 2 storied. The short-circuit test measurement and control room will be accommodated on the ground floor. The exhibition room for presenting description of this laboratory and the reception room will be provided adjacent to the entrance hall. The storage room and the machine room will also be on the ground floor. The 1st floor will contain the chief's room, assistant chief's room, research staff's room, clerical office, conference room, stack room etc.

The floor space of each room is given below. Minor modifications are expected in the detailed design stage if necessary.

Room	Floor Area (m^2)	Accommodation (man)	Note (m^2/man)
Chief's room	39	2	19.5
Assistant Chief's room	39	2	19.5
Research staff's room	78	8	9.8
Short-circuit testing control room	117	4	-
Clerical office room	59	7	8.4
Conference room	78	(20)	(3.9)
Guest waiting room	39	-	-
Reception cum information room and watchman's room	42	3	-
Stack room	29	-	-
Storage room	39	-	-
Exhibition hall	39	-	-
Entrance hall	39	-	-
Rest room	55	-	-
Machine room	59	-	-
Corridors	166	-	-
Total	917	26	-

(4) Fog Testing Building

This building consists of a hall 3 stories high to contain the fog generating facility, a 2 storied wing and one storied wing.

The measurement and control room and other facilities are accommodated in the 1st floor of 2-storied wing.

The fog room and the measurement and control room of this building must shut off the electromagnetic interference and radio noise coming from or going outside during the test, and thus must be provided with electromagnetic shields.

4-4-2 Structural Design

The Islamabad Building Regulations, established in 1963 by Capital Development Authority (CDA), are based on the former BS. construction design standards, and recently, US standards have been partially adopted as construction standards. Although this site for construction of the laboratory is outside the capital city planning zone, US Building Code Requirements for Reinforced Concrete (ACI-318-82) or Japanese standard will be used as the construction design standard.

(1) Seismic Force

According to the seismic risk map produced by Dr. Hattori of the Architecture Research Institute of Japanese Ministry of Construction, the maximum acceleration in an earthquake which occurs in this project site at a frequency of once in 50 years is expected to be 20 to 50 gals.

Based on this estimate, the design seismic force can be calculated as below.

$$C_b = (20 \sim 50) \times 2.5/980 = 0.05 \sim 0.13$$

where C_b is the design base shear coefficient.

(2) Ground Condition and Soil Bearing Strength

According to the boring data obtained at 3 locations in the land planned for construction of 500 kV substation by WAPDA, which are approximately 500 meters away from the site of this laboratory, the upper layer (down to 2.0 -- 5.6 m from surface) of the laboratory premise is clay, and the N value is more than 40 at a depth of 1.5 m. The lower layer (more than 2.0 -- 5.6 m below surface) is shale, having N value of more than 60. The water level in bore hall is from 4.9 m to 12.8 m, being estimated to change in a wide range by season and location. The soil bearing strength of the upper layer is expected to be more than 10 tons/m^2. However, the soil under the foundation must be protected from the effect of the waste water and other water, as the soil water content is susceptible to changes.

The soil bearing strength of more than 20 tons/m^2 can be expected for the lower layer approximately 5.0 meters below surface.

(3) Structure Material and Type

The reinforcing bars and steel frames shall be procured in Japan, for economy and other reasons.

The concrete aggregate and cement shall be procured in Pakistan.

The building structures shall be reinforced concrete structure, which is commonly used in Pakistan. This selection is also based on the consideration of economy. The short-circuit generator building and the roof of the fog testing building shall be steel frames due to the following reasons.

(a) Short-circuit Generator Building

(i) A 15 ton overhead traveling crane shall be installed on a building having 12 meter span and 11 meter height. It is rather difficult to adopt a reinforced concrete structure.

(ii) As the construction of this building forms the critical path of the Project's construction work, it is better to use the steel structure whose construction period is short.

(b) Fog Testing Building Roof

The roof must support a hung load of 4 tons with 10 meter span at a height 15 meters from ground surface. For this condition, the shoring supporting the concrete form in construction will become enormous if the reinforced concrete structure is used, and the steel structure is more economical.

4-4-3 Facility Plans

(1) Electrical Facility Plans

(a) Incoming power line

WAPDA will provide two coming 11 kV power cable to its 8 panelboards consisting of 5 outgoing with 2 incoming and one bus coupler. This all shall be located in the short-circuit generator building at the location to be indicated by the Japan side.

(b) Main feeder connection

The power shall be supplied by underground cables to the distribution board of each building from the low voltage switchboard. The electrical system shall be 3 phase 3 wire 400 V and 3 phase 4 wire 400/230 V.

(c) Electric outlet

Wiring and piping shall be provided from each distribution board to lighting equipment and wiring equipment. The voltage of the lighting equipment and wiring equipment shall be 230 V. The lighting equipment and the average illuminance of outstanding rooms are shown below.

Room	Lighting Equipment	Average Illuminance
Office room	fluorescent lamp	400 Lux
Control room	fluorescent lamp	800 Lux
Guest Waiting room, general machine room	fluorescent lamp	200 Lux
Hall, corridor, rest room	fluorescent and incancescent lamp	100 Lux
Generator room, laboratories	mercury lamp projector	150 Lux

Special illumination will be used in some part of the rooms below.

Exhibition hall	spot light
Fog laboratory	moisture protection shielded light

(d) Telephone facility

A MDF and telephone exchange system shall be installed in the administration office building, capable of handling around 30 extension handsets.

The wiring from the exchange to each building shall be provided by means of underground cables. The installation of the public line cable to the MDF shall be born by the Pakistan party.

(e) Public address system

A main amplifier shall be installed in the administration office building. The paging speakers shall be provided in the fog testing building, short-circuit testing building, and several places in the premise of the laboratory.

In the fog testing building and the short-circuit testing building, independent address systems shall be provided for sending message from the control rooms to the testing room or testing ground.

(f) Lightning rod

The roofs of buildings shall be provided with lightning rods.

(g) Electromagnetic Shield

Fog room and control room of fog testing building shall have electromagnetic shield structure. The shield shall be grounded.

(h) Special grounding work

The grounding circuit board shall be designed for each testing room, for which the grounding terminals can be connected as required. Grounding works shall be provided on each outdoor and indoor testing equipment.

(2) Water Supply, Sewerage and Sanitation Plan

(a) Water supply facility

Water shall be supplied by gravity system from the secondary water supply main valve of an elevated water tank. The piping shall be provided by HIP pipes (impact resistant vinyl chloride pipe).

(b) Sewerage and air vent systems

The sewerage piping shall be provided from each draining taps to the outdoor sewerage pipe. The water discharge system shall have

separate flow in buildings and confluence flow outside buildings. The air vent system shall be a combination of vertical and horizontal vent pipes. The piping for both sewerage and air vent systems shall be VP pipes (vinyl chloride pipes).

(c) Hot water supply system

Hot water shall be supplied by locally installed electric water heaters. The piping shall be HT pipes (heat resistant vinyl chloride pipes).

(d) Outdoor fire hydrant system

Outdoor fire hydrants shall be provided. In case of fire, the fire engine will be started for fire extinguish operation. The piping shall be SGP pipes (galvanized steel pipes).

(e) Fire extinguisher

Movable powder fire extinguishers shall be provided in the electric rooms, testing rooms and machine rooms. Small fire extinguishers shall be provided in appropriate locations.

(f) Sanitation equipment

Sanitation equipment compatible to the customs in Pakistan shall be selected, and shall be appropriately incorporated in the building designs.

(3) Air Conditioning and Ventilating System

(a) Air conditioning system

To deal with the hot summer and fairly cold winter, major rooms shall be equipped with air conditioning. Based on considerations on economy and facile maintenance, air cooled split type air conditioning units with electric heaters shall be provided.

(b) Ventilation system

The ventilation of the building shall be natural ventilation in principle. The machine rooms and rest rooms shall be provided with Type 3 ventilation. Type 1 ventilation shall be provided for fog test room so that its moisture is removed quickly after a test.

(c) Drying equipment

A drying equipment shall be provided in the fog testing building to dry the test samples.

4-4-4 Building Material Plan

Considering the meteorological condition with the highest temperature of over 40°C and the lowest of below -2°C, the material shall be selected based on considerations of durability and ease of maintenance. In principle, the locally prevailing methods and materials shall be employed.

(1) Construction

The locally prevailing construction methods shall be used in structuring. The reinforced concrete structure and bricks shall be mainly employed.

(a) Cement

Cement is produced by the State Cement Corporation. In recent years, production ability for cement has improved. Cement is being produced according to the British Standards with good quality, so cement will be procured in Pakistan.

(b) Reinforcing bars

Both deformed bars and round bare are produced in Pakistan. However, the supply is insufficient and the quality is not uniform. In addition, in this project, the construction period is limited, therefore imported steel bar will be used.

(c) Bricks

The local products shall be used, as brick laying is common practice in Pakistan and its supply is stable.

(2) Roofs

The locally common practice is the reinforced concrete roofs with waterproof treatment. This method shall be used in principle.

However, metal roofs shall be employed only on the short-circuit generator building, which has steel beams, and on the fog room in the fog testing building, due to the following reasons.

(a) The level of the roof above ground is high, and it is more economical to use the steel roof rather than reinforced concrete roof.

(b) The metal roof is lighter and the structure cost can be made lower.

(c) The metal roof presents no functional problem.

(3) Exterior Wall

The outside wall shall be generally reinforced concrete finished with plastering. some walls shall be dressed with one layer of bricks.

(4) Interior Wall

The interior finish of the exterior walls shall be plaster or paint finished. The partition walls shall be made of one layer of brick with plaster finish. The paints shall be procured in Pakistan, except for special paints.

(5) Floor

The floor shall be finished with terrazzo, or concrete slab with integral trowel finish. These are common floor materials and thus easily procured and also superior in durability.

(6) Ceiling

The concrete slab real ceiling shall be finished by paint. The suspension ceiling is provided for some particular rooms with calcium silicate board or rock wool acoustic board on light steel furrings. The heat insulator shall be provided inside suspension ceiling.

(7) Fittings

The aluminum sash shall be employed for the window and the doors imported shall be steel, to provide air tightness and high durability against frequent use. As there are sand storms in some season, the building interior must be protected from dusts. The locally manufactured wooden fittings have low precision, and there is risk of deformation because products are mainly made of solid materials. Thus metal fittings are employed in this project.

The doors imported shall be steel.

The equipment hatch of the test buildings shall be equipped with steel shutters.

4-5 Basic Design Drawing

The basic design drawing as attached herein are as follows;

Fig. 4.2 Single Line Diagram of Testing Equipment
Fig. 4.3 Plan of Short Circuit Testing Facilities
Fig. 4.4 Plan of High Voltage Testing Facilities
Fig. 4.5 Circuit Diagram for Synthetic Test
Fig. 4.6 Fog Room
Fig. 4.7 Layout Plan
Fig. 4.8 Short Circuit Generator Building
Fig. 4.9 Short Circuit Testing Building
Fig. 4.10 Administration Building (Plan)
Fig. 4.11 Administration Building (Elevation and Section)
Fig. 4.12 Fog Testing Building

Fig. 4-2 SINGLE LINE DIAGRAM OF TESTING EQUIPMENT

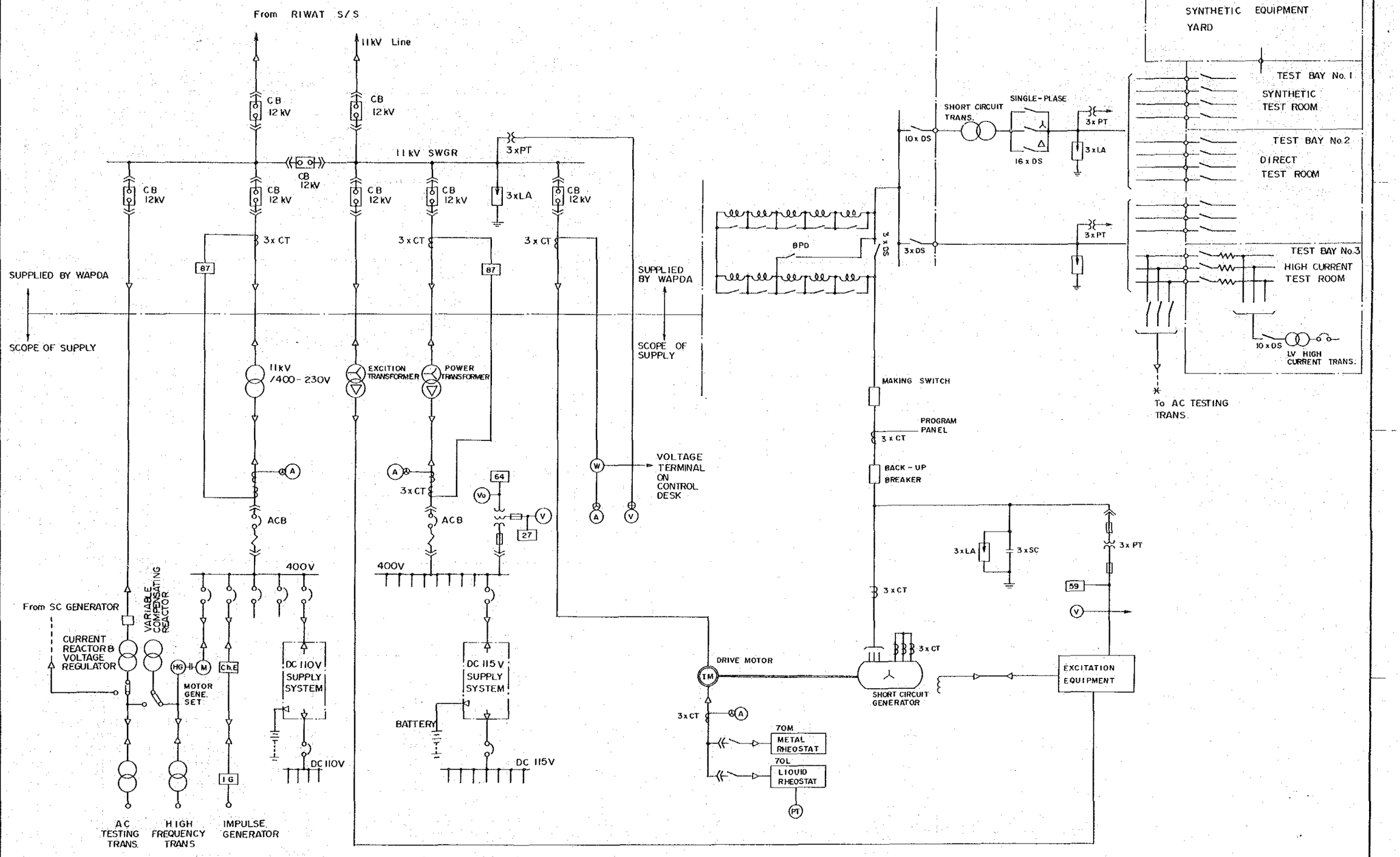
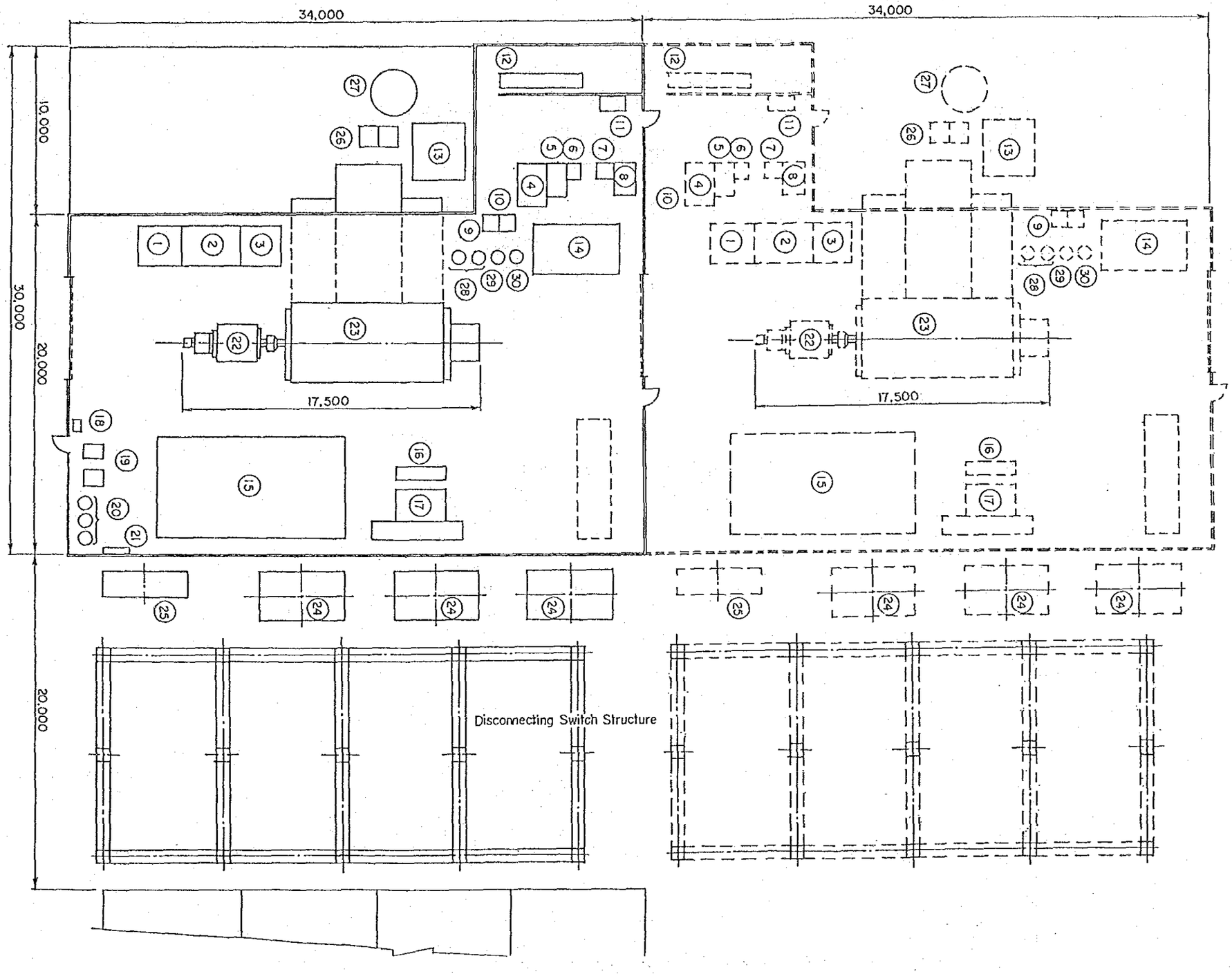
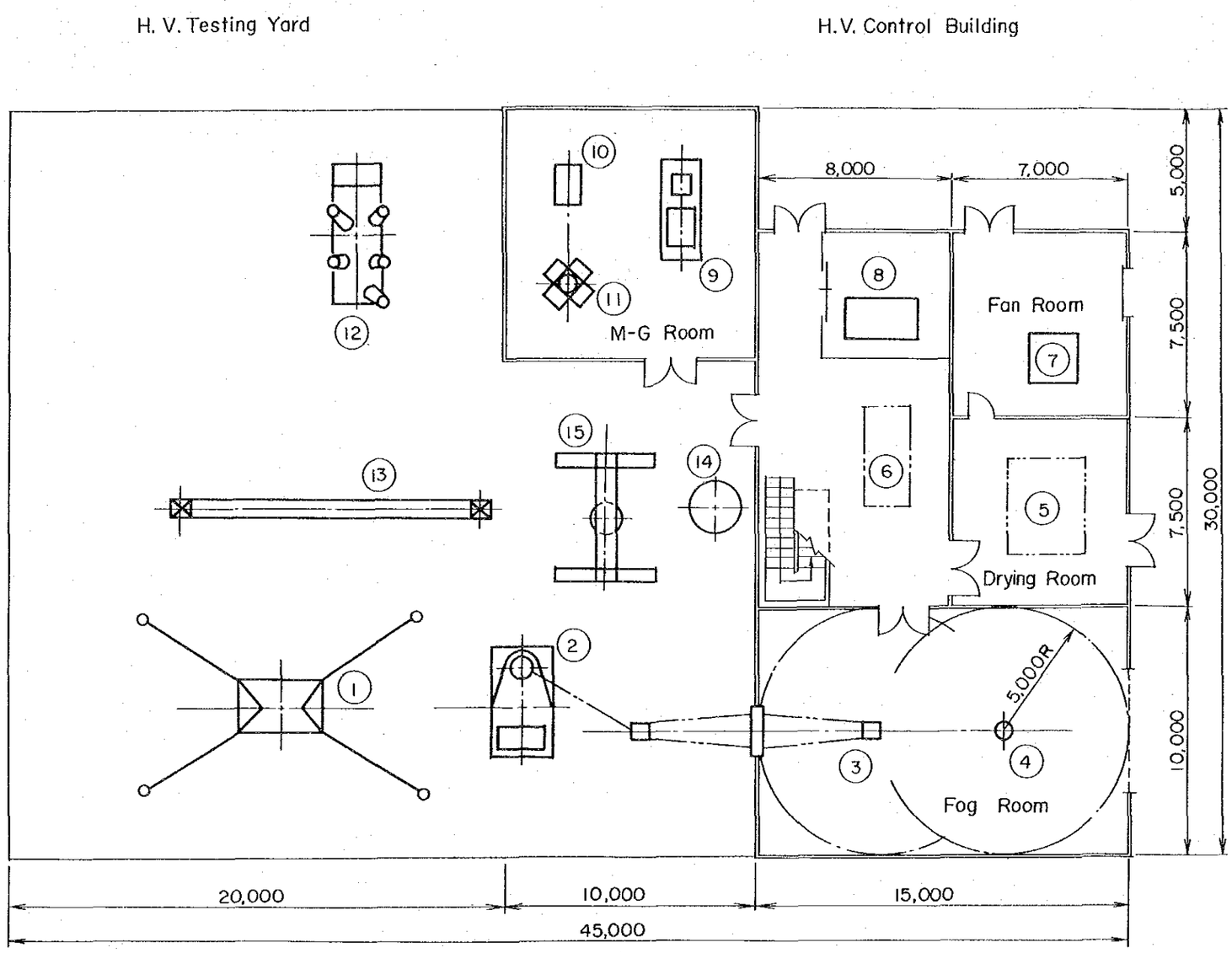


Fig. 4.3 Plan of Short Circuit Test Facilities



No	Device
1	Metal Rheostat
2	Liquid Rheostat
3	Control Panel
4	Thyristor Rectifier
5	Field Circuit Breaker
6	Excitor Cubicle
7	Generator Protection Panel
8	Generator Control Panel
9	Lub. System Local Panel (AC)
10	Lub. System Local Panel (DC)
11	Battery Charger
12	Battery
13	Excitation Transformer
14	Lubrication Oil System
15	Reactor
16	Making Switch
17	Disconnecting Switch
18	Air Comp. Control Panel
19	Air Compressor
20	Air Tank
21	Reducing Valve
22	Driving Motor
23	Short Circuit Generator
24	Short Circuit Transformer
25	L.V. Heavy Current Transformer
26	Station Transformer
27	Cooling Tower
28	Lubrication. Pump (AC)
29	Lubrication Pump (DC)
30	Jack up Oil Pump

Fig. 4.4 Plan of H.V. Testing Facilities



No	Device
15	Standard Sphere Gap
14	Water Tank
13	Gantry Tower
12	High Frequency Transformer
11	Induction Regulator
10	Compensating Reactor
9	Induction Generator
8	Boiler for Fog Test
7	Fan and Heater
6	Frame for Pre-deposit
5	Insulator Hanger
4	Insulator Strings
3	Wall Bushing
2	AC Testing Transformer
1	Impulse Voltage Generator

Fig. 4.5 Circuit Diagram for Synthetic Test

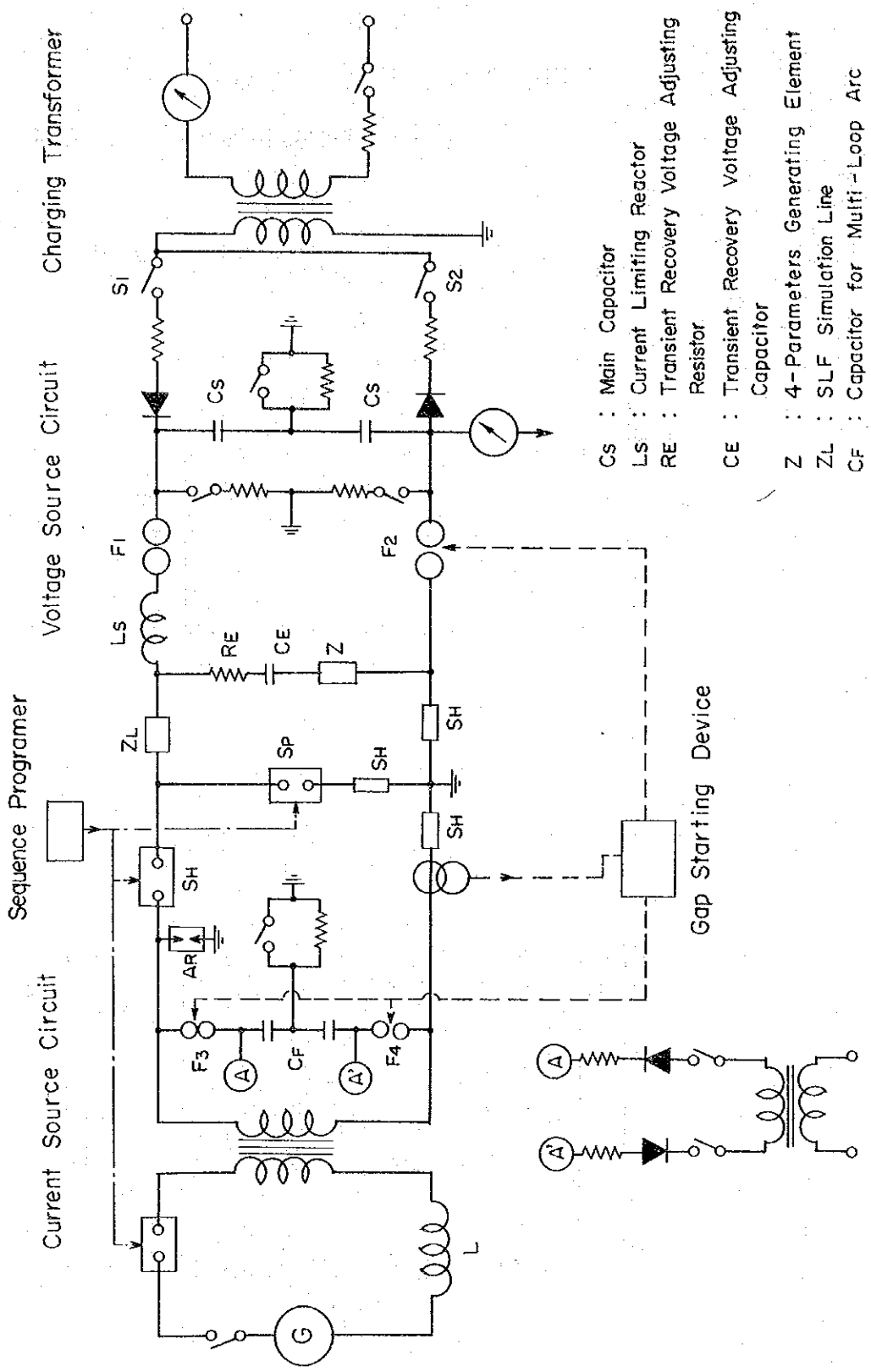
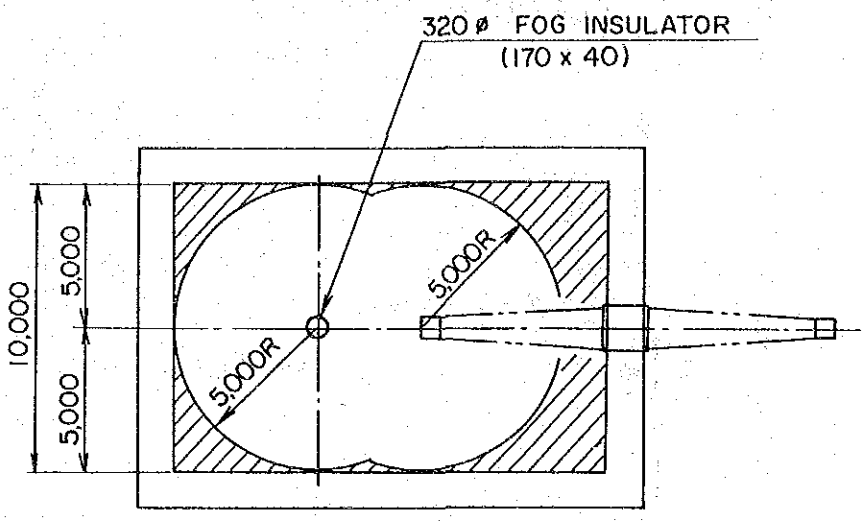


Fig. 4.6 FOG ROOM

500kV: EQUIVALENT SALT DEPOSIT DENSITY: 0.3 MG/CM²

(unit : mm)



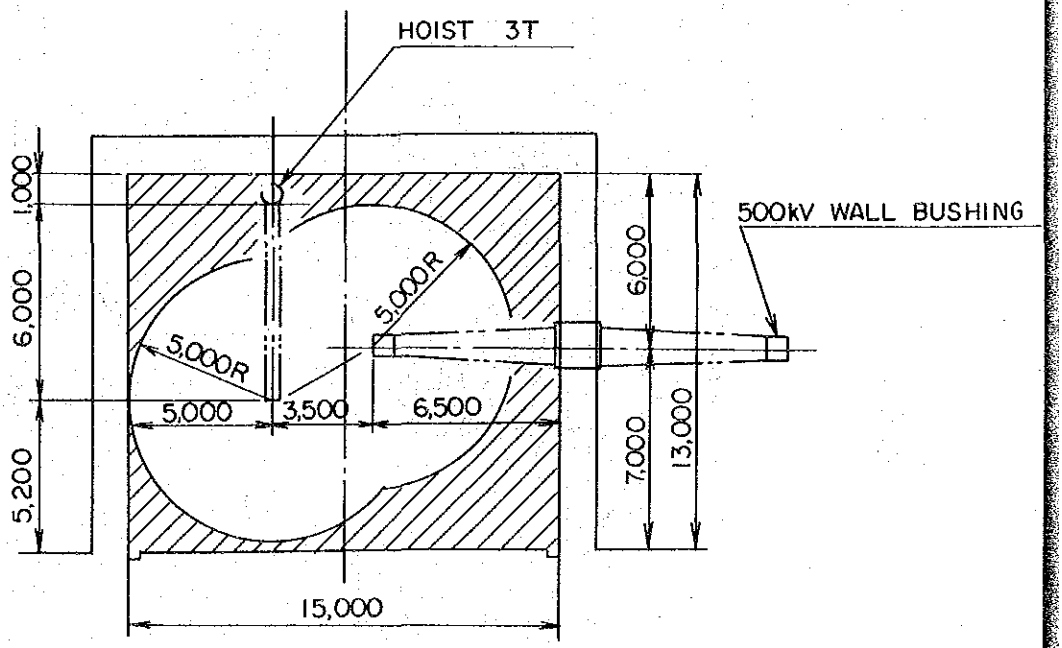


Fig.4-7 LAYOUT PLAN

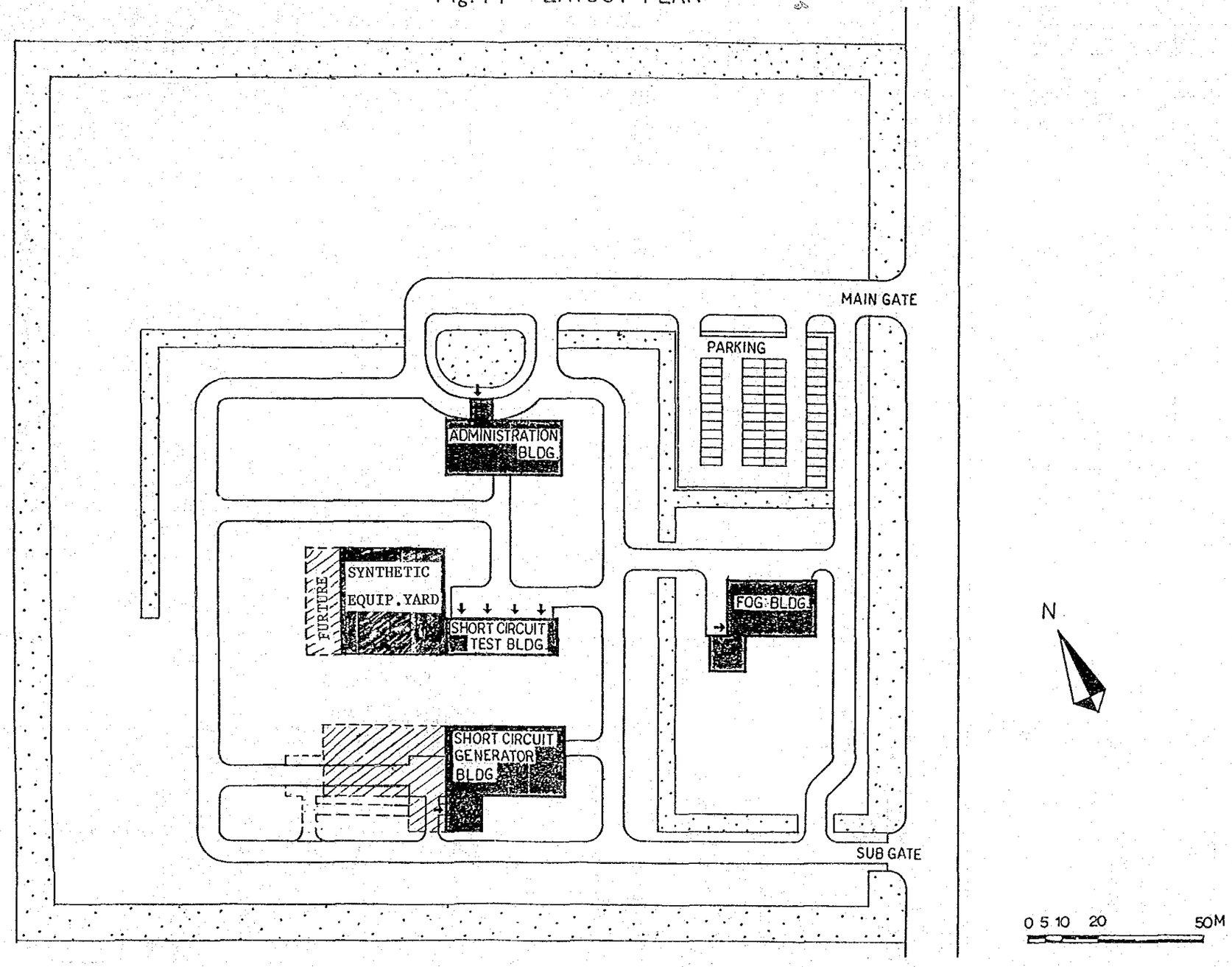
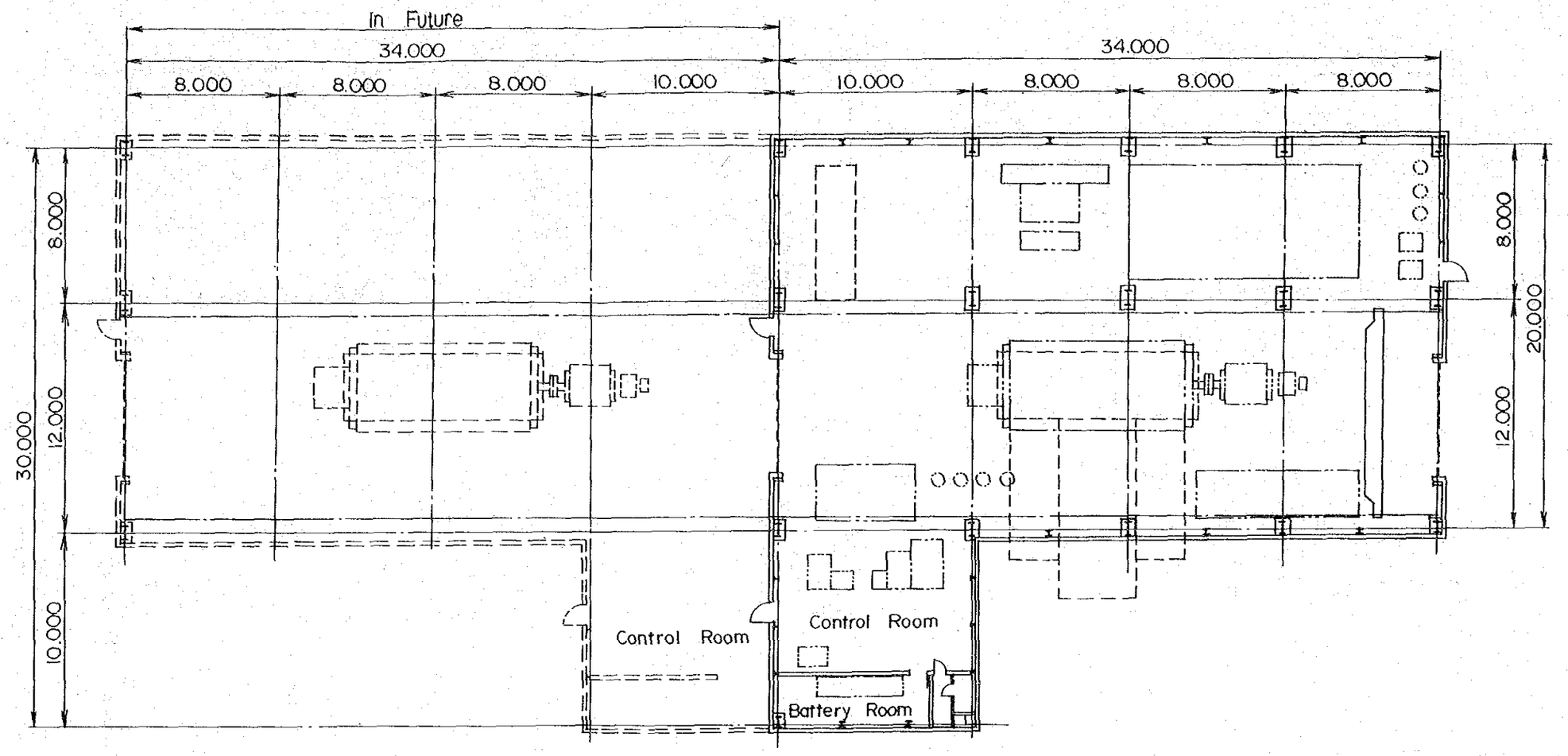
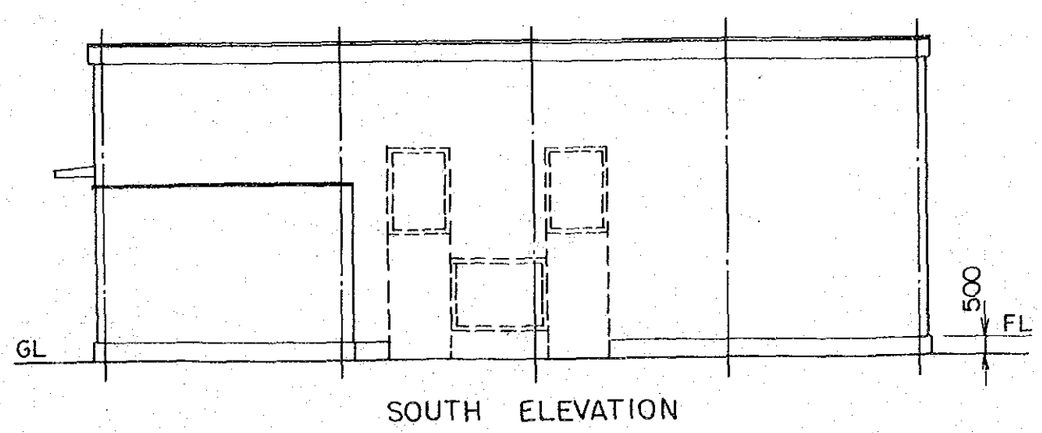
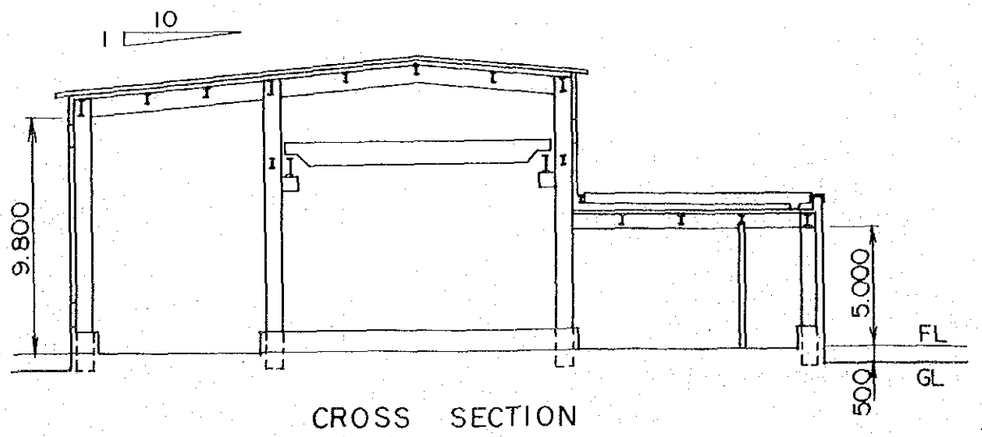


Fig. 4·8 SHORT-CIRCUIT GENERATOR BLDG.



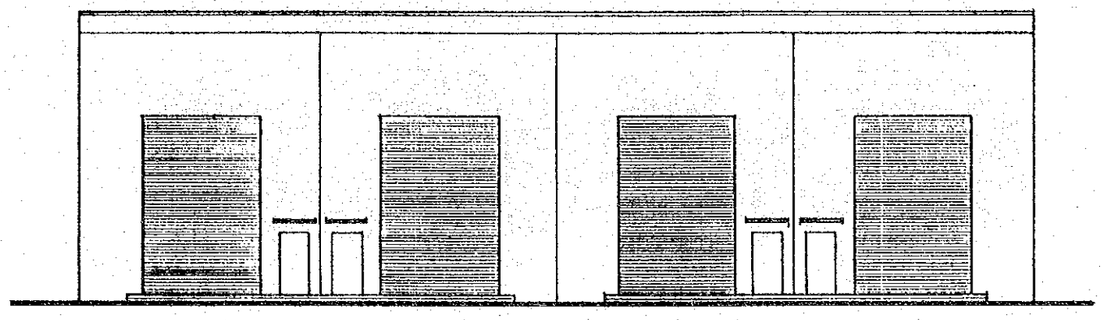


SOUTH ELEVATION

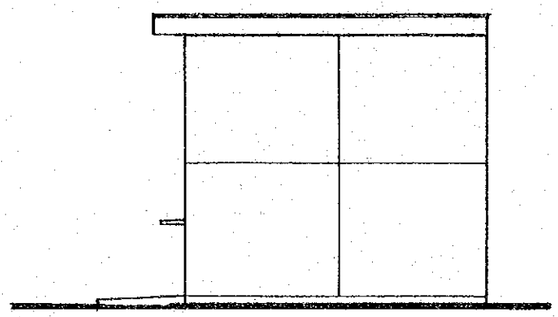


CROSS SECTION

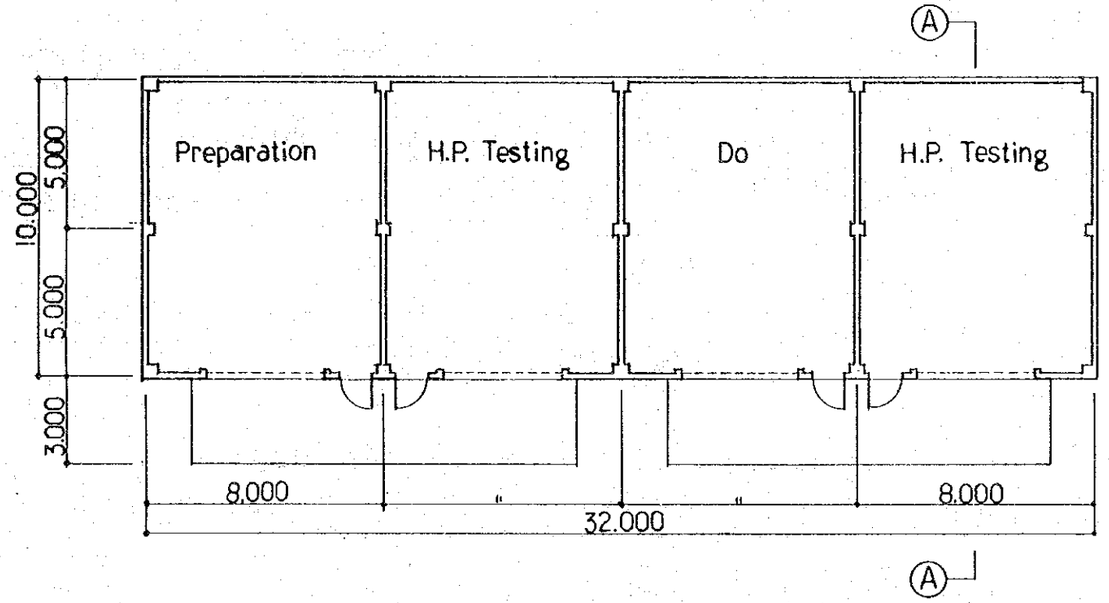
Fig.4·9 SHORT CIRCUIT TESTING BLDG.



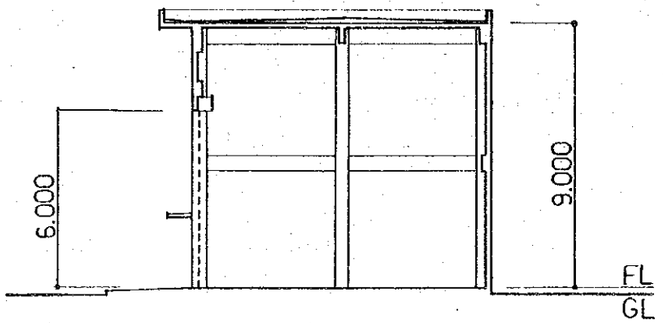
NORTH ELEVATION



WEST ELEVATION



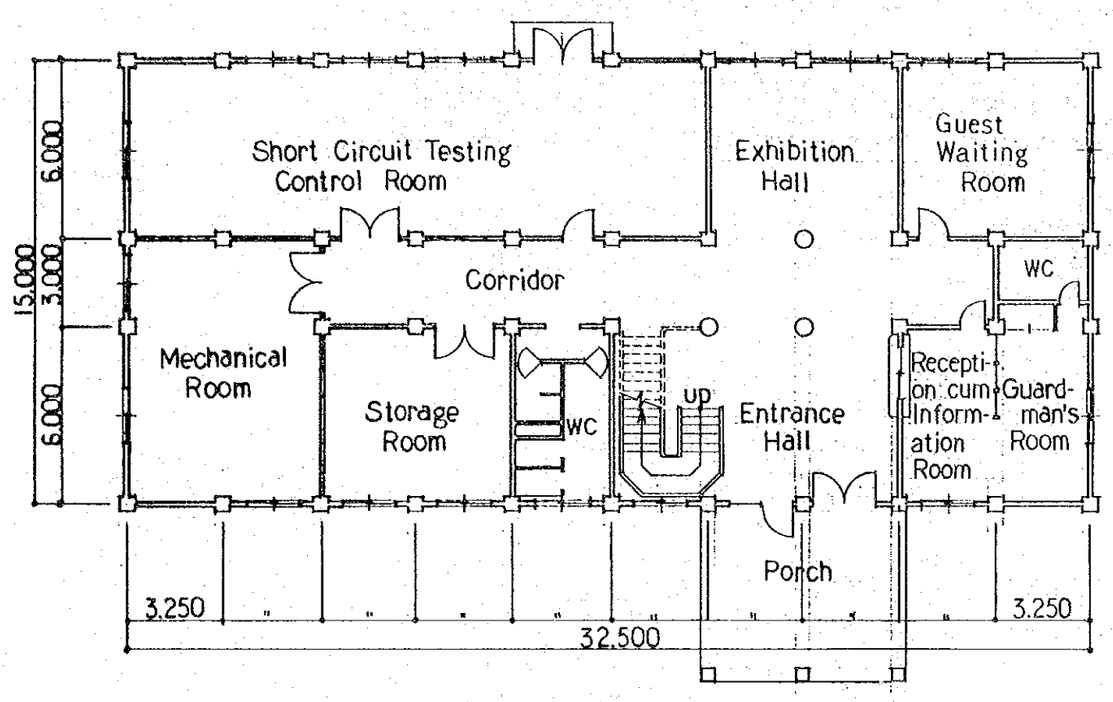
GROUND FLOOR PLAN



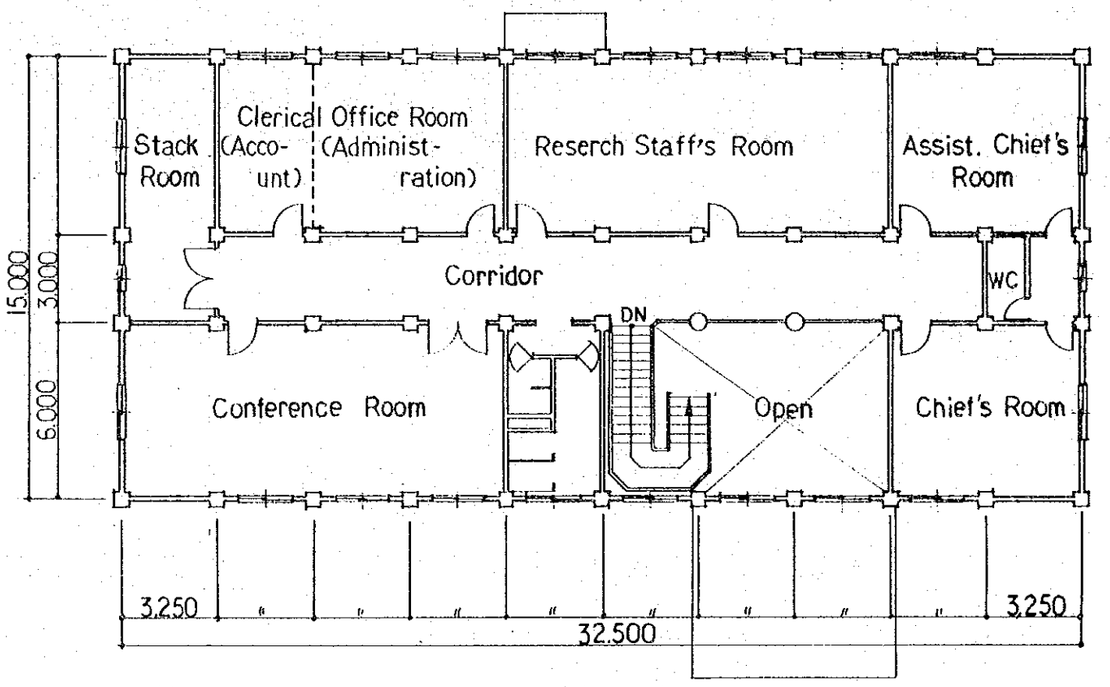
A-A SECTION

0 1 2 4 10M

Fig.4-10 ADMINISTRATION BLDG. (1)



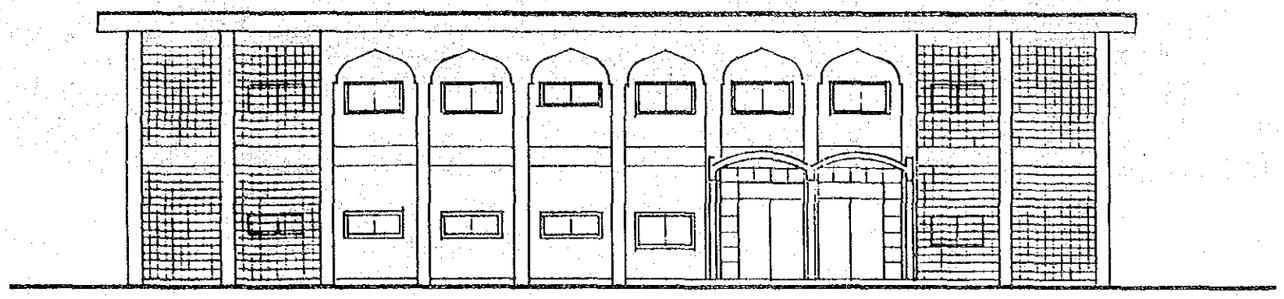
GROUND FLOOR PLAN



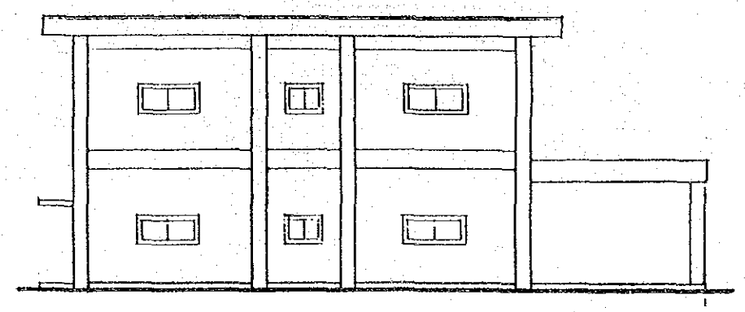
FIRST FLOOR PLAN

0 1 2 4 10M

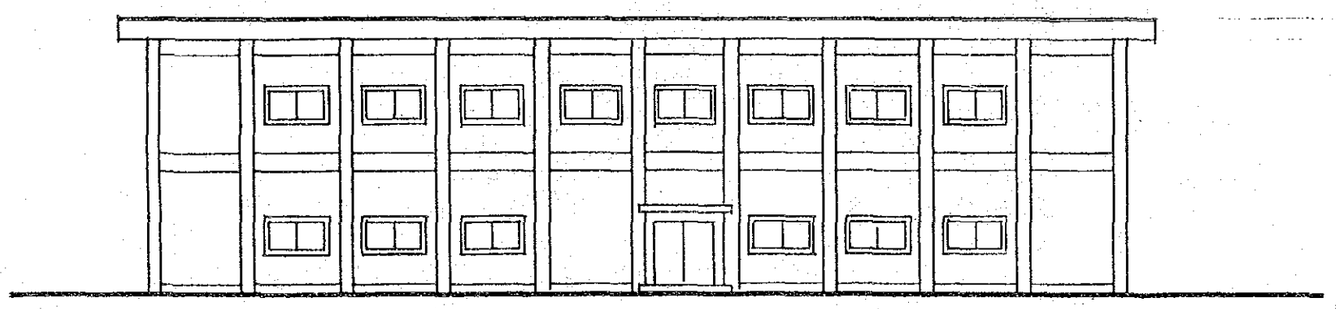
Fig. 4-11 ADMINISTRATION BLDG. (2)



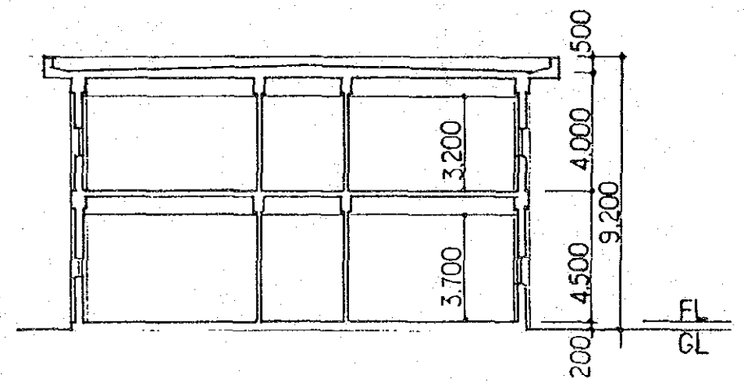
NORTH ELEVATION



EAST ELEVATION



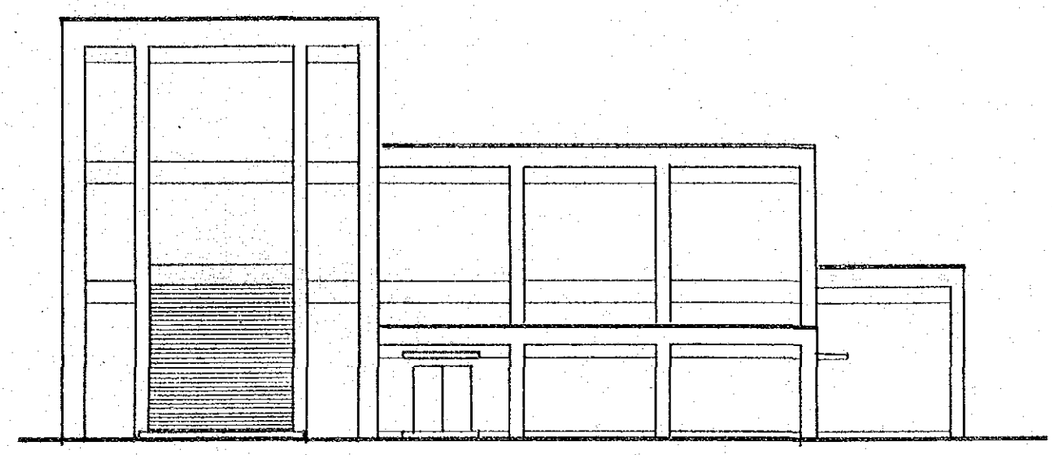
SOUTH ELEVATION



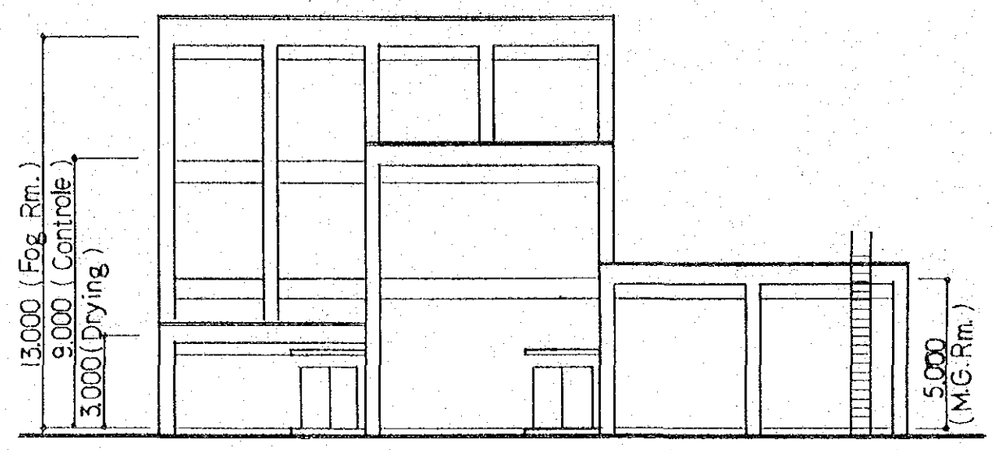
CROSS SECTION

0 1 2 4 10M

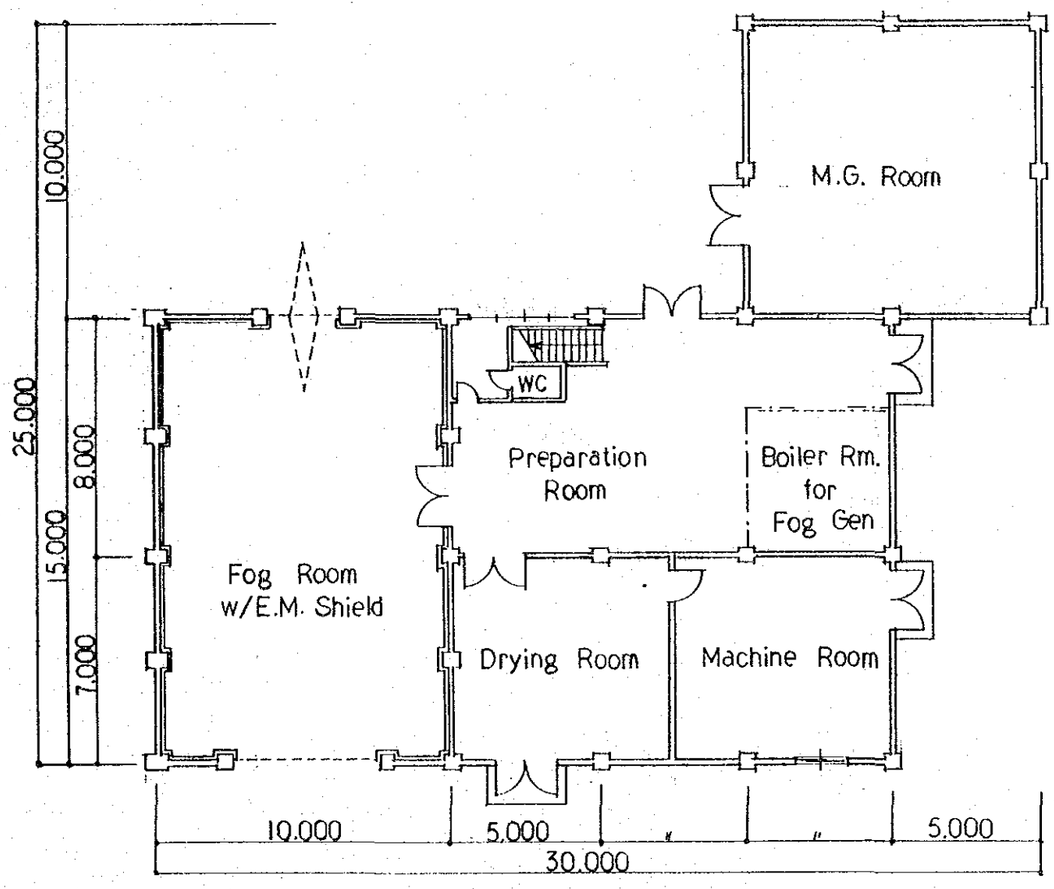
Fig. 4·12 FOG TESTING BLDG.



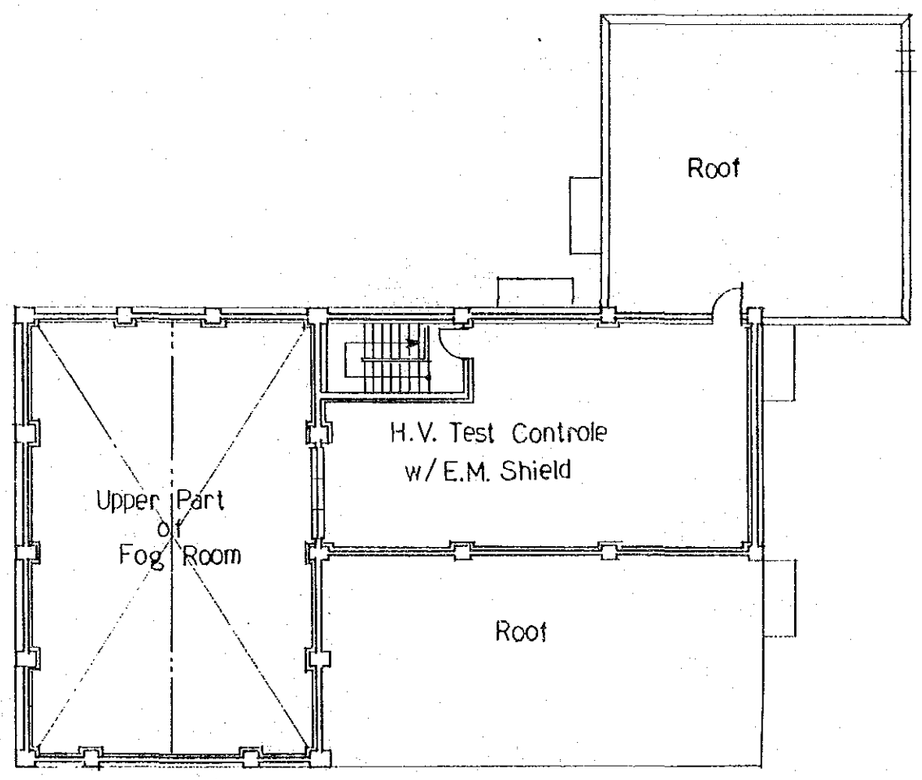
NORTH ELEVATION



WEST ELEVATION



GROUND FLOOR PLAN



FIRST FLOOR PLAN

0 1 2 4 10M

4-6 Construction Plan

4-6-1 Construction Environment and Construction Work Criteria

The equipment to be procured for this Project are not conventional, mass production models, but mostly specialized equipment of which the design and manufacture require considerable period of time. Particularly, the design and manufacutre of the short-circuit generator will take about 15 months, and the transportation, installation, adjustment and test operation will require about 11 months.

The construction work of this Project will be contracted based on an agreement between the Water and Power Development Authority of Pakistan and a Japanese corporation. The procedure for contracting will include the tender, review of tendered documents, etc. to select the contractor. The contract between the Water and Power Development Authority and the Japanese contractor shall be effective by the attestation of the Japanese Government.

4-6-2 Scope of Work

The scope of works to be performed by the Government of Pakistan and the Government of Japan for this Project shall be as stated below.

(1) Scope of Construction Work Performed by the Government of Japan

(a) Supply of equipment and materials stated in 4-3

(b) Marine and land transportation of equipment referred to above

(c) Foundation works for test facility equipment

(d) Installation and adjustment tests of test facility equipment

(e) Construction of buildings related to the test facilities

(f) Consulting services related to the detailed design, tendering and supervision of construction work

(2) Scope of Work Performed by the Government of Pakistan

(a) Procurement of land, survey and registration of premise, and land preparation

(b) Construction of fence and gate for the premise

(c) Construction of roads inside and outside the premise

(d) Construction of power distribution lines, water supply, a water tank, sewerage outside buildings, sewerage tank and other necessary related facilities

(e) Construction of electric power facility for the construction work

(f) Construction of electric power facility required for the testing laboratory (2 circuit of 11 kV distribution line)

(g) Construction of dormitory

(h) Test boring in the premise and measurement of the resistivity of water to be used by the testing laboratory

(i) Procurement and furnishing of furniture (including carpets, curtains, tables and chairs)

(j) Other necessary works which are not included in the Grant Aid by the Government of Japan

As stated in the Minutes of Discussions, the Government of Pakistan is responsible to take necessary measures for exemption of all tax and customs duties applicable to equipment, materials and construction works supplied by the Government of Japan, and to manage and operate this facility in a suitable manner.

4-6-3 Construction Work Management Plan

After the basic design and survey of this project is completed, the Cabinet of Japan will decide upon the grant aid funding of this project, the Government of Pakistan and the Government of Japan will exchange notes, and the detailed design and construction work management will be started in

accordance with the consulting agreement which will be concluded between the Water and Power Development Authority of Pakistan and a Japanese consulting corporation. The project will be implemented in accordance with the Guidance for Japanese Grant Aid Program following the signing of Exchange of Note (E/N) between both Governments.

(1) Detailed Design

The Consultant shall consult with the Pakistan party in order to determine the general conditions, special conditions, and detailed technical specifications required for implementation of contracted work based on the basic design parameters. The consultant shall also prepare the documents required for tender based on the detailed design.

(2) Construction Work Management

(a) Tender for selection of contractor

Before starting the construction management, the Consultant shall, for the purpose of selecting the contractor, place public notice of tender invitation, accept the tender request, hold the tender condition explanation meeting, and issue the tender documents. After a certain period for tendering, the Consultant shall accept and review the tenders, and help the conclusion of contracting agreement between the Pakistani party and the Japanese Contractor.

(b) Review for drawings for approval

Concerning the equipment and material drawings for approval, the building design drawings and calculation documents submitted by the Contractor, the necessary work for the approval shall be conducted by the Consultant who acts for the Pakistani party, for the purpose of implementing this Project promptly.

(c) Witnessing shop tests

The witnessing of the shop tests of equipment manufactured by the contractor, and certification of the equipments shall be conducted by the Consultant. The operation personnel for this

testing laboratory in Pakistan shall be invited to witness the shop tests of special equipment, with the objective of providing opportunity for technical education.

(d) Supervision of construction work

The Consultant shall have technical supervisors of each specialized field stationed at the site for supervision of the construction work in accordance with the agreement made between the Pakistani party and the Consultant. In addition, special technical experts shall be dispatched to the site at critical stage of the work such as consultation before start of work, transportation of equipment and equipment adjustments and tests, to supervise this project in such a manner that it is completed within the period specified in E/N.

(e) On-the-job training

As stated in 3-4 "Technical Cooperation", operating personnel having substantial technical capability is required for operation of the facilities of this project. For this reason, the Consultant, with the assistance of the Contractor's engineers, shall provide on-the-job training for the operating personnel of this facility during the equipment installation works, adjustments and testings.

(f) Reporting progress of work

The Consultant shall report, whenever appropriate, to the Government of Japan on the status of progress of this project during the whole periods in which the Contractor manufactures, transports, installs equipment and does other works.

4-6-4 Equipment and Material Procurement Plan

All equipment for this testing laboratory will be manufactured in Japan. However, concerning the construction work of the buildings accommodating testing equipments and the equipment foundation works, all products procurable in Pakistan shall be effectively utilized, including aggregates, cement and bricks. The procurement plan for the architectural materials is given in 4-4-4 "Building Material Plan".

4-7 Implementation Schedule

As stated in 4-6 "Construction Plan", this project will be implemented in two phase items, that is, the detailed design to be conducted by the Consultant, and the construction work to be conducted by the Contractor. This is due to the constraint imposed by the budgetary system of the Japanese Government on the grant cooperation procedures and to the request of the Pakistan Government for early completion of the Project.

The detailed design and the construction work cited above shall be started simultaneously after Exchange of Note (E/N).

The schedule of this project is presented in Table 4.1.

4-7-1 Detailed Design

After conclusion of E/N, the Consultant will start the detailed design and production of the tender invitation documents as stated in 4-6-3 "Construction Work Management Plan" as unlike conventional power generation, substation or transmission plan, the detailed design of this testing laboratory requires sophisticated technical studies. For this reason, and in view of the difference of the equipments required from the mass-production merchandises, 5 months are required for the detailed design.

4-7-2 Construction Work

After conclusion of E/N, the following works and constructions will be started.

(1) The agreement for the construction management will be concluded between the Pakistan party and the Japanese Consultant.

(2) After tendering, the Contractor will be selected. (As most of the equipments purchased are of special models, the tender review period is assumed to be 2 months.)

(3) The equipment item that takes the longest time for manufacture is the short-circuit generator (about 15 months for design and manufacture).

(4) Approximately 2 months are required for the marine and land transportation of equipments and materials.

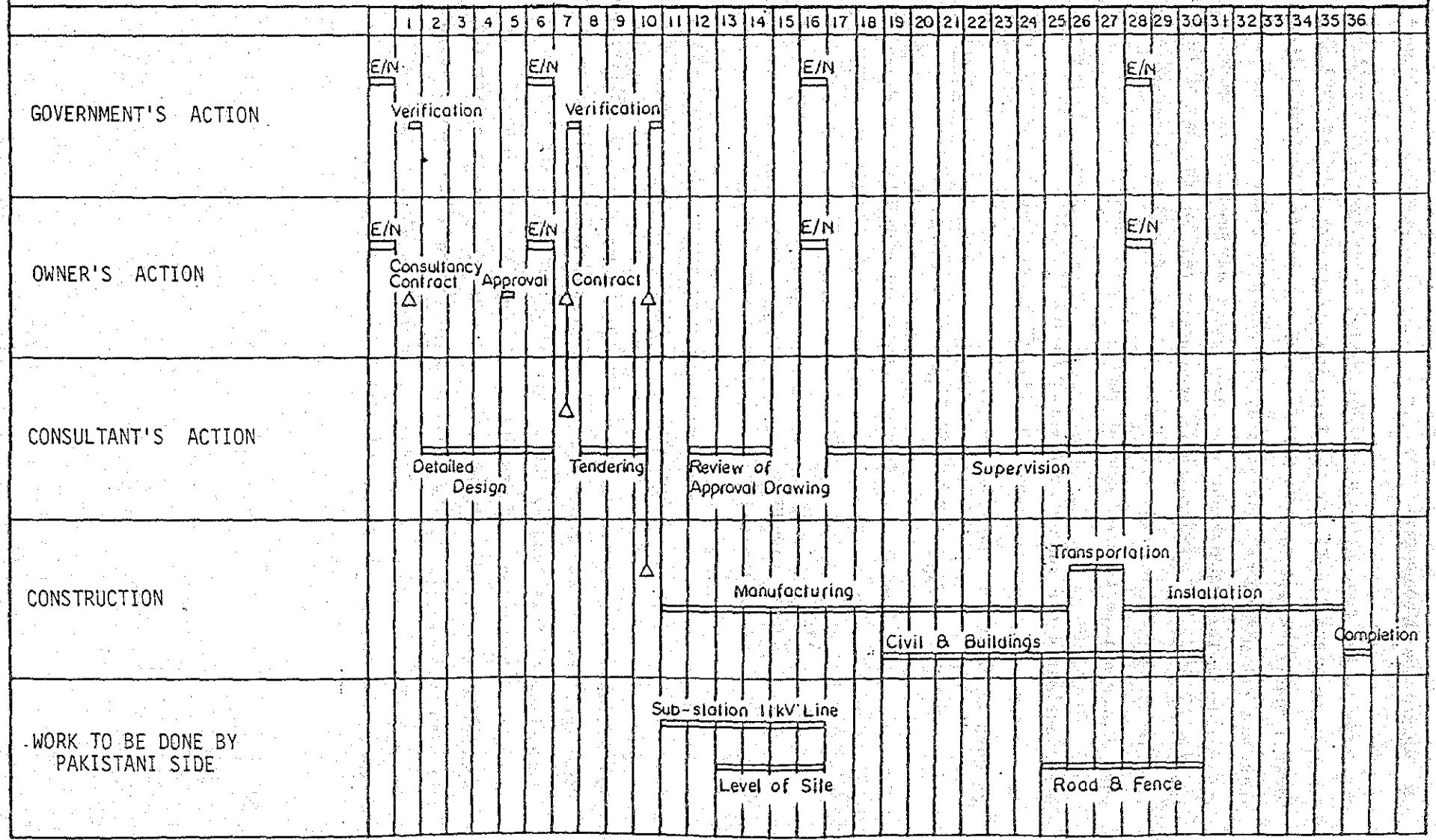
(5) Approximately 8 months are required for installation of the short-circuit generator.

(6) After installation of all facility equipment is completed, the time required for adjustment tests before transfer is about 1 month.

(7) Although it will take approximately 14 months for the building and outdoor equipment foundation constructions, these works can be performed while the equipments are being manufactured and transported.

(8) Based on the above estimates, the period of this project is assumed to be 36 months.

Table 4.1 IMPLEMENTATION SCHEDULE



4-8 Maintenance/Management Costs

According to the conception of WAPDA, this testing laboratory will be used not only by WAPDA itself for the type test currently commissioned to foreign countries and for the basic researches related to high voltage and heavy current phenomena, but also by the domestic electrical equipment manufacturers for improvement and development of domestic power equipments. The fee to be paid by the domestic manufactureres for the use of this facility is not yet determined, but WAPDA plans to use this income to fill some part of the maintenance/management costs.

WAPDA estimates the annual maintenance/management costs for this testing laboratory at 8,648,000 rupees (95,130,000 Yen). The content of this expense is as in the table below.

Item	Annual maintenance and management costs (in 1,000 rupees)
Salary	2,800
Repair expense	5,210
Miscellaneous	638
Total	8,648

WAPDA plans to cover this expense with the income from the utilization of this facility by manufacturers. As the income for several years after completion of this testing laboratory could be small, the expense must be borne by WAPDA as part of its operation expenditures. Since the annual operation expenditure of WAPDA amounts to Rs 6,472 million (for the 1984/85 business year), the above expense for this laboratory accounts for only 0.13% of this amount. It is expected that WAPDA will have no trouble supporting the operation of this laboratory.

4-9 Estimated Project Cost to be borne by the Government of Pakistan

In constructing this Project, the estimated cost to be borne by the Government of Pakistan are as follows:

Million Rupees

Item	1986/87	1987/88	1988/89	Total
(1) Acquisition of Land	6	-	-	6
(2) Construction of Residential Colony	-	10	17.6	27.6
(3) Construction of Water Supply and Drainage	-	3.1	-	3.1
(4) Construction of Road Inside and Outside	-	0.5	-	0.5
(5) Construction of Gate and Fence	-	0.3	-	0.3
(6) Leveling of Site	0.3	-	-	0.3
(7) Construction of Distribution Lines	-	2.0	-	2.0
Total	6.3	15.9	17.6	39.8

CHAPTER 5 PROJECT EVALUATION

CHAPTER 5 PROJECT EVALUATION

Today in Pakistan, only small scale electrical testing facilities exist in some universities, which is insufficient for a nation operating 500 kV class transmission system.

This High Tension, and Short-Circuit Testing Laboratory is going to be built prior to the entire project, as a central facility of a power research center that will be established in future, as well as a testing facility for verification regarding international standards on domestically made electrical equipment.

5-1 Quality Improvement in Domestic Product

The type tests to verify the performance of distribution equipment produced in Pakistan today are executed in KEMA testing laboratory in Holland. However, these tests will be conducted domestically when the Laboratory is completed. Therefore, a large amount of money and time will be saved. Also other tests at various production stages which are not accepted by KEMA today will be carried out, by which the development in production technology and improvement in product quality will be expected, resulting in reliable domestic production whose demand is expected to grow in the future.

Also, engineers' technology improvement is expected when the testing facility is used effectively by domestic electrical equipment manufacturers.

5-2 Improvement in Reliability Towards Electrical Business Operation

The constant operation of such testing facility will improve the quality in domestically made products, thus reducing the accident occurrence rate. It enables a highly reliable and stable electricity supply.

It will also reduce the number of power failures, and raise the reliability of electrical power supply organizations.

The transmission and distribution loss due to poor electrical equipment quality in Pakistan is as high as 26.7% of its total generating volume. It

is remarkably high compared with Japan's 6%. Therefore, its loss reduction by quality improvement will increase power supply as a result, contributing greatly to the consumers' well-being.

5-3 Savings in Foreign Currency

Today, WAPDA relies upon other nations for the type tests for domestic products including transformers and breakers. However, the numbers to be tested are restricted by a limited budget in foreign currencies, although WAPDA has spent about Rs 4.5 million per year. Such type tests will be done domestically at the High Tension, and Short-Circuit Testing Laboratory after its completion, thus increasing the number of testing remarkably.

WAPDA will be able to save about Rs 16 million per year according to the estimated annual testing cases, as described in 5-5 ECONOMIC ANALYSIS.

5-4 Research and Development of New Products

The High Tension and Short-Circuit Testing Laboratory will be used not only for type test on final products but also mainly for research and development regarding quality improvement.

The research will also be made regarding basic phenomena on high voltage and heavy current including salt pollution on transmission lines, which will contribute to technology standard improvement.

The domestic type test will also enable various other tests on production lines, resulting in easy improvement and development of the product and finally an improvement in production technology.

5-5 Economic Analysis

(1) Conditions for Economic Analysis

(a) Service life of the high tension and short-circuit testing laboratory

The testing facilities installed at the Laboratory are special equipment but are almost the same type as those used for the substations. Therefore, these service life are determined as 30

years, which is the same as the total service life of the substations.

(b) Financing Conditions with Domestic Currency

The financing conditions regarding borrowing money for construction by Pakistan Government is a 10-year term equal payments, with 4% interest.

(c) Power Costs

The average electricity fee per kWh of WAPDA is applied to the operating costs for short-circuit generators.

(d) Price Rise Ratio

The operation and power cost increase during a 30-year life is appropriated as income which is equivalent to increase in profit of testing by this economic analysis.

(e) Interest During Construction

The interest on the loan for construction, which is paid by Pakistan Government, will be included in the construction costs.

(2) Income

(a) Estimated Operation Frequency of Testing Laboratory

The annual operation time of such testing facility is usually 200 days, excluding holidays and others.

3-4 days for breakers and 2-3 days for transformers are required at this laboratory to perform the same tests as those practiced today at KEMA, including the preparation of test results as well as its review.

Therefore, the number of tests per year will be restricted to:

Type test and others to establish WAPDA standards on breakers; about 30 cases.

Other equipment tests and various tests requested by manufacturers: about 50 cases.

However, the above numbers are estimated under the sufficient operating conditions including testing technology, facility maintenance, testing systems and testing methods. Therefore, at least 3 years will be required before maximum capability can be established.

Meanwhile, the number of test cases are estimated in the table below.

Year / Items	1990	1991	1992	1993	1994	1995
Circuit Breaker	10	10	20	30	30	30
Transformer	10	10	20	30	30	30
Other Device	30	30	30	50	50	50

WAPDA procured 600-unit of breakers for 11 kV and 50-unit for 145 kV during 1982-1983. They also procured 14,000-unit of transformers for 11 kV and 30-unit for 132 kV during 1983-1984.

It is evident that the number of equipment to be purchased by WAPDA will be increased in order to meet the growing demands in future.

WAPDA has ordered only 2-3 type tests on breakers and transformers to KEMA recently because it had to save foreign currency.

The demand for type tests of domestic products that will increase in the near future, and various tests regarding WAPDA standards will increase further. Therefore, the estimated figures in the previously described table are appropriate.

(b) Estimated Income

Assuming that the estimated number of tests including type tests in the above (a) are tested by other nations, now the entire testing cost will be taken over by this testing laboratory, regarding its cost as income for this economic analysis.

The unit testing price per case is determined as below, based upon KEMA's and Japan's experience.

* Breakers:

Type test cost	Rs 550,000
Packaging, marine & land transportation cost (return trip)	Rs 90,000
Total	Rs 640,000

* Transformers:

Type test cost	Rs 90,000
Packaging, marine & land transportation cost (return trip)	Rs 90,000
Total	Rs 180,000

* Test of power-fuse, cut-out, etc. Rs 18,000/test

Therefore, the income will be Rs 8.7 million in 1990, Rs 17 million in 1992, and Rs 25 million after 1993.

(3) Costs

(a) Operation/Maintenance Costs

The annual operation cost of this testing laboratory is, as described in 4-8, 8.648 million rupees (95.13 million Yen) as of 1990, including operation and maintenance, salary, travelling expenses and other related costs.

(b) Power Costs

Annual income of WAPDA in 1984-1985: Rs 7,279.5 million
Annual power sales in 1984-1985: 13,756 million kWh
Average sales price: Rs 0.529/kwh (¥5.82/kwh)

The power cost per year is calculated assuming the capacity of the driven motor for the short-circuit generators at 2,400 kW and a load factor of station service transformer at 30%.

(c) Depreciation

The total construction costs, including costs paid by both the Pakistan Government and the Japanese Government, and the interest during construction will be depreciated equally over 30 years.

(d) Economic Analysis

The profit and loss statement estimated from this testing laboratory operation is analyzed in consideration of several conditions as mentioned above.

Expenditures exceed income during the first five years (until 1994), due to less testing cases caused by technical training for laboratory operation.

Income and expenditures will be almost equalized after 1995, and there is no remarkable problem with regard to the annual operating and maintenance cost.

Accordingly this laboratory is valuable for WAPDA.

The adequacy of this project is evident from the above analysis.

CHAPTER 6 CONCLUSION AND RECOMMENDATIONS

CHAPTER 6 CONCLUSION AND RECOMMENDATIONS

6-1 Conclusion

As described in the previous chapter, the Government of Pakistan has planned to improve and expand the power generation, transmission and distribution facility for rural electrification and industrial developments as one of the specific targets in the 6th Five-Year Economic Development Plan. With this objective, the electric utilities of this country are engaged in the construction of new power generating facilities and the 500 kV extra high voltage transmission system for nation wide interconnection of power systems.

These programs for improvement and expansion of electric power facilities are necessary increasing the demand for various electirc power equipment. Thus the Government of Pakistan is planning to implement domestic production of 132 kV circuit breakers and 220 kV transformers in addition to the already made 11 kV distribution equipment.

However, there is no testing facility for verification of the performance of domestically manufactured electrical equipment in this country, and Pakistan is compelled to commission the electrical equipment tests to foreign nations, with fairly large expenditure in the precious foreign currencies. This tendency is expected to be magnified as the ratio of domestic production of electric equipment in Pakistan increases.

If this High Tension and Short-Circuit Testing Laboratory of this project is to be implemented in such a stiuation, the type test of the domestically manufactured electrical equipment can be carried out in Pakistan on its own. This will not only save the foreign currency expenditure as mentioned above, but enhance the reliability of electric equipment by reducing the power system failures which, unfortunately, are rather frequent at the present time.

The availability of this testing laboratory inside Pakistan for the domestic electric equipment manufacturers will not only contribute to improvements and development of equipment, but it will be a very efffective as the measure of developing domestic industries in Pakistan.

Based on overall considerations on such factors as described above, the Grant Aid by the Government of Japan on this project can be deemed as an act having significant meaning.

6-2 Recommendations

The construction of this Testing Laboratory under the Japan's Grant Aid will have considerable effect on the Pakistan's electric utilities, and thus there is the strong desire on the side of Pakistan to realize this project.

However, the spontaneous efforts by the Pakistani parties, as described below, are essential in order that this Testing Laboratory fully exhibits its usefulness as expected.

(1) Importance of Works to be Undertaken by Pakistani Parties

For this Testing Laboratory, that is, land procurement and preparations, and facility constructions including electric power, water supply and sewerage, will practically determine the schedule of this project. Thus it is mandatory for the success of this project that Pakistani parties promptly see to it that budgetary preparations and implementation plans are established according to the proposed schedule.

(2) Institutional Arrangement for Implementation and Operation of the Project

Although it has been decided that the implementation and operation of this project is to be conducted by the Power Wing in WAPDA, it is imperative that WAPDA promptly designate the manager responsible for this project, as well as engineers and others.

(3) Personnel Plan

As the function of this facility is high tension, short-circuit testing, staff having sufficient experience and technical calibre is required for management and operation of this facility.

Accordingly, the training of personnel employed for the operation of this facility is an indispensable factor, and it is required to

promptly select the operation personnel to have them take part in the project from the phase of construction and have them obtain the technical knowledge of this facility.

(4) Technical Cooperation

A substantial level of technical calibre is required for operation of this project, as mentioned in (3) above. Concerning the technical training of the Pakistan personnel, it is difficult to expect that this facility can be operated in a satisfactory manner by simply conducting training on personnel in the equipment manufacturers' shops and on-the-job training provided by consultants and manufacturer's staff. Thus it is required that the Japanese experts are stationed to provide technical guidance after completion of this project.

(5) Maintenance and Management Expenses and Budgetary Measures

As described in 4-9, an expense of 8,648,000 rupees (approximately 9.5 million Yen) is required for the maintenance of this facility, including the salaries, repair costs and the miscellaneous. These expenses are to be covered by the income of this facility, as described in 5-5. However, a budgetary appropriations must be secured, because the expenses must be borne by WAPDA as part of its operation expenditure for the first few years until the technology for operation of this facility is mastered by the Pakistani personnel.