2-2-3 Present Condition of Weather Surveillance Radars

(1) Existing Weather Surveillance Radars

The PMD possesses five weather radars in Pakistan as shown in Table 2-2-10 and Figure 2-2-6. Four of these (Weather Surveillance Radars or "WSR"), apart from the radar at Sialkot, are used for the purpose of detecting aerial distribution of rainfall. The radar at Sialkot (Quantitative Precipitation Radar or "QPR") is used for measuring the quantity of rainfall relating to flood forecasting and warning. Of these radars, only those at Karachi (the PMD headquarters) and at Sialkot use frequencies in the C-Band which is best suited for the observation of rainfall. The radars at Lahore, Sargodha and Cherat, all of which use the X-Band, are marine radars adapted for meteorological observation and lack adequate detection capability to cover sufficient distances for observation of rainfall; monitoring of the rainfall conditions using these radars is limited to areas in the vicinity of the locations of the radars.

(2) Observations by Weather Surveillance Radars

Observations by WSR is carried out eight times a day at three hour intervals starting at 00:00 UT (Universal Time) and at one hour intervals during the monsoon season and times of abnormal weather conditions.

Observations by QPR at the Flood Forecasting and Warning Centre (FFWC) are made only during the monsoon season from June to October. In principle, observations are made at three hour intervals; however, during long periods of rain, observations are continuously carried out in order to measure hourly rainfalls.

Table 2-2-10 Existing Weather Surveillance Radars

Name of Radar Site	Place	Model	Feature		Year of Installation	Maker	Country
			Frequency band and Output power	Detection range			
Karachi	Karachi Head-quaters	JMA-109A	C-band, 250kw	400km	1967	JRC	Japan
Lahore	Sialkot	WSR-75	C-band, 250kw	400km (200km in quantit-atively)	1979	EEC	U, S, A
Lahore	Lahore Airport	42-A	X-band, 75kw	200NM	1975	Plessy	U, K
Sargodha	Meteoro-logical Office	42	X-band, 75kw	200NM	1965	Plessy	U, K
Cherat	Air force Base	42	X-band, 75kw	200NM	1964	Plessy	U, K

Source; PMD

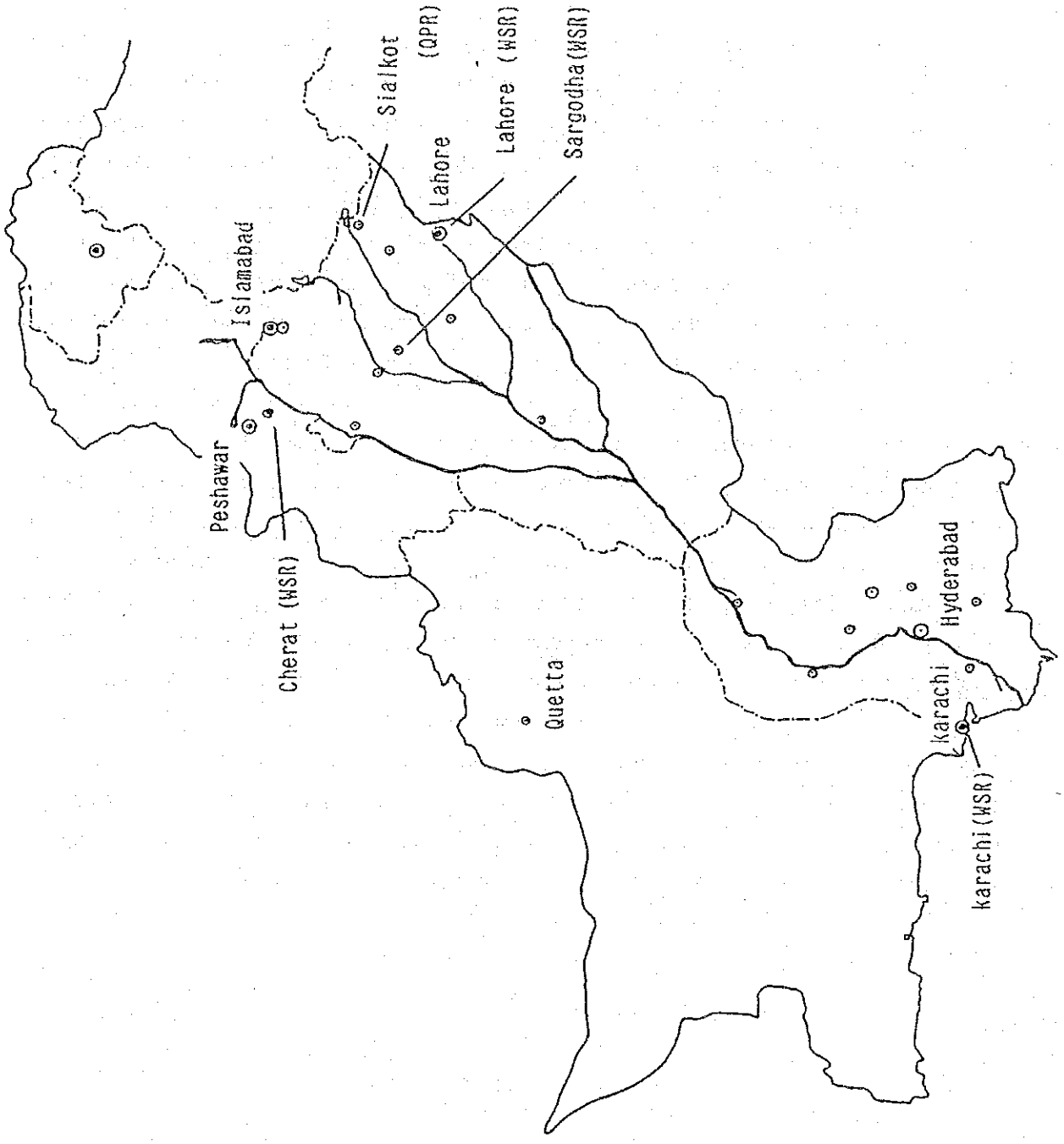
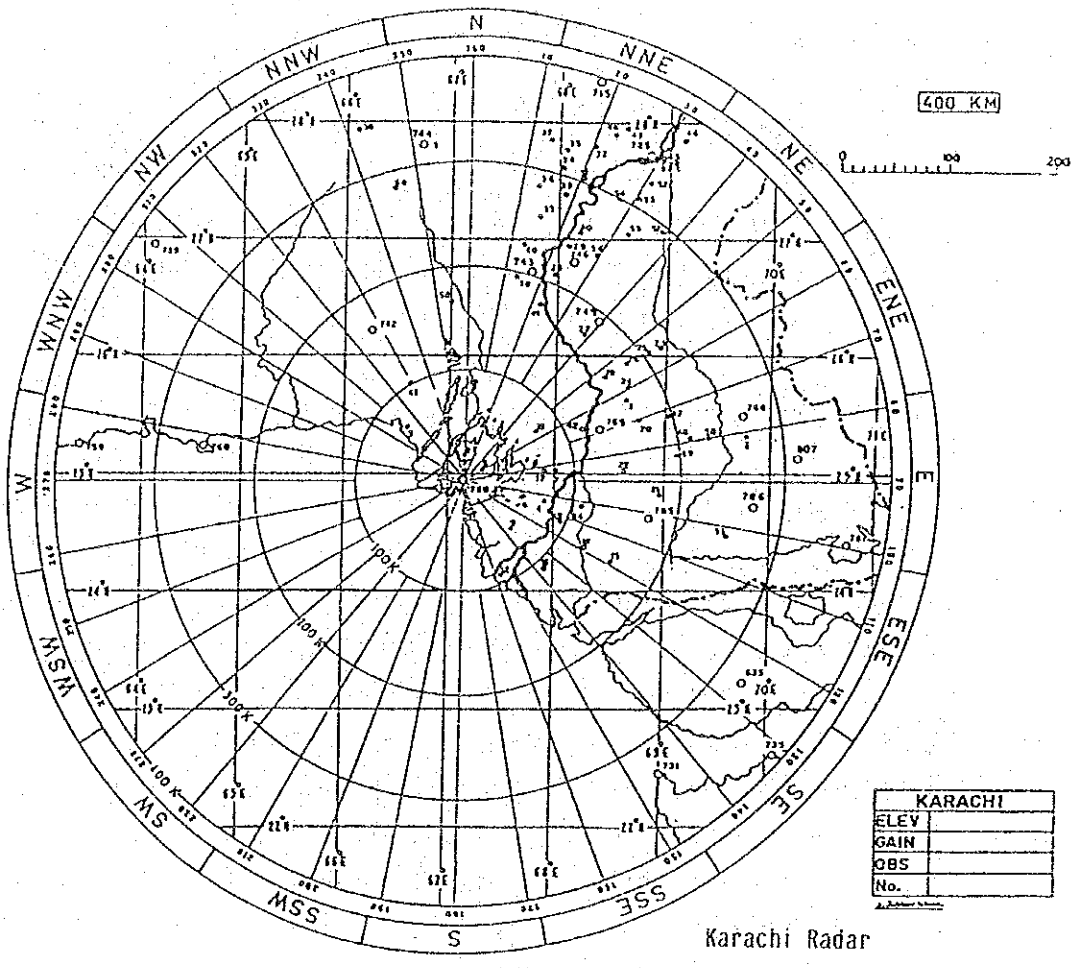


Fig.2-2-6 Location of Existing Radars

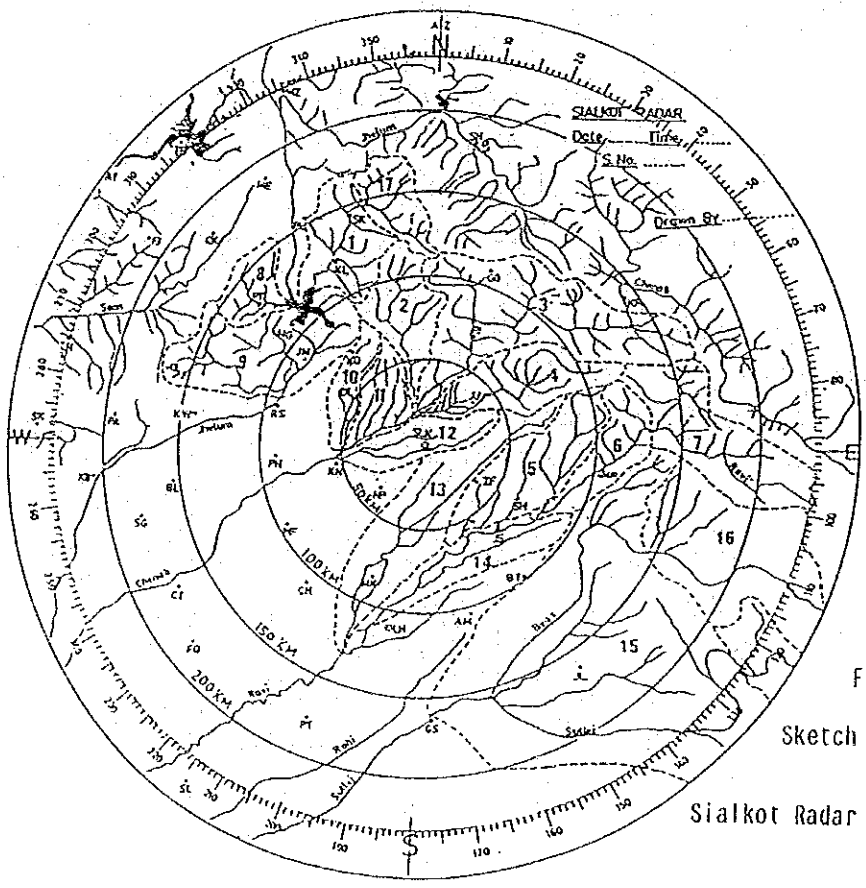
(3) Methods of Observation and Communication

Observations by radars are carried out by the electronic assistants at the Regional Meteorological Centres (RMC) who make sketch sheets records of the distribution of rain from the PPI scope on the radar as shown in Figure 2-2-7. However, there are no means of transmitting these sketches (e.g. facsimiles) to the users. Therefore, radar reports containing the direction of and the distance from the rain area, are converted into WMO codes for radar reports and distributed through telecommunication, or handed by messengers. A radar report contains only the position and the movement of the rain area, not its intensity and height, because of the limited capability of existing radars.

The radar at the FFWC is used for continuous observation only during the monsoon season. Radar echo data are processed on a computer in order to obtain hourly rainfall quantities in each coverage area, on the upper stream sections of major rivers and the results are printed as hard copies. Estimated figures for the distribution of the rain and the hourly rainfall amounts in each detectable area observed, are transmitted to the FFWC at Lahore through exclusive telephones, SSB or teleprinters. Special-purpose personal computers are used at the FFWC to predict rivers runoff from estimated rainfall over detectable areas obtained by radars, combined with rainfall data collected from land based rain gauges. However, since there are no means of picture transmission, the pictorial information (sketches) from the radars (which are most effective for issuing warnings) cannot be used in monitoring the situation and are merely stored as data for use in later analysis.



Karachi Radar



Sialkot Radar

Fig.2-2-7

Sketch Sheet of Radar

(4) Existing Radars

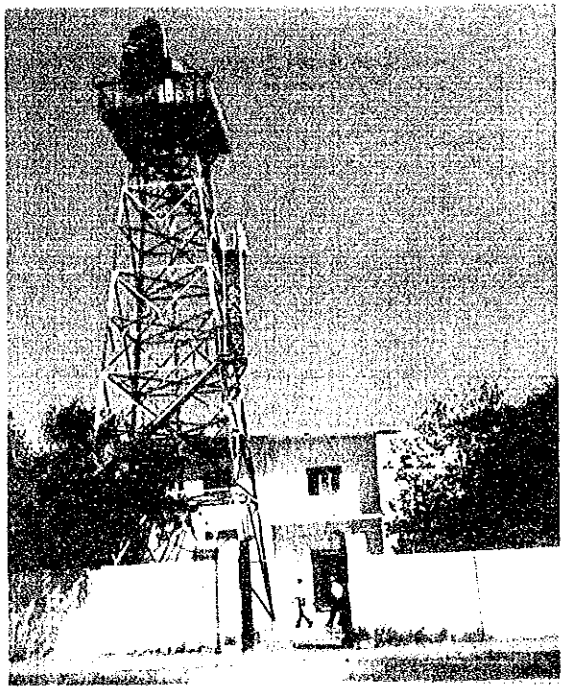
A survey was made on operational conditions of the radars at Karachi, Sialkot and Sargodha. As the radars at Lahore and Cherat are located in an airport and an airforce base, respectively, permission could not be obtained to make investigations and so only topographic conditions of their locations could be investigated.

1) Weather Surveillance Radar at Karachi (Photographs 1 to 4)

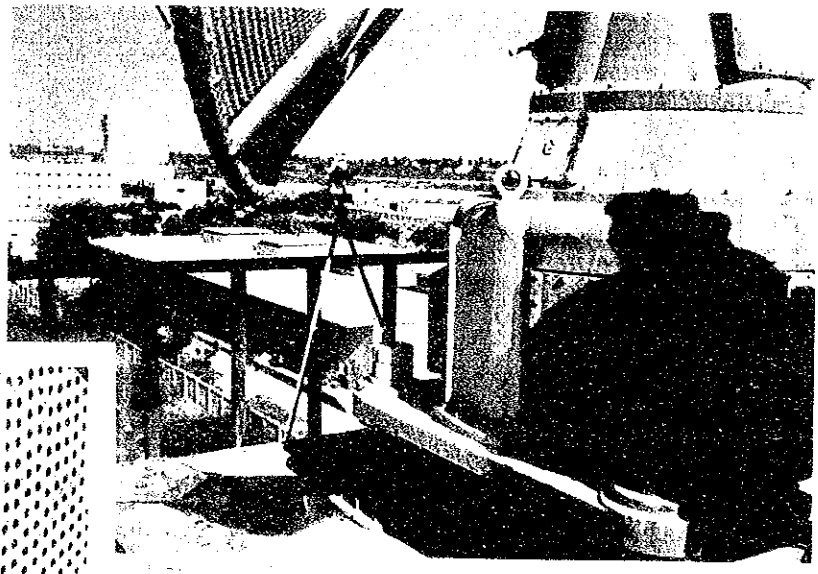
The radar located within the premises of the PMD headquarters at Karachi was manufactured in May 1963, but due to the fact that the antenna tower and operations building had not been completed at that time, four years were spent on installation and adjustment. Since the commencement of observation in 1967, the radar has been in operation for over twenty years. As shown in Table 2-2-11, the main electric circuits are composed of electronic tubes. Therefore, main spare parts cannot be secured as they are no longer manufactured. Only a PPI scope (which gives a two-dimensional plan of rainfall) is in operation. The radar is outdated and its capability for data processing is poor, and hence it cannot function as a meteorological radar for measuring rainfall intensity.

Table 2-2-11 Condition of the Radar in Karachi

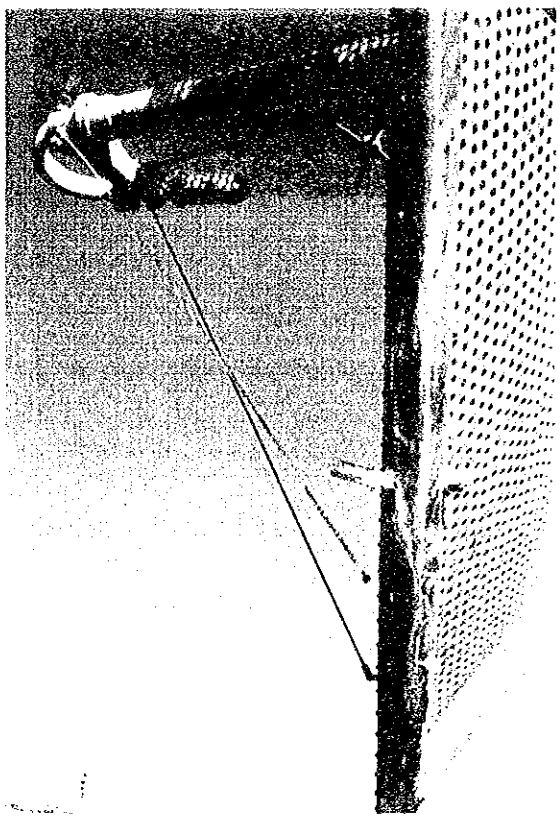
Item	Condition	Remarks
Antenna	Unsatisfactory	1, The radar beam is abnormal due to damage of the feed-horn, which cannot be recovered. 2, Vertical movement of the antenna is not possible due to damage of the driving motor system.
Antenna Control Unit	Unsatisfactory	1, The antenna can only rotate with a fixed elevation angle; the antenna cannot be directed to an arbitrary azimuth and elevation angle. 2, Consumables such as relays and timers of the system have never been renewed, and therefore almost no part of the system is in normal operation.
Transmitter/ Receiver	Unsatisfactory	1, No stable voltage is obtained due to deterioration of wires and insulation in high voltage parts of the modulater 2, Insulation is deteriorated due to leakage of insulation oil of the high voltage transformer. 3, Receiver sensitivity is not sufficient due to a) mechanical failure of the mixer of the receiver. b) adjustment of capability is not made after replacement of the tubes.
Iso-Echo Device	Out of order	Quantitative measurements of precipitation are not possible due to non-operation of the iso-echo device during the last 10 years.
Indicator	PPI and A-scope are available but in unsatisfactory condition	1, Sparks between the terminal plates have frequentry occured in the system. 2, Images of PPI are blurred due to the fact that focus adjustment of the cathode ray tube is not made. Therefore, accurate information cannot be obtained from the image.
Clock	Out of order	
Dehydrator	Out of order	Has been removed since its outage.
Automatic Voltage Regulator	Out of order	The AVR dose not function. Electric supply is made through direct connection between the input side and the output side.
Stand-by Generator	Out of order	The required voltage cannot be obtained due to failure of the generator, though the engine is workable.



Radar Tower and Radar Observatory



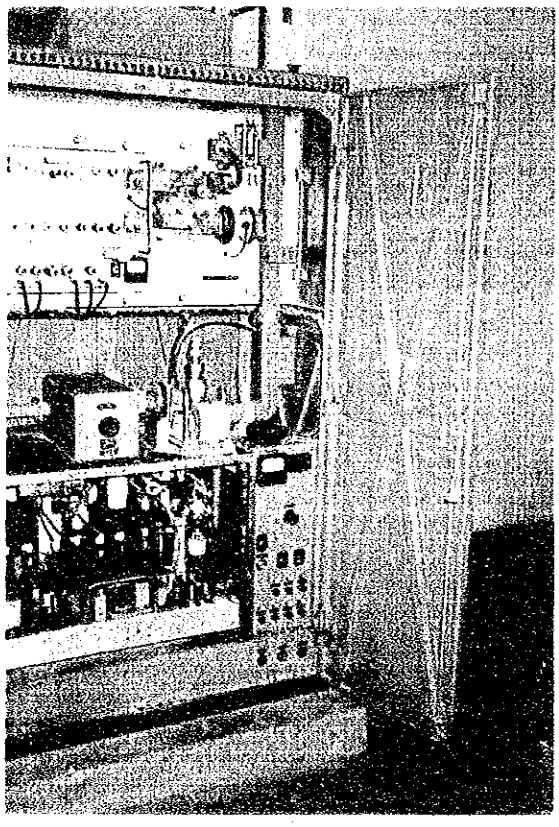
Pedestal of Antenna

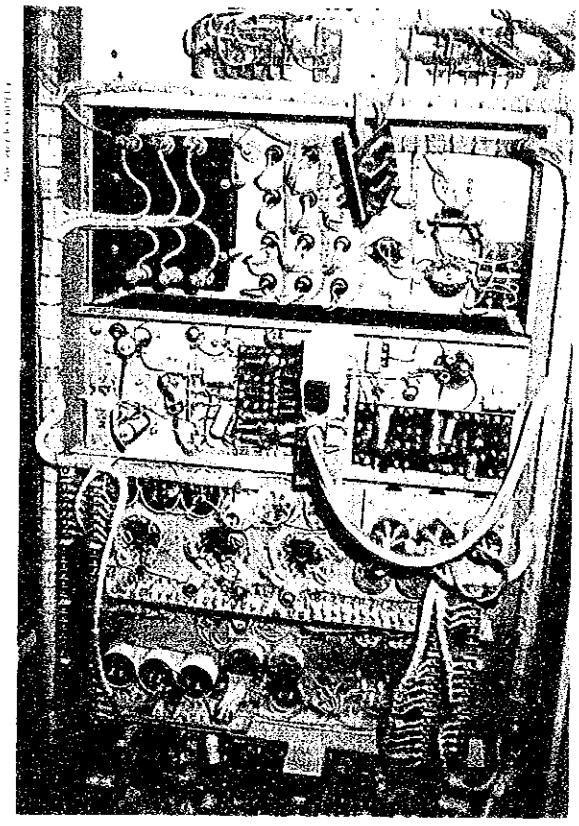


Parabola Antenna

(Photograph 1) Existing Weather Surveillance Radar at Karachi (1)

Transmitter/Receiver　　Antenna Control Unit

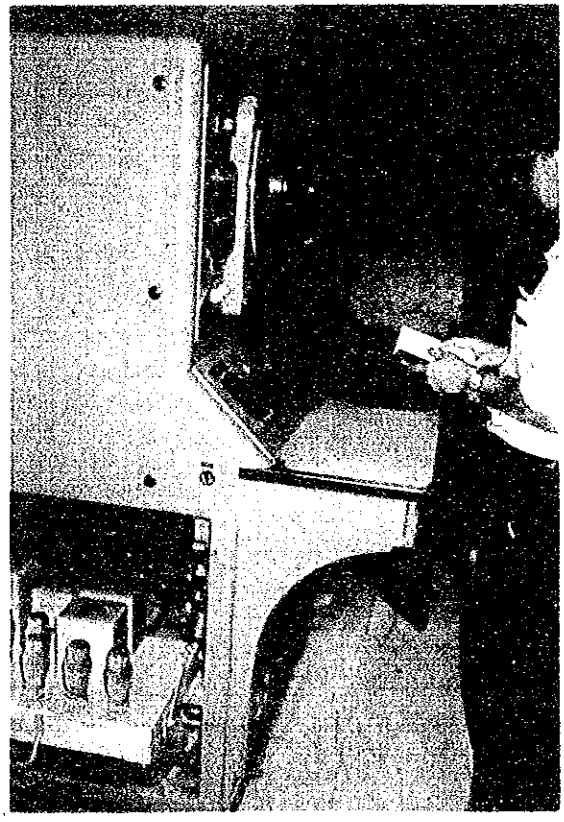




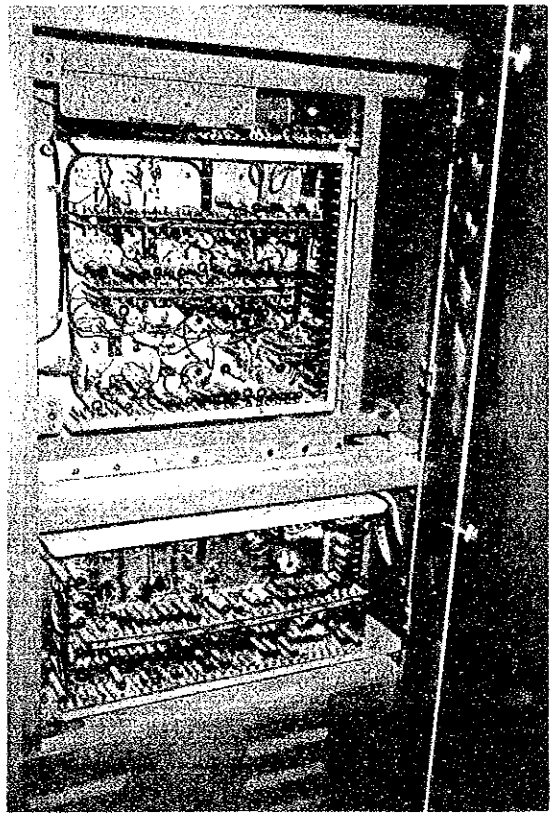
Inside of Transmitter/Receiver　　Inside of Antenna Control Unit

(Photograph 2)　Existing Weather Surveillance Radar at Karachi (2)

Radar Observation Room

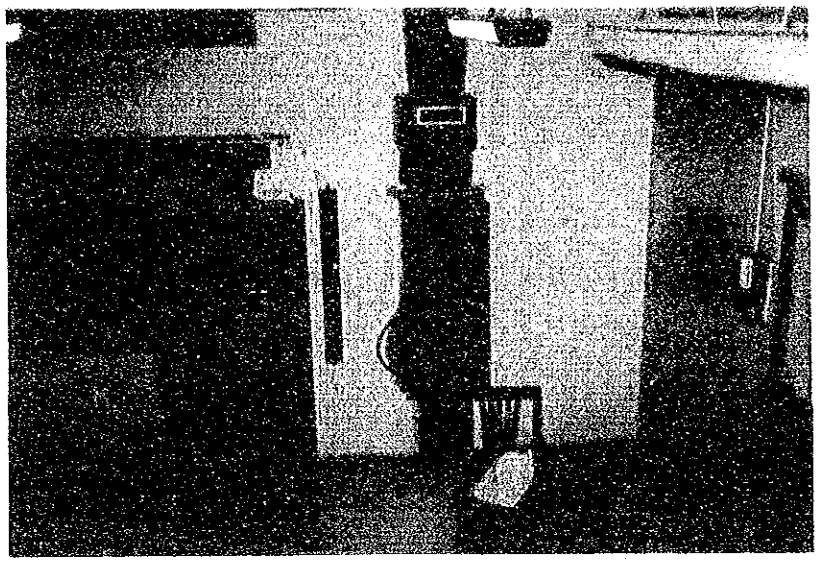


Indicator

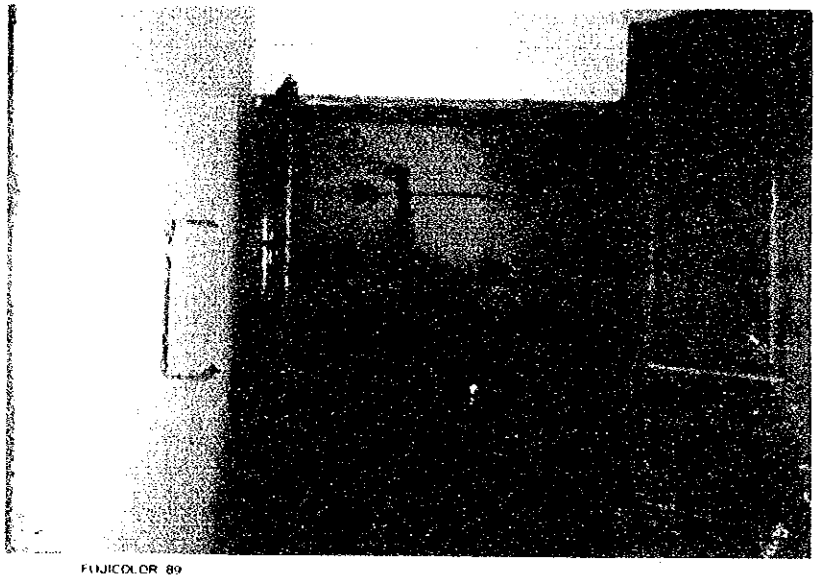


Inside of Indicator

(Photograph 3) Existing Weather Surveillance Radar at Karachi (3)



Iso-Echo Device　　Clock　Distribution Board



Stand-by Generator　　Automatic Voltage Regurator

(Photograph 4)　Existing Weather Surveillance Radar at Karachi (4)

2) Weather Radar at the FFWC

The FFWC is located in Lahore, but its radar was set up at Sialkot to the northeast of Lahore in 1979 and its purpose is to detect rainfall in Kashmir and the Indus Basin within a 200 km radius. The composition of the radar is shown in Table 2-2-12 and the radar is in a relatively good operational condition. There are doubts, however, as to its capability of detecting precipitation intensity accurately, both from the point of view of its operation and processing of data. These doubts are as follows.

① Operation

a) The elevation angle of the radar antenna is fixed according to the PMD observation manual at +1 ° or +3 ° at present.
b) The equipment for the calibration of the radars has not been calibrated for about 10 years since installation and therefore, the operation of the radar cannot be guaranteed.

② Data Processing

a) The software for the data-processing is not clear. The following items are not in agreement with actual observational data.
   ① Ground clutter rejection
   ② Range correction
   ③ Determination of B and β constants
   ④ Processing of the precipitation intensity

Table 2-2-12 Condition of Radar in Flood Forcast and Warning Centre Lahore

Item	Condition	Remarks
Radome	Rather aged	The size of the radome is not sufficiently large for the parabolic antenna. Therefore the required characteristics (beam width, gain, etc) are not obtained.
Antenna	Good	The waveguide is not checked.
Transmitter/ Receiver	Good	
Indicator	Good	An iso-echo function is included.
Dehydrator	Good	
Automatic Voltage Regulator	Good	
Computer	Good	The capability of processing precipitation intensity and ground echo clutter is not checked.

3) Weather Surveillance Radar at Sargodha

The radar was installed in the outskirts of the city several kilometres away from the urban area in 1968. The height of the radar tower is 22 m above the ground and the antenna and the transmitter/receiver are located on the roof. The main indicator is in the observation room on the ground floor and the antenna is placed on the iron hut containing the transmitter/receiver.

The radar (transmitting) frequency is 9375 MHz (X-band). Transmitting peak power is 75 kW. A flat reflector with a width of 2 m and a height of 0.6 m rotates horizontally at 11 rpm (parabolic reflectors rotating at 4 to 6 rpm are normally used in weather surveillance radars). This radar is a modified marine radar.

This type of radar has a large beam width in the vertical direction because of the shape of the reflector and is not adequate for quantitative observation of rainfall. As a result, the radar is used mainly for monitoring the movement of rainfall echo rather than for quantitative observation of rainfall and since a linear amplifier is used in the transmitter-receiver, quantitative observation of rainfall is in fact, impossible.

The indicator is capable of displaying echoes from rain within a radius of 200 nautical miles, but it is not possible to carry out quantitative observation of the rain echo, using the transmitting peak power and wave length. Since this radar has been in operation for over 20 years, the reduction of capability due to deterioration of parts cannot be prevented and it is at present only barely maintaining operation.

4) Weather Surveillance Radars at Lahore and Cherat

Radars at Lahore and Cherat could not be inspected by this team, but according to information from the PMD these two radars are of the same composition as that at Sargodha, only with differences in the capability of the indicators. So it is thought that their operational conditions will not largely differ from that of the Sargodha radar.

(5) Maintenance Conditions

1) WSR at Regional Meteorological Centres

All these radars have been working for more than twenty years. Nine electronic assistants engage in maintenance work at Karachi and five at Sargodha. The greatest problem is deterioration of the parts used in the equipment, coupled with the impossibility of obtaining spare parts and replacements. The electronic assistants are kept busy by major and minor troubles that occur almost every day and no regular inspections are carried out at present, due to lack of equipment for calibrating the radars. Therefore, the radar observations of the images on the PPI have been carried out with necessary adjustments of the radar.

2) Radar at the FFWC

There is a set of equipment for calibrating the radar and five electronic assistants carry out inspections once a week, but the measurement equipment has not been calibrated and accuracy of the radar cannot be guaranteed.

Inspections by the manufacturers of the radars were carried out twice in two years after the installation, but since then engineers of the PMD have been carrying out maintenance work using the instruction manuals or through oral instruction. As a result, not only at Sialkot but at all the radar stations, the same engineers are engaged in maintenance work as at the time of the installation ten to twenty years ago. There are naturally no regular inspections through the contract made with the manufacturers.

2-2-4 Problems in Existing Weather Surveillance Radars

The main problems that became apparent in the study are summarised as follows.

1) The radars are getting old and their original capability cannot be maintained. It is impossible to collect data on rainfall over wide areas and to obtain the necessary information for the weather forecasts.

2) Since the parts needed for maintaining and repairing the radars are no longer produced by the manufacturers, it is difficult to carry out further maintenance. Radar observation itself has become critical.

3) There are no means of communication for transmitting pictorial information. Pictorial information cannot be distributed to users and the effective use of the data is hence hindered.

The PMD are making efforts to make improvements and to solve these problems in the weather surveillance radars. However, due to financial difficulties and other reasons the PMD can not solve these problems immediately.

2-3 Circumstances and Substance of the Request

(1) Circumstances of the Request

The Pakistan Meteorological Department is responsible for carrying out meteorological services in Pakistan. Efforts have been made to modernize meteorological services in accordance with "PC-1, the Modernization Project of Pakistan Meteorological Department" established in 1985, taking into account the importance and urgency of upgrading of meteorological service in order to prevent natural disasters, e.g., the sudden occurrence of local torrential rain due to Cb-clusters accompanying an ITCZ and cyclones. Replacement of obsolete meteorological instruments and the introduction of modern electronic instruments and communication techniques should be made as a matter of urgency. Details of the plan are shown below.

a) Establishment of a Numerical Forecasting Centre
   Introduction of computers for numerical weather prediction to the Karachi headquarters.
b) Replacement of the weather surveillance radar at Karachi
c) Installation of APT for NOAA
   - at the airport meteorological stations at Karachi, Islamabad and Quetta
d) Installation of Automatic Meteorological Measuring Equipment
   - at the airport meteorological stations at Karachi, Lahore, Islamabad, Peshawar, Gwadar, Multan and Quetta
e) Installation of Aeronautical Meteorological Measuring Equipment
   - at 26 existing airports and 2 airports under planning
f) Installation of SSB Communication Equipment
   - at 25 observatories
g) Installation of Radio Meteorological Facsimiles
   Installation of transmission equipment at the Karachi Headquarters and reception equipment at Gilgit, Gwadar, Skardu, Hyderabad, Multan and Quetta.

The PMD considers that the most important theme in the modernization plan is the improvement of meteorological observations which are the most basic element in the meteorological service. Serious consideration is given to the existing difficulty of obtaining meteorological information from neighbouring countries like Iran and Afghanistan which hampers proper

meteorological service. Damage caused by sudden occurrences of local torrential rain should be reduced.

In view of the above, the PMD gives the highest priority to the following two projects:

① Replacement of the Weather Surveillance Radar at Karachi

② Installation of a Weather Surveillance Radar at Islamabad

The PMD requested the Government of Japan for grant aid for these two projects in January 1987 and March 1989, respectively.

(2) Substance of the Request

On receiving the requests mentioned in the previous section, the Government of Japan sent a study team to Pakistan to make a precise study of the meteorological service there and the need for weather surveillance radars in order to assess the pertinence of the request for grant aid. The study team discovered that the PMD is particularly interested in the replacement of the existing radar at Karachi and the installation of a new radar at Islamabad, among the vital work of improving the meteorological observation, and it was judged through the study that the replacement of the Karachi radar and the installation of the Islamabad radar, will contribute greatly to the improvement of the meteorological service in Pakistan. The study team and the Pakistan Meteorological Department reaffirmed the importance of installing radars at Karachi and Islamabad and agreed on the plan the "Project for the Establishment of a Meteorological Radar Network in the Islamic Republic of Pakistan". The minutes of discussions (included in Appendix) were exchanged at Islamabad on 3 November 1988.

Chapter 3 Substance of the Project

Chapter 3 Substance of the Project

3-1 Purpose of the Project

The purpose of the "Project for the Establishment of a Meteorological Radar Network in the Islamic Republic of Pakistan" is to replace the weather surveillance radar at Karachi and install a new weather surveillance radar at Islamabad with a view to upgrading the PMD meteorological service, in particular the observation of rainfalls, enabling the PMD to detect movements of cyclones and Cb-clusters in the ITCZ that result, in sudden occurrence of local torrential rain and gusts, and furthermore, contributing to the increase in accuracy of meteorological information, thus protecting the lives and properties of Pakistani people, against natural disasters.

3-2 Selection of Sites for Weather Surveillance Radars

3-2-1 Reasons for Selection of Sites

In order to prevent various meteorological disasters caused by heavy rain, it is necessary to improve the rainfall observation network. The most effective and economic means of observing rainfall throughout Pakistan is to establish a network of a sufficient number of weather surveillance radars. For reasons mentioned below, radars are to be first installed at Karachi and Islamabad.

(1) Karachi

Karachi is the largest commercial centre in Pakistan and, besides the concentration of population, it is the gateway to the country by sea and air and in a position subject to damage caused by a local torrential rain during the monsoon season and by cyclones. As a result, there has been an increasing requirement in recent years for the PMD to provide prompt weather information for air service and shipping organisations and for the provision of information on cyclones and local torrential rain, to organizations engaged in agriculture and disaster prevention, where there is a need for an accurate and speedy response to these requirements. For the purpose of detecting heavy rain in the southern Pakistan Region accurately and speedily, a weather surveillance radar, with a detectable range of 400km is the most adequate observation instrument. The existing old radar at Karachi cannot meet these requirements. Consequently, this radar will have to be replaced by a new one that makes use of the latest technology.

(2) Islamabad

Islamabad, the political centre of the country, is located in the northern part of the agricultural region of the Punjab, which is the backbone of the Pakistani economy, on the upper reaches of three rivers, the Indus, Jhelum and Chenab.

Islamabad is important and carries out administrative work for agriculture and water control. If a weather surveillance radar with a detectable range of 400 km is installed at Islamabad, the occurrence of a heavy rain caused by a meteorological disturbance in the north of Pakistan will be detected. This will contribute greatly to flood control at the dam in the northern region, and to irrigation in the granary area of the southern region. A radar with the

same capability as that at Karachi is to be installed at Islamabad to meet the requirements placed on the PMD for the provision of meteorological information relating to agricultural irrigation, river flow control and prevention of natural disasters.

3-2-2 Selection of Sites for Weather Surveillance Radars

It is most important to select an open area as a radar site in order to make the most efficient radar observations. In addition, operational conditions such as facilities for carrying out maintenance work must be taken into account. Based on the present study, sites were selected at Karachi and Islamabad as described below.

(1) Karachi

The most suitable site for the radar at Karachi, will be the site adjacent to that of the existing radar station on the premises of the PMD.

The PMD Headquarters are located in the northeastern part of the city, between University Road and Karachi Airport and the existing weather surveillance radar station is located on this premises. The location is particularly suited to the installation of a weather surveillance radar, as there are neither natural obstacles such as mountains, nor artificial obstacles such as buildings, in the surrounding area and therefore it is possible to carry out observations over a wide area both inland and at sea. The place selected has a good view towards Karachi Airport, and therefore the place would be suitable for transmission of radar echo data to the airport.

The existing tower for the radar antenna cannot be used for the installation of a new radome because of its structure and strength. The building of the radar station is old and unsuitable for the installation of new radar, because there are problems in dust prevention and airtightness, as a result of damage within the building. A new radar station will be installed at a site approximately 30 m to the south of the existing station on the premises of the PMD. The reason can be summarised as follows;

a) Proximity to the transformer facilities
b) Access to water supply and drainage
c) Sufficiently large area for construction

(2) Islamabad

The PMD proposed the following two sites for the weather surveillance radar station.

a) Summit of Margara Hill
b) On the premises of the meteorological centre at Islamabad

Mountains rise to the north of Islamabad and these mountains will be obstacles to radar observations if a radar is set up within the premises of the meteorological centre. If a radar is installed on the summit of Margara Hill, there are more mountains to the north which become obstacles. According to a PMD suggestion relating to the climatic characteristics over these areas, those obstacles are not significant, because meteorological disturbances which bring rainfall are approaching from the west or the southeast at Islamabad. As a result of investigation, it was thought that there was no significant difference between the two sites in the radar observation coverage to the south (which the PMD is particularly interested in) while the coverage to the north could be enlarged by introducing observation methods most suited to the landscape of Islamabad. In view of the above, it was decided that the site within the meteorological centre be chosen.

3-2-3 Observation Coverage of Weather Surveillance Radars

The observation coverage of the two radars to be installed are shown in Figure 3-2-1 and the main cities and airports within the range are listed in Table 3-2-1.

As shown in Figure 3-2-2, the maximum range of a radar for detecting precipitation cells depends upon the height of the antenna of the radar, the beam angle of radio waves transmitted from the antenna and the curvature of the earth surface. Accordingly, the maximum range of a radar for detecting precipitation cells with an elevation of 6,000 m or higher to their top cloud heights, would be about 200 km from the radar site and a radar for detecting cyclones or Cb-clusters developed in the ITCZ, which are accompanied with huge clouds reaching 10,000 m, would be about 300～350 km from the radar site.

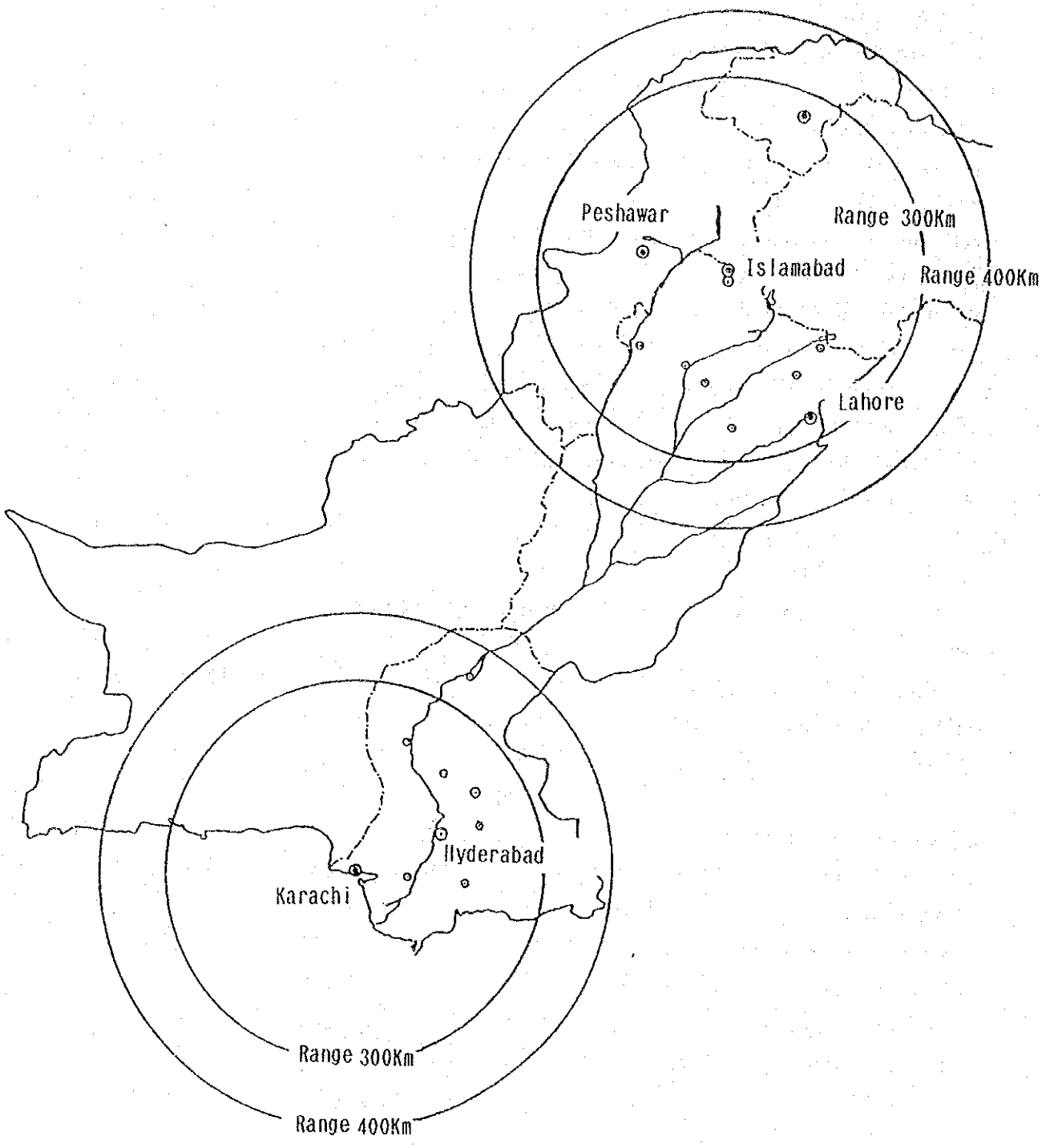


Fig.3-2-1 Detection Area of Radars

Table 3-2-1 Major Cities and Airports in Observation Area of Radars

Name of Radar Station	Observation Area (Inside of detection range of 300km)		
	Major City	Population (In thousand)	Major Airport
Karachi	1, Karachi	5,200	1, Karachi
	2, Hyderabad	750	2, Hyderabad
	3, Mirpur Khas	120	3, Nawabshah
	4, Larkana	120	
	5, Nawabshah	100	
Islamabad	1, Lahore	2,950	1, Islamabad
	2, Faisalabad	1,100	2, Lahore
	3, Islamabad/ Rawarpindi	1000	3, Peshawar
	4, Gujranwala	600	4, Faisalabad
	5, Peshawar	510	
	6, Sialkot	300	
	7, Sargodha	290	

Source; Statistical pocket Book of Pakistan 1984 and PIA

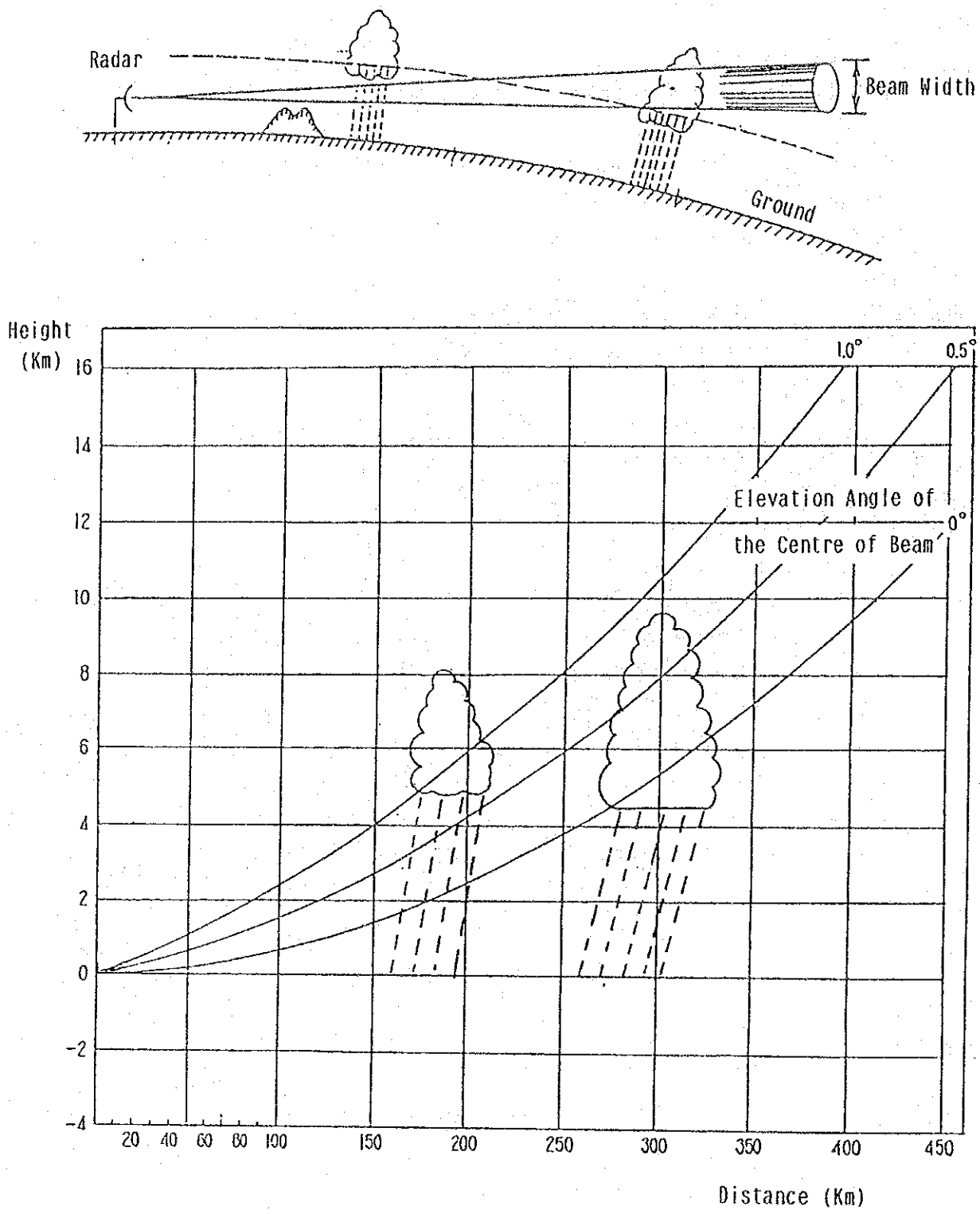


Fig.3-2-2 Conception of the Maximum Detectable Range

3-2-4 Electricity

Weather surveillance radars use power supplied from the commercial grid. Instability in electricity supply may result in serious damage to the electronic equipment. The operational condition of electricity supply is an important factor in designing weather surveillance radars.

The following items were investigated at Karachi and at Islamabad.

① Voltage Fluctuation
② Power Cuts
③ Availability of Emergency Generators

The results are described below.

(1) Karachi

Electricity supply was rather stable. Voltage fluctuation remained within ± 10 % and the waveforms were occasionally distorted by noise. The longest power cut during the last one year lasted for about five hours. Radar observation was interrupted about 20 times during the period due to electricity outage. Power cuts are particularly frequent in the rainy season. An emergency generator with a capacity of 45 kVA was installed for the exclusive use of the radar station in case of power cuts. However, this generator has not been in use for about 10 years. It is impossible to obtain spare parts for repair of the generator, due to the fact that the generator is out of date.

(2) Islamabad

The situation regarding voltage fluctuation and power cuts is similar to that at Karachi. However, no emergency generator is available at the meteorological centre.

Before the installation of radars at Karachi and Islamabad, it is considered necessary to install emergency generators in case of power cuts. Automatic voltage regulators and uninterruptible power supply units will have to be made available in order to protect the radar against voltage fluctuation and power cuts, thus ensuring continuous operation of the radar.

3-3 Radar Towers

The facilities accommodating the weather surveillance radars (radar towers and observation buildings) greatly affect the effective operation and the aging of the radars. The ancillary facilities at Karachi and at Islamabad have, therefore, been planned as follows.

Radomes will be used to protect the antennas from strong winds and so prevent disruption to observation.

3-3-1 Present Situation

(1) Karachi

1) Existing Steel Tower

The existing radar tower (of steel) and the building of the radar station are located near the centre of the premises of the PMD Headquarters. The construction of the tower and of the building was initiated in 1962 and 1964, respectively, and was completed in 1966. The radar equipment had already been manufactured in May 1963 but, since the radar tower and the observation building had not yet been constructed, four further years were needed before the process of installing and adjusting the radars was completed.

The height to the platform at the top of the existing radar tower is 19.8 m and the height of the stance at the base 5.9 m. The top of the tower is reached by climbing the spiral steel staircase on the outside of the tower. If the radome is placed on the tower while installing the new radar, the wind pressure according to structural calculations considering the shape of the radome will be 1.8 times what it is at present. As a result from the structural analysis, based on actual measurements taken on site, it has become clear that the diagonal bracing at the base of the steel structure will buckle and the existing steel tower built 27 years ago will fail to bear the uplift totalling 15 tons that will accompany the installation of the radome. To prevent this buckling and to enable the tower to resist the additional 15 tons of uplift, it will be necessary to strengthen the diagonal braces and to place additional reinforced concrete as foundation at the base of the steel frame.

Since the outer diameter of the radome is approximately 7 m, (allowing for 1 m of maintenance space around the outside of the radome) it will be necessary to place a platform with sides of at least 9 m long, on top of the steel frame having sides of 2.5 m long. This will result in an unstable structure requiring

a large amount of reinforcement between the platform and diagonal braces.

2) Existing Radar Station

The existing radar station is a building of two storeys, 16 m long and 7 m wide. On the ground floor are the supervision room, electricity generator room and the room for administrative personnel, while on the first floor are the radar equipment room and the observation room. 25 years have already passed since the station was built and there are considerable damages due to age in various places inside and outside the building resulting in breakdowns of radar equipment due to infiltration of dust into the building. For these reasons, the existing building is unsuitable as a facility for accommodating various parts of the weather surveillance radar equipment which consists of the latest electronic parts.

3) Alternative Facilities

With the existing radar station building and its tower being unsuitable for installation of the radome, investigations were carried out on the feasibility of using other facilities on the PMD premises as alternatives. As shown in the map of the Karachi premises in Chapter 4, 4-4, seven facilities - PMD Headquarters Main Building, Institute of Meteorology and Geophysics, Meteorological Workshop, Central Meteorological Store, Storage for Cylinders, Seismic Observatory and Upper Air Observatory - are choices as facilities related to meteorological observation. The results of the investigations are as follows and it was concluded that none of the facilities would serve as alternative sites.

- PMD Headquarters Main Building

It is the tallest building on the premises with three storeys in the lower half and five storeys in the upper half. From the point of view of its height it is the most suitable facility for installation of the new radar but this building cannot be used because of the water tank on the top storey.

- Institute of Meteorology and Geophysics

The building has two storeys and the construction of a further storey is planned for use as a research facility. It is not suitable as an alternative from the point of view of its function, as well as that of its structure, since three more storeys will need to be added to provide the height required for the radar.

- Meteorological Workshop, Central Meteorological Store, Storage for Cylinders,

Seismic Observatory and Upper Air Observatory

They are all one-storey buildings without structural provisions for vertical extension. About 18 to 20 years have passed since their construction and many indications of aging are found in them. They would, therefore, be unsuitable as alternatives from the point of view of their functions.

(2) Islamabad

The roof of the existing building within the PMD Agrometeorological Centre was considered as a possible location. The ground floor of the building was constructed in 1975 and the first floor added in 1987. It is of simple brick masonry. It is considered that the roof surface will not be strong enough to support the approximate one ton of extra load that would be created if the radome and the antenna were installed on the roof. The building cannot be used as an alternative from the point of view of its structure.

3-3-2 Plan

(1) Karachi

Taking into account the request from the PMD and the results of investigations from the point of view of; securing the facility in carrying out equipment works for electricity, water supply and drainage; and support structure of radar observation personnel, it was decided that a new radar tower will have to be built on the minimum scale necessary at a point 30 m to the south of the existing station building, within the PMD premises. Since the present project is to do with supply of equipment of which the radar tower is an ancillary facility and since it is hoped that the Pakistani side make their own efforts in works for expansion, the tower will be designed to accommodate only four members of staff, which is the minimum required for carrying out observation work (three observation staff and one for electrical works).

(2) Islamabad

As at Karachi, a new radar tower will be built on the minimum scale necessary, on a site unused at present in the southwestern part of the PMD premises.

3-4 Outline of the Project

3-4-1 Responsible Organization and Operational Staffing

(1) Organization Responsible for Implementing the Project

The Pakistan Meteorological Department (PMD) will be responsible for the operation and the maintenance of the radars after replacement. The PMD will also carry out the leveling of land at the Karachi and Islamabad sites and will be responsible for the removal of the existing radar at Karachi.

(2) Operational Staffing

The operation of the new radars will be carried out by eight radar observers, five mechanicians and nine others at both sites. Three radar observers and one mechanician will be stationed at the radar tower and the rest in the existing building.

3-4-2 Basic Plan

The existing weather surveillance radar at Karachi is to be replaced by a new one, and a new weather surveillance radar is to be installed at Islamabad. As the main purpose of these radars is to detect precipitation, accompanying Cb developed along the ITCZ, they are to have a coverage as wide as possible, and must be capable of observing the precipitation ranging from light to heavy rain. Preparations will be made for the operation of the radars in unstable electricity conditions, by installing automatic voltage regulators to protect the radars against voltage fluctuation of the commercial power supply and stand-by generators for use during power cuts. Furthermore, to make possible the effective use of radar data, a system capable of calculating cumulative precipitation will be used and colour monitors will be placed in the forecast rooms in the main buildings at Karachi and Islamabad. At Karachi, a colour monitor will also be installed within the airport for use in securing safety of flights.

New radar towers will be built as ancillary facilities for accommodating the radars. The project is to be carried out using existing facilities as far as possible and the new facilities will be designed to accommodate only the minimum personnel necessary, for carrying out observation on the radar screen.

3-4-3 Outline of the Radars and Facilities

(1) Description of the Radars

The radar equipment will be composed of 1) radar, 2) analysing equipment, 3) parts for power supply and spare parts. As regards the radar, the equipment will consist of (a) parts for transmission and reception, (b) parts for signal processing and display, and (c) parts for protecting the radar. Parts for power supply and spare parts will consist of (a) power supply equipment, (b) airconditioning equipment, and (c) spare parts. Composition of each part is shown below.

1) Radar

a. Transmission and Reception
   Antenna Assembly, Antenna Control Assembly, Transmitter/Receiver etc.

b. Signal Processing and Display
   Main Indicator, Video Processor

c. Radar Protection
   Radome, Automatic Voltage Regulator

2) Analysing Equipment
   Data Processor, Colour Monitor, Floppy Disk, Modem, Uninterruptible Power Supply Unit

3) Power Supply and Spare Parts

a. Power Supply
   Stand-by Generator, Power Control Panel, Starting Battery, Day Tank etc.

b. Air Conditioner

c. Spare Parts and Maintenance Parts

(2) Outline of Facilities (Radar Towers)

The radar towers will be large enough to accommodate the equipment of the weather surveillance radar and the minimum number of personnel necessary for observation (total of four, including three for observation and one for controlling electricity). The facility will consist of the roof, Equipment Room, Observation Room, Analysis Room, Data Room, Maintenance Room, Storeroom, Electricity Room and Standby Generator Room.

		Karachi	Islamabad
Roof	;		
Radar Equipment Room	;	Fourth floor	Third floor
Radar Observation Room	;	Third floor	Second floor
Analysis Room & Data Room	;	Second floor	First floor
Radar Maintenance Room	;	First floor	Ground floor
Storeroom,Electricity Room & Standby Generator Room	;	Ground floor	Ground floor

3-4-4 Administration and Personnel

The plan for disposition of personnel at Karachi and Islamabad is as follows. Of these, three radar observers and one mechanician will be stationed at the radar tower and the rest in the existing building.

Personnel	Karachi/Islamabad	Number of personnel working in radar tower
· Radar Observer		3
Meteorologist	1	
Assistant Meteorologist	1	
Professional Assistant	2	
Meteorological Assistant	3	
Senior Observer	1	
· Mechanic		1
Electronic Engineer	1	
Assistant Electronic Engineer	1	
Electronic Assistant	2	
Radio Mechanician	1	
· Others (Driver, Sweeper etc.)	9	

3-5 Technical Cooperation

The weather surveillance radars to be installed under this project will employ recently developed technology, and therefore, radar echo data will be processed and stored as digital data. One of the most remarkable functions of these radar systems is the display with colour codes of the intensity of rainfall as well as record and replay of radar echo data. In this respect, a system of operation and maintenance of the radars will have to be intensified for prompt recovery from failure. Technical cooperation in training in newly developed radar technology should be carried out as follows in order to ensure 24 hour operation.

	Purpose	Number	Period
· Reception of Trainees to Japan	Operation of new radars	2 (one for each site)	2 Months

Chapter 4 Basic Design

Chapter 4 Basic Design

4-1 Principle and Conditions of Basic Design

4-1-1 Principle

In designing new radars to be installed at Karachi and Islamabad, the following four conditions should be taken into consideration.

① The main phenomena to be observed are rainfall accompanying cyclones and Cb-clusters generated along the ITCZ.

② The prevention and mitigation of natural disasters and safety operations of aircraft should be kept by detecting rainfall phenomena accompanying Cb-clusters speedily and by monitoring rapid changes in actual rainfall conditions.

③ The weather radar should be durable against natural environmental conditions in Pakistan.

④ Observation and operation techniques of the user side should be taken into consideration.

4-1-2 Conditions

1) A significant feature of Cb-clusters is that they show extremely rapid changes in time and space, a formation distance ranging from several kilometres to several tens of kilometres and a continuous formation time ranging from several ten of minutes to a maximum of about three hours. The height of a Cb may reach 10,000 m or more. A Radar with a detectable range of 400km are required for close observation of cyclones and the development and decline of those Cb-clusters which occupy rather small areas but are tall and change rapidly.

2) Echoes are displayed on the CRT of colour display after the elimination of non-precipitation echo, processing of quantitative measurement of precipitation and X-Y coordinates conversion. Moreover, one hour rainfall amount is calculated from rain intensity for the promotion of the use of rainfall amount in the PMD.

Display:

① Range; 500 km × 500 km

② Precipitation intensity mesh; 2.5km

③ 1-hour rainfall amount mesh; 5 km

Function:

- Observation of actual condition
- Measurement of precipitation intensity
- Calculation of time-depth rainfall amount

For this purpose, digitalisation of received data will be required.

Apart from the conventional ways of utilisation, radar images at the radar site are displayed in the PMD Headquarters Karachi and Islamabad office at the same time.

3) Because of the climate in Pakistan, it is not possible to maintain suitable temperatures in the sealed observation room. Air conditioning will be required to maintain stable operation in the rooms where the radar observation equipment is located. Automatic voltage regulators and standby generators will also be required to ensure that the operation of the radars are not hampered by voltage fluctuation and power-cuts of the commercial power supply.

Radomes and lightning conductors will be needed to protect the equipment from gusts, hail and thunder that usually accompany Cb-clusters.

4) The PMD have more than ten years of experience in maintaining the weather surveillance radars under comparatively difficult conditions and have kept up meteorological observation. They possess sufficient basic knowledge concerning radars. All in all, it is thought that a sufficiently stable operation can be assured in the maintenance and the administration of the new radars as was the case in the past so long as a certain level of supply of parts not produced in Pakistan can be secured.

4-2 Basic Design of Radars

The capability and the composition of the radars will be considered on the basis of the above factors. An efficient system will be aimed at that makes full use of experience and technology developed by the Japan Meteorological Agency in the observation of heavy rains and typhoons. The social environment of Pakistan and the purpose of the use of the radars reported in sections up to Chapter 3 will be considered to create radars of capability and composition most suited to the conditions of the Pakistan Meteorological Department.

4-2-1 Equipment Plan

(1) Weather Surveillance Radar

The equipment that make up the radar system consists of the following groups.

a. Transmitter/Receiver Assembly
b. Data Processor and Display
c. Branch Display Assembly
d. Others (power supply)

The names and the capability of the parts that make up each of these groups are shown in Table 4-2-1, Figure 4-2-1 and Figure 4-2-2. Here, the conditions required for the new equipment that is to be introduced into Pakistan are described for each of the groups from a to c.

a. Transmitter/Receiver Assembly

Since the purpose is observation of Cb-clusters and quantitative observation of rainfall that accompanies them, the frequency band of the radio waves that decides the basic character of the radars must be chosen to avoid interfering with the airport surveillance radars at both Karachi and Islamabad. It will be appropriate to use the 5300 MHz Band (C-Band). Since this frequency band is the same as that used by the weather surveillance radar at Karachi in operation at present, there is the added advantage that there is no need to apply for the allocation of a new radar frequency band. Judging from the object of observation in the same way, there is also a need to secure a maximum detectable range of 400 km (250 to 350 km in actual use) and the transmitting power required will be 250 kW. The diameter of the antenna

should be as large as possible from the point of view of resolution. The diameter of the antenna will be 4 m which is the minimum size required to enable the radar to observe rain from the point when it is relatively weak and to detect the development and the decline of rainfall.

b. Data Processor and Display

The data processing equipment for converting received signals to intensity of rain according to the radar equation and the colour monitor for displaying the results are necessary, as well as for monitoring the state of rainfall, for judging whether the radar is operating properly in carrying out the observation. The main functions of this part are as follows.

① To reduce the ground echo and extract only the echo from the rain
② To obtain the image of the rainfall converted into X-Y coordinates simultaneously with the observation
③ To obtain cumulative hourly rainfalls

c. Branch Display Assembly

Branch display of precipitation intensity data and hourly rainfall data is made at the PMD Headquarters, Karachi Airport and Islamabad Office for the purpose of monitoring images of rainfall conditions at required sites. The images of the monitoring display are displayed on a subindication assembly, and these images are recorded on floppy disks for playback.

(2) Standby Generator

As has already been reported, the radar observation would seriously be interfered by a large fluctuation of voltage, and power-cuts. Installation of stand-by generators is required for ensuring continuous radar observation.

To facilitate maintenance at the site, the generators should be of a water-cooling type with diesel engines using car engines parts.

The estimated total capacity of the generator is 60 kVA, made up of 35 kVA for the radar, 10 kVA for airconditioning, 5 kVA for items required in carrying out observation such as lighting, and 20 % of the amount for marginal capacity. The volume of the fuel tank is also an item that needs to be take into account in the operation of the generators. Taking into account the fact that the maximum duration of power-cuts in Pakistan is about five hours,

allowing for the supply of fuel being stopped for up to six days because of conditions such as cyclones and floods and estimating the amount of fuel consumed by a 60 kVA-class generator at 14 ℓ per hour, a day tank with a capacity of 420 ℓ (14 ℓ x 5 hours x 6 days) should be installed to prevent interruptions in observation.

Table 4-2-1 Equipment of Each Radar Site

	Required number		Remarks
	Karachi	Islamabad	
1, Radar Equipment			
a, Radome	1	1	The assembly for protecting the radar antenna against winds.
b, Antenna (Diameter; 4m)	1	1	The assembly for emitting a radio beam and receiving a radio wave reflected from the object.
c, Transmitter/ Receiver (C-band, 250kw)	1	1	The assembly emits a radio beam and detects and amplifies a radio wave received.
d, Antenna Control Unit	1	1	The assembly for controlling rotation in vertical and horizontal directions.
e, Dehydrator	1	1	The assembly for air compression inside of the waveguide.
f, Main Indicator	1	1	The assenbly to display radar echos on the screen.
g, Digital Video Integrator Processor	1	1	The assembly which performs range correction, ground clutter rejection and averaging of digital signals received from precipitations.
h, Data Processor	1	1	The assembly to culculate the amount of precipitations for the required time duration which are obtained from digital signals.
i, Monitor Display	1	1	The assembly to perform colour monitoring display of the echo signals of the precipitation on the XY cordinate.
j, Modem (2400bps)	6	4	The assembly to modurate and demodurate digital echo signals for dissemination. (Including that for colour monitoring= Karachi;3, Islamabad;2)
k, UHF-band Radio Equipment	1	0	The assembly to disseminate radar echo signals from the radar site to the second display assembly located at the Karachi airport.

	Required number		Remarks
	Karachi	Islamabad	
l, Colour Display	2	1	The assembly to display echo signals on the screen for colour monitoring.
m, Uninterruptible Power Supply Unit	3	2	The system to protect monitoring display, colour display and data processor against damage caused by power-cut of the commercial electricity.
n, Automatic Voltage Regulator (AVR)	1	1	The assembly to protect the radar against damage caused by voltage fluctuation of the commercial electricity
2, Power Supply			
a, Stand-by Generator	1	1	The system for generating electric power supply with a view to maintaining radar observation in case of failure of commercial electricity.
b, Generator Control Board	1	1	
c, Starting Battery	1	1	
d, Service Tank	1	1	
e, Distribution Board	1	1	
3, Air Conditioner	1 set	1 set	
4, Spare Parts	1 set	1 set	Sufficient for two years

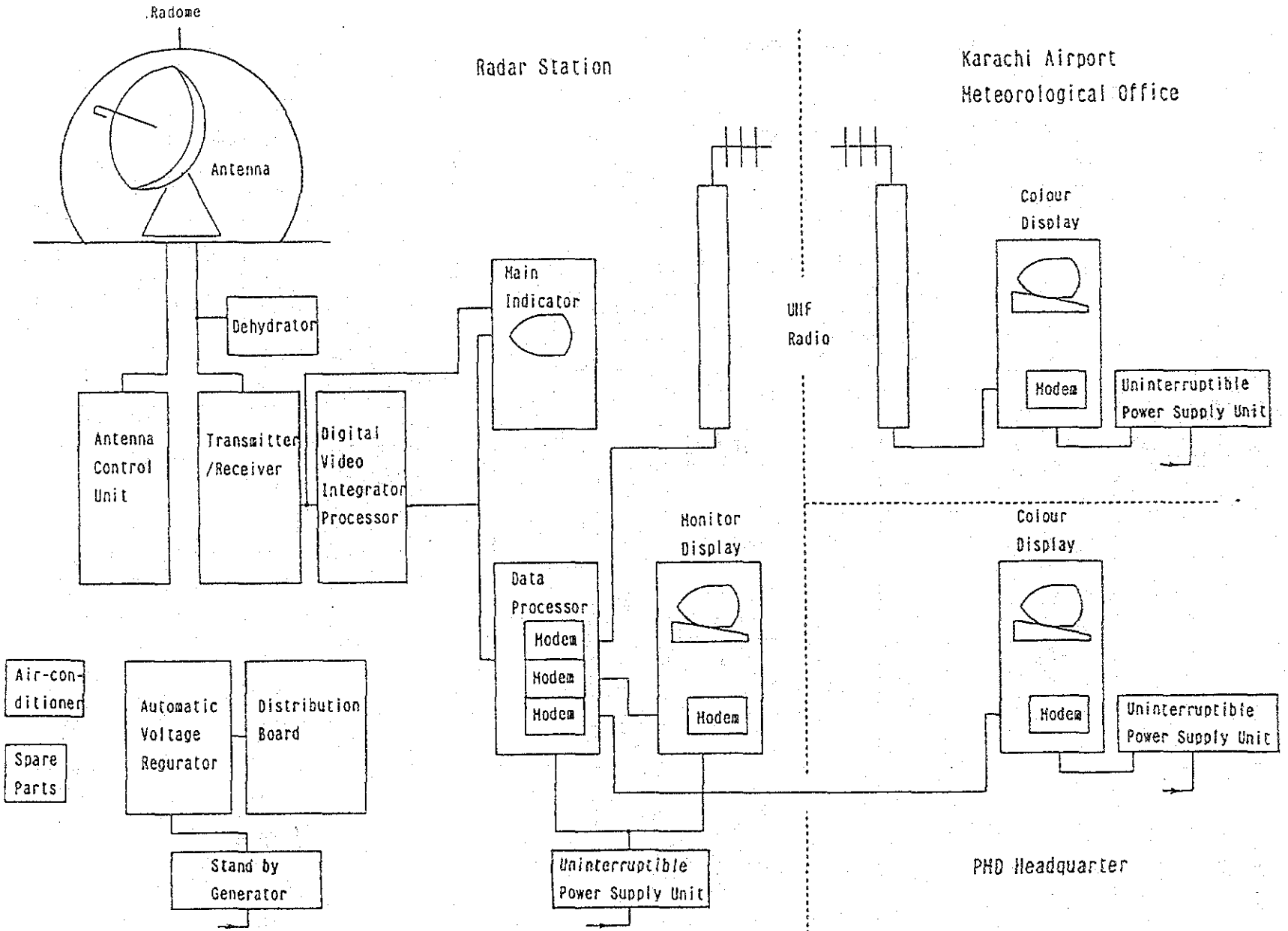


Fig. 4-2-1 Block Diagram of Radar System (Karachi)

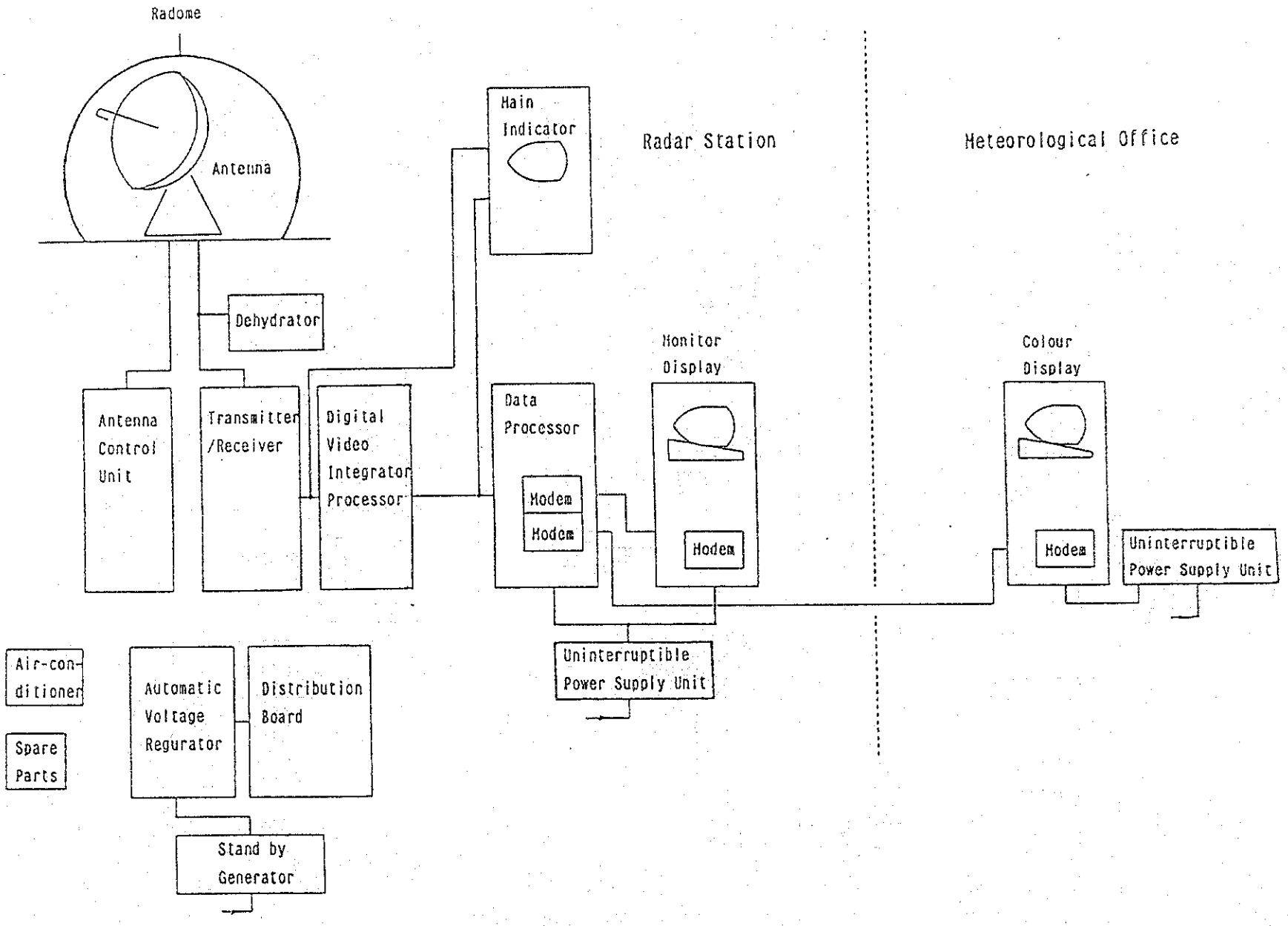


Fig. 4-2-2 Block Diagram of Radar System (Islamabad)

(3) Air conditioning

The purpose of installation of an air conditioner is to conduct smooth observation and smooth operation of the radar equipment in consideration of the natural environmental conditions in Pakistan. Karachi and Islamabad are both located in the high temperature areas where it sometimes reaches 45℃ in summer. Accordingly, it is very important to install air conditioners for protecting the equipment against such severe environmental conditions. For Islamabad, heating will also be included in the air conditioning system because the temperature goes down considerably in winter.

1) Rooms to be equipped with air conditioning system

Air conditioners will be installed in the following two rooms:

- Radar Equipment Room
- Observation Room

For other rooms, only a ventilation system will be introduced.

2) Design conditions

The following design conditions will be introduced based on the building design, meteorological data furnished by the PMD, CDA's standard and the design conditions of American Society of Heating, Refrigeration and Air-conditioning Engineers (ASHRAE).

- Outside temperatures

  Karachi

Summer season	36.7℃	D.B.,	27.8℃	W.B.
Winter season	10.6℃	D.B.,	7.2℃	W.B.

  Islamabad

Summer season	42.2℃	D.B.,	26.7℃	W.B.
Winter season	3.3℃	D.B.,	1.1℃	W.B.

- Room temperatures

Summer season	25℃	D.B.,	approx. 50%	R.H.
Winter season	20℃	D.B.,	approx. 50%	R.H.

- Number of staff

  Three staff members each will be engaged in Radar Equipment Room and the Observation Room.

· Heat dissipation of the equipment

The total estimated heat dissipation from the radar equipment is approximately 2,500 kcal/hour in each of the above rooms, consisting of 2,200 kcal/hour from the radar equipment, and 15 % of the amount for allowance.

The total capacity of the air conditioner will be approx. 15,000 kcal/hour at each site, consequently.

3) Method of air conditioning

An air conditioning unit of an air-cooled type will be installed with a view to easy handling and maintenance. A whole heat exchanger will be adopted for air intake to reduce the operational cost.

The outside units will be installed on a shockproof base placed on the roof of the lower part of the building.

For the heating system at Islamabad, an electric heater will be installed in each unit together with a humidifier for keeping adequate temperature and humidity in the rooms.

The air conditioners will be periodically changed over to the standby air conditioners manually. Troubles occurring in the air conditioners and related equipment can be monitored in Observation Room.

4-2-2 The Scheme of the Radar Towers

The scheme of the radar towers to accommodate the whole of the radar system will be as follows:

(1) Conditions of Construction;

① A radome will be installed on the roof of the tower;

② The transmitter/receiver assembly shall be installed as close as possible to the antenna in order to minimise the loss of transmitting power from the antenna through the waveguide;

③ The room for the installation of the radar equipment shall be airtight and equipped with air conditioners to protect the equipment room the high temperature, high humidity and dust;

④ The radar tower at Karachi shall be of the same height as the existing radar tower.
The radar tower at Islamabad should be of the maximum height permitted by the building codes and restrictions.

(2) Configuration Plan

① The height of the tower shall be 19.0m (5 storeys) at Karachi and 15.5m (4 storeys) at Islamabad, respectively.

② The radome and the antenna shall be installed on the roof.
The Equipment Room, Observation Room, Analysis Room, Data Room, Maintenance Room, Storeroom and Electricity Room shall be arranged on each floor according to the plan of the radar tower.
The standby generator is installed at the engine bed on the ground floor.

③ A special attention will be paid in structural design, as heavy instruments such as Antenna, Antenna Control Unit, Dehydrator and Transmitter/Receiver Assemblies shall be installed in the upper part of the tower.

④ The floor area of each Observation Room shall be 32.0 ㎡ both at Karachi and at Islamabad, providing enough space for four persons (three operators and one electrical assistant) to work in satisfactory conditions.

4-3 Basic Design of the Radar Towers

4-3-1 Site and Layout Plan

(1) Karachi

1) Project Site

The premises of the PMD Headquarters, which is the project site for construction of the tower, occupy a large area extending over 1.1 km from northwest to southeast and approximately 400 m from southwest to northeast. A quarter of the area in the southwestern part of the premises have been designated as a residential area for the staff members and there are buildings including the main building, the institute of meteorology and geophysics, the meteorological workshop, the central meteorological store, and the storage for cylinders occupying the front parts near the road from the centre to the northwest.

The site for the tower selected by the PMD is a flat area of approximately 4,000 m^2 between the existing radar tower and the storage for cylinders near the centre of the premises and is particularly suitable, with merits such as facility of laying new water pipes branching from the existing pipes, the proximity to the existing sewage pipes and its position opposite the power substation that caters for the whole of the premises.

2) Layout Plan

The new radar tower will be located parallel to the road running through the premises and will be almost at the centre of the selected site allowing for future horizontal extension by the PMD and flexibility of planning for external work. The position of the tower will be decided so as to make the tower face the power substation opposite the road running through the premises to facilitate induction of power from the substation to the standby generator room and so as to make effective use of the sewage disposal route running through the premises, as shown in the Basic Design Drawing No.02.

(2) Islamabad

1) Project Site

The project site, Islamabad Meteorological Centre, is situated approximately 1.3 km to the south of the Zero-Point, which may be called the gateway to Islamabad, in one of the districts designated for construction of special institutes called H-8. The premises are positioned on a corner where two roads under construction cross each other at an angle. Across the road on the east (Old Saidpur Road), there is a graveyard and across the road on the south the offices of WAPDA are now under construction. There are no buildings around the premises that may obstruct the radar except for the WAPDA building and the site is suitable for construction of a radar tower.

The premises of the meteorological centre form an irregular square and have an area of approximately 8,200 ㎡. A half of the area on the side of the road to the east is taken up by the existing buildings and gardens while the area in the northwest at the back of the buildings and the southern corner of the premises are taken up by the quarters for the staff, but there is an empty space of about 2,400 ㎡ and this space will be used for the construction of the radar tower. There is a gentle incline of about 1 m from north to south but this will not cause any problems for the construction of the tower.

2) Layout Plan

The radar tower needs to be constructed away from the 11 kV high-voltage power line traversing the premises from north to south. There is also a parabolic antenna for reception of NOAA images at the southern end of the roof of the existing building and this antenna faces west, perpendicular to the direction of the existing building. To ensure safety , layout of the tower to the north of the line running along the south wall of the existing building will be avoided.

These two conditions greatly limit the area where the radar tower can be built within the unused ground mentioned above. As shown in the Basic Design Drawing No.05, the new tower will be constructed 25 m away from the southern boundary parallel with the existing fence, leaving a space of 6.1 m (20 feet) from the western boundary to conform to the building regulations of the Capital Development Authority (CDA) at Islamabad.

(3) External Work Plan

It has been confirmed that the PMD will carry out the construction of roads, parking lots around the radar towers, etc., including planning of facilities in future within the premises, and hence, these are not included in the scope of grant aid from Japan.

4-3-2 Building Design

(1) Floor Plan

1) Allocation of Main Rooms

The rooms necessary for functioning of radar tower are the following eight rooms: Radar Equipment Room, Observation Room, Analysis Room, Data Room, Maintenance Room, Electricity Room, Standby Generator Room and Store Room, whose outlines and functions are listed in Table 4-3-1. The three main rooms, the Radar Equipment Room, Observation Room and Analysis Room cannot be separately allocated because of their functions and they should be considered as making up a unified zone or a block.

As explained in the next section, the required number of storeys for the tower wil be five at Karachi and four at Islamabad. The three main rooms mentioned above will be located as a block in the upper part of the tower at both sites and the other rooms including Maintenance Room, Storeroom, Electricity Room and Standby Generator Room in the lower part.

Since it will be desirable to make the waveguide between the antenna and the receiver as short as possible, Radar Equipment Room will be located on the top floor of the tower, Observation Room directly below this and Analysis Room below the Observation Room. The Data Room will adjoin Analysis Room to coordinate their functions and there will also be lavatories (for 1 person) annexed to Observation Room and Analysis Room which will be staffed usually. As the three main rooms in the upper part need to be protected from dust intrusion and the noise from the equipment in other rooms, they will be separated from the adjoining staircase with walls and airtight doors and the staircase itself will be located within the building and not exposed to the outside.

As the tower at Karachi is a storey higher than that at Islamabad, the Maintenance Room in the lower part will be located on the first floor for economic reasons.

Table 4-3-1 Description of Each Room of Radar Towers

Room	Floor Area(m²)	Number of Personels	Use of each room of radar towers
Roof	(83.0)	—	To load Antenna assembly, Radome and UHF antenna assembly(only in Karachi)
Radar Equipment Room	32.0	—	To set Antenna control assembly, Dehydrator, Transmitter/Receiver, Air conditioner and UHF radio transmitter/receiver (only in Karachi).
Radar Observation Room	32.0	1	To set Signal processor, Main indicator, Data processor, Monitor display, Uninterruptible power Supply, Modem, Airconditioner and Automatic voltage regurator. In this room, a radar observer is working.
Analysis Room	20.7	3	To make analysis of radar data and to disseminate analysis reports to users in off-line areas.
Radar Data Room	11.3	—	To store radar echo data and others data.
Radar Maintenance Room	32.0 Karachi 34.1 Islamabad	—	To store spear parts, test equipment and special tools and to carry out maintenance work.
Electricity Room	12.4	—	To set power distribution board and Water supply assembly.
Stand by Generator Room	34.1	—	To set a stand-by generator and ancillary equipment.
Storeroom	15.1	—	To store consumables, such as oil, grease, etc.
Total floor area ; 189.6m² (Karachi) 191.7m² (Islamabad)			

2) Determination of Span of Standard Floor Space in Upper Part

The area required for the Radar Equipment Room and Observation Room as worked out from the size of the radar equipment and the layout is around 30 to 35 ㎡. Judging from the number of steps required between each floor, the staircase will need about 15 ㎡ and the lavatories and pipe shafts another 5 ㎡. The space required for these rooms on each floor of the upper part adds up to around 50 to 55 ㎡ in total. The suitable distance between the columns, on the supposition that an outside wall will be constructed on the outside of the wall, will, therefore, be about 7 m. Since the estimated diameter of the radome to be constructed on the roof is approximately 7 m and even allowing for a maintenance space of about 1 m around the outside of the radome, the length of the cantilever slabs will be kept within 1.5 m, an estimation of 7 m span will be appropriate. For the basic design of the tower, 30 cm will be taken as the module and the span of the standard floor on the upper parts of the tower will be 6.9 m x 6.9 m (area between the centre of the walls : 51.4 ㎡). The layout plans of the radar machinery are shown in the Basic Design Drawing No.08.

3) Estimation of Floor Areas of Other Rooms

The bases for estimation of the required areas for other rooms shown in Table 4-3-1 are as follows.

Analysis Room

To accommodate three staff members. The average area per person in office rooms is approximately 7 ㎡, so about 20 ㎡ will be allotted in total.

Data Room

Allowing the room to be adjoined to the Analysis Room, approximately 10 ㎡ will be apportioned to the room out of the span division mentioned in the previous section. It will be capable of storing the observational data for about ten years which is the preferred time span for the record..

Maintenance Room

The space required to accommodate the spare parts and special instruments is estimated at about 10 ㎡. Repair work of the equipment is to be carried out in this room and an estimated area of 20 to 24 ㎡ is required for two men

working. The total space required will be about 30 to 35 ㎡.

Electricity Room

The area is determined from the sizes of equipment to be installed in the room such as the distribution board, cable racks, and pressure pumps, 10 to 15 ㎡ will be required.

Standby Generator Room

Approximately 20 ㎡ will be required to accommodate a 60 kVA engine generator. 15 ㎡ will be added for the service tank (420 ℓ) and the automatic switchboard. The total will be worked out at approximately 35 ㎡.

Storeroom

Approximately 15㎡ will be apportioned for storage of consumption goods such as oil and grease.

The total floor area of the radar towers will be 277.5 ㎡ at Islamabad and 296.7㎡ at Karachi, where there is additional space required for an extra storey.

(2) Elevation Plan

Because of the heights required for the radars, the new radar towers will be of four storeys at Islamabad and of five storeys at Karachi. The shape of the building when the various rooms required are allocated functionally and economically will have the bottom part extended sideways, and the tower at Karachi will be of an L shape, while that at Islamabad will be of an upside-down T shape, as shown in the Basic Design Drawings Nos. 04 and 07, respectively. As explained in the previous section, the upper parts of the towers will be made into a zone with the function of radar observation and the lower parts with that of maintenance such as Electricity Room and Standby Generator Room.

These designs were made on the assumption that the minimum number of staff required will be stationed at the towers. Since, however, there are possibilities of the PMD transferring all the observation personnel to the towers, the ground floors were designed allowing for further horizontal extension. Face brick masonry, which will give a soft texture suitable for administrative functions, will be used in exterior finish for the ground floor taking stability of the building into consideration.

Outside walls of the upper parts will have simple paint coated plastered finish suitable for a radar tower accommodating radar equipment which make use of the latest technology. As the radar observation equipment need to be kept away from direct sunlight and dust, the rooms in the upper part must comprise enclosed spaces. The windows and openings should be of the minimum sizes required for circulation of air and should be positioned away from the equipment. Consequently, they will be located at the centre of the tower on each floor.

(3) Sectional Plan

1) Height of the Tower and Each Floor

The minimum height of the tower from the surrounding ground level to the roof slabs calculated from the requirement on installation of the radars are 19 m at Karachi and 15 m at Islamabad.

The suitable height of each floor is 3.5 m considering such items as the estimated height of the equipment and wiring space in the ceiling. This figure will be adopted as the standard height of each floor in the upper storeys.

The rooms in the bottom storey will not be equipped with air conditioning. Since heat is generated in Electricity Room and Standby Generator Room and because of the storage function of Storeroom, it will be desirable to raise heights of the ceilings. For these reasons, the height of the bottom storey will be 4.5 m which is greater than that of the upper storeys. The ground floor level will be raised 50 cm above the surrounding ground to allow for rainfall in Pakistan.

It is worked out from the above that the tower at Karachi will be of five storeys and the height of its roof slabs 19 m. The tower at Islamabad will be of four storeys and the height of its roof slabs 15.5 m. For both sites, the figures show the minimum reasonable design and the height of the tower at Islamabad will conform to the administrative directions of the CDA for the area (maximum of four storeys and maximum height of 60 feet).

2) Ceilings

In Radar Equipment Room and Observation Room, a false ceiling will be introduced to protect the machinery from the dust gathering on the table racks, to raise the airtightness of the rooms and to reduce the noise from the machinery. Ceiling boards to be used will have a high level of sound absorption. As these rooms will be air conditioned, false ceilings will also be effective for the system. From the estimated heights of the equipment, the height of the ceiling will be about 2.7 m.

As each lavatory is crossed by the pipes connected to the pipe shafts, ceilings are to be boarded with water resistant materials and their height will be about 2.5 m.

3) Radome and Radar Equipment Room

The base of the radome and the antenna assembly will be unified with the roof slabs and the load of the radome and the radar assembly is to be taken by a beam at the centre of the roof slab. The base of the radome will also function as the rise of the waterproof layer on the outside of the radome and simple waterproofing will be applied on the inside of the radome. Access to the inside and the outside of the radome will be secured through steel ladders and hatches are to be provided in Radar Equipment Room and Anteroom, respectively.

4) Method of Lifting Equipment

To lift the equipment directly into Radar Equipment Room and Observation Room from the outside, large openings will have to be made in these rooms, which is not desirable in the light of airtightness and dust prevention. The equipment will, therefore, be transported from the staircase and a loading balcony will be provided outside the landing of Staircase on the route between the two rooms. The hooks for lifting the equipment should be able to withstand a load of 2 tons and beams for the lift are to be set up protruding from below the roof slab and on the upper part of the balcony.

(4) Structural Plan

1) Structural Design Standards

In Pakistan, the Capital Development Authority (CDA) and the Karachi Development Authority (KDA) lay down building regulations. Both generally follow British Standards (BS), but there are no standards for structural design established especially for Pakistan. Since, while Pakistan is a country prone to earthquakes situated on the Eurasia Seismic Zone, the British Standards themselves are not set for areas prone to earthquakes, the KDA encourages the use of UBC Standard (United Building Code, 1982) of the U.S. as bases for calculation of figures related to seismic forces. In the structural design of the radar towers, therefore, UBC Standard will be used for matters related to earthquakes, and as for other external forces, such as wind load and bearing capacity of soil, design will be made in accordance with the local circumstances in Pakistan.

2) Design Load and External Forces

a) Dead Load

The weights of all the structural and finishing materials to be used for the tower will be calculated. As an extra fixed load, 3 tons which is the estimated total weight of the radome and the antenna assembly installed on the roof, will also be included in the load.

b) Live Load

As most of the rooms in the radar tower either accommodate machinery or function as storerooms, the live load is considered to be uniform throughout except for the roof. The live load is estimated to be nearly the same as the standard load of telecommunication equipment rooms in Japan and the following figures will be adopted.

For floor slabs and beams	500 kg/sq.m.
For rigid frames	400 kg/sq.m.
For calculation of seismic force	300 kg/sq.m.

Considering maintenance staff walking on the roof, the load on the roof is estimated at 180, 130 and 60 kg/ ㎡, respectively, on the basis of the Building Standard Law in Japan.

c) Wind Load

The maximum wind speed in the past 33 years at Islamabad was 89 mph (approx. 39.5m/s) recorded in July 1970. No data could be obtained for Karachi, but KDA has adopted the maximum wind speed of 140 km/h (approx. 38.9 m/s) for the purpose of calculating wind pressure in design. The maximum figure of 39.5 m/s at Islamabad has been adopted for the purpose and the figure of 40 m/s will be used in actual calculations to be on the safe side.

d) Seismic Forces

Calculations will be made on the basis of UBC Standard as encouraged by the KDA. The distribution of earthquakes in Pakistan is shown in Figure 4-3-1, from which it can be observed that both Islamabad and Karachi belong to grade III (minor areas) with seismic accelerations of g/15 to g/20. The same seismic zonal factors can be used for both sites and the figure of Z = 3/8 given in the "Seismicity of Karachi" published by the KDA will be adopted. Co = 0.10 will be used as the standard shear factor.

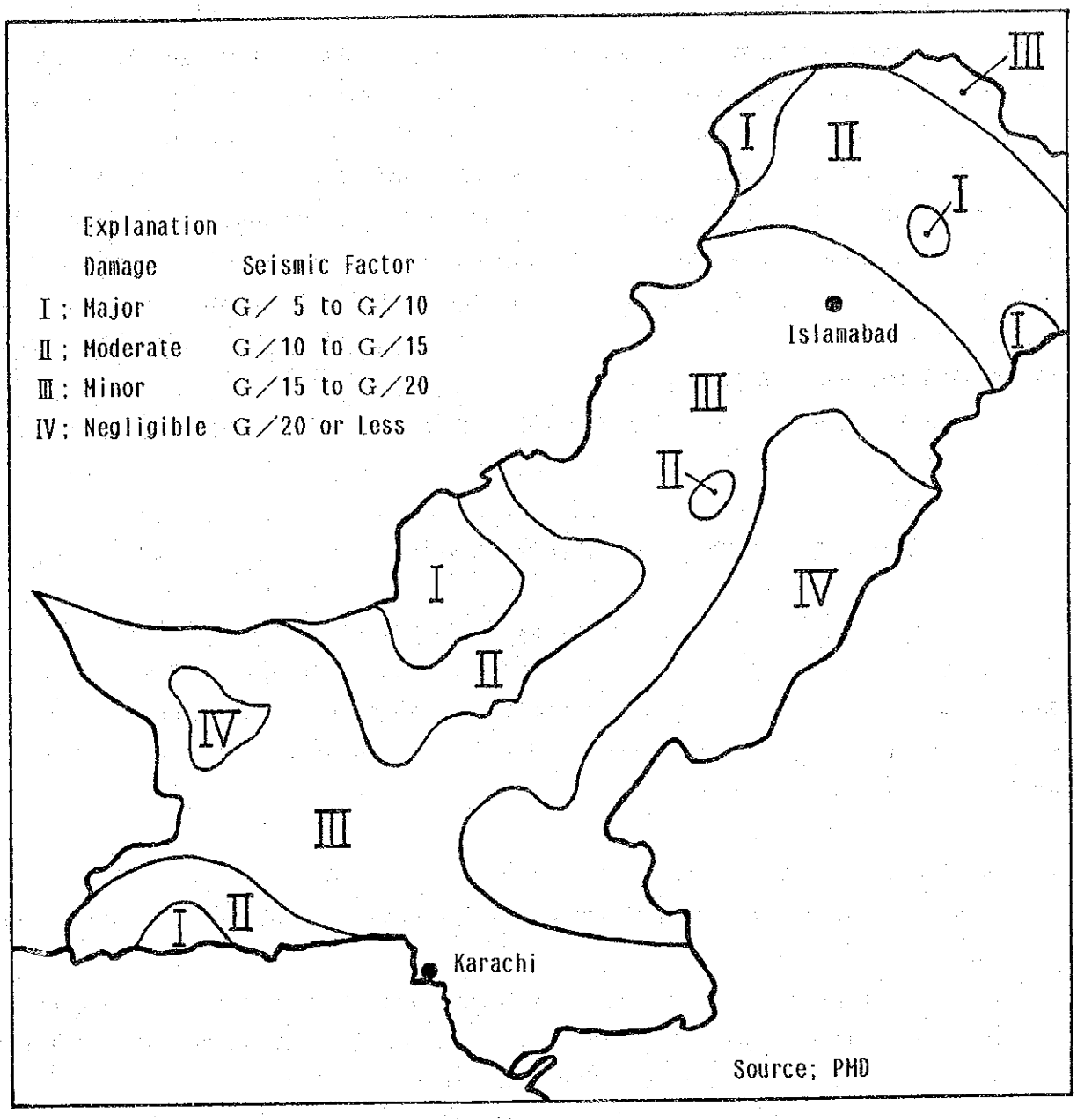


Fig.4-3-1 Seismic Zones of Pakistan

e) Bearing Capacity of Soil

According to the information provided by the CDA and the KDA and the results of soil investigations carried out at the sites, the soil of the site at Islamabad belongs to the clay silt layer and there is very little sand, while that at Karachi is mainly sand and there is little clay and silt. Based on the CDA's and KDA's boring data from the areas around the sites, the expected bearing capacity of soil at Islamabad is 1 to 2 ton/sq.ft. and that at Karachi 1 to 1.5 ton/sq.ft. To be on the safe side, the figure of 1 ton/sq.ft. (approx. 11 ton/sq.m.) is adopted for purposes of basic design. As the surface soil is relatively soft at both sites, the depth of embedment for the base will be set at 1.2 m within the range of 1 to 1.5 m encouraged by the CDA and the KDA.

The final values will be decided by carrying out boring tests at the sites.

3) Construction Method and Construction Materials

A rigid framed structures of reinforced concrete, most suited to the functions as radar towers, will be adopted and, as the soil at both the sites have adequate bearing capacities, a direct foundation will be designed. Steel framed structures will not be used because of the disadvantages listed below.

(Disadvantages of Steel Framed Structures)

- The quality of steel frames produced in Pakistan is not uniform and their supply is not stable.
- There are problems in processing, welding and construction techniques in Pakistan and materials will have to be imported from Japan and engineers sent over if steel framed structures are to be applied.
- Even if steel frames are used for columns and beams, for the purposes of installation of the equipment and to maintain airtightness of the rooms, they will have to be surrounded by walls of brick or concrete, and the floors have to be of concrete with deck plates as their base.
- In addition to the above, as the foundation needs to be of concrete, the volume of concrete required will not be greatly reduced and the construction period cannot be shortened even if steel frames are procured in Pakistan.

- Although steel frames are not combustible, since they are not fire-resistant, they need to be given a fire-resistant cover when used as the main construction material and this will lead to a large increase in the cost of the finishing materials.
- From the above, it is estimated that the cost of steel framed structures will be 30 to 50 % higher than that of a rigid framed structures of reinforced concrete.

Since the construction materials of concrete aggregate and cement (BS standard material) can be obtained in Pakistan and as their quality is good and their supply stable, local materials will be used for the construction. For the reinforcement, both deformed and round bars conforming to BS specifications are produced in the country and there are no disadvantages in its quality except for the demerit that the length of bars are 12 m and that they are bent in the middle for transportation. The structural materials as well as the finishing materials, will be obtained in the country.

4-3-3 Building Equipment Plan

(1) Electrical Installation

1) Initial Power Reception and Mains

a) Karachi

There is a transformer equipment approx. 70 m northwest of the planned construction site within the PMD Headquarters premises. The transformer supplies all the electricity used by the facilities within the premises. Electricity of 200 A is supplied to the existing radar station from the switchboard at present and it was confirmed in the discussions with the PMD that this power supply will be used for the new radar tower and the existing station is to be served through a spare circuit. As at Islamabad, the laying and the connection of the new lines to the main switchboard within the new tower are to be carried out by the Pakistani side and the work on the lines from the main switchboard is to be carried out by the Japanese side. As it is expected that the main lines at both Karachi and Islamabad will be laid underground, a manhole will be provided in front of Electricity Room where the main switchboard is to be located and the manhole and the switchboard will be connected with an appropriate sleeve.

b) Islamabad

There is a pole-mounted power transformer with a capacity of 50 kVA within the premises of the Islamabad Meteorological Centre and power is supplied from here to the meteorological centre and the quarters of the staff nearby. The power reception capacity of the new tower is approximately 50 kVA and the existing transformer needs to be replaced with a new transformer with a large enough capacity to cater also for the tower. The laying of the line on the secondary (low voltage) side from the transformer by a 3 phase 4 wire system at 400/230 V 50 Hz and the connection to the main switchboard in the tower is to be carried out by the Pakistani side and the electrical work from the switchboard will be carried out by the Japanese side.

The main switchboard will be located in Electricity Room on the ground floor and power will be supplied for use in items such as the radar equipment, lighting, water supply and air conditioning through metal ducts and steel

conduits or vinyl conduits.

The system of the mains are shown in Figure 4-3-2.

2) Lighting Fixtures

Fluorescent lamps will be used to reduce operational costs and to raise efficiency. The planned illumination in each room will be as follows in accordance with Japanese Industrial Standards (JIS).

Radar Equipment Room, Observation Room, Analysis Room and Data Room.	..... 400 luxes
Electricity Room, Standby Generator Room, Storeroom.	..... 200 luxes
Corridor, Staircase, Lavatories.	..... 100 luxes

As it is expected that CRT equipment will be installed in the Observation Room, glareless illumination method will be introduced to provide suitable lighting ambience.

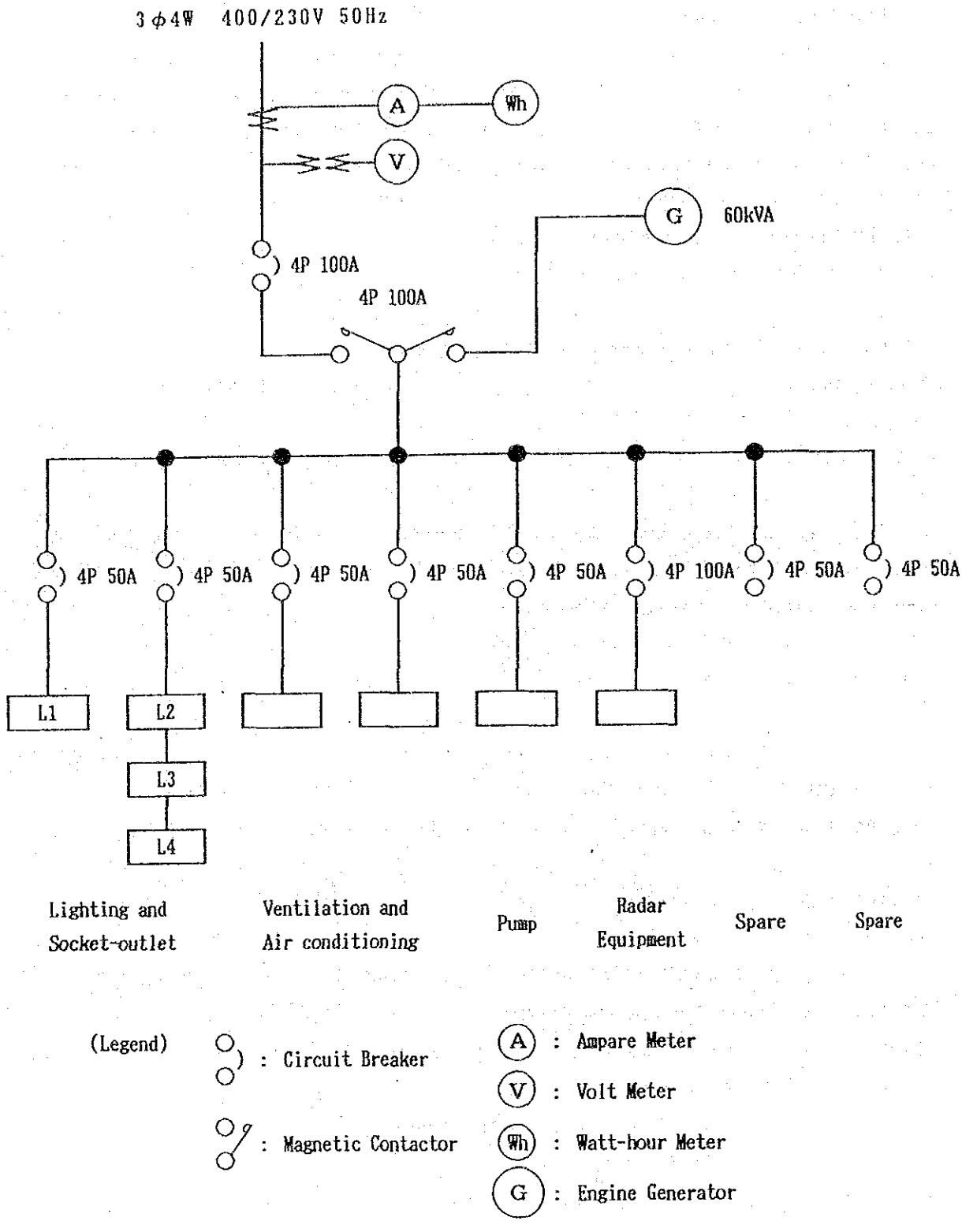
3) Socket Outlets

Socket outlets for ordinary use and for use in operation of the equipment will be installed in each room. They will be of round pin types with an earth in accordance with BS specifications adopted in Pakistan.

4) Telephone Conduits

Telephone conduits will be provided between the telephone terminal boxes and from the boxes to the telephone outlets to facilitate the wiring and the installation of telephones at the required locations in each room.

Figure 4-3-2 POWER-RISER DIAGRAM



5) Earthing System

An earthing system will be provided as required for the radar equipment and for the building ancillary equipment.

Required earth resistances are as follows;

for building ancillary equipment ..... 100 Ω
for radar equipment ..... 10 Ω
for lightning conductors ..... 10 Ω

(2) Water Supply, Drainage and Sanitation

1) Source of Water

The project sites at both Karachi and Islamabad are served by the city water supply. At Karachi, the new facility will be served by laying a branch line from the existing water line served from the water tank on the roof of the PMD Headquarters and crossing the premises. A water supply point will be located at a suitable position around the building. At Islamabad, city water will be served by providing a water supply point with a gate valve at a suitable point near the boundary of the premises.

At both the sites, the Pakistani side will be responsible for laying the line up to the water supply points and the connections.

2) Calculation of Quantity of Water

Because of the special nature of the radar tower, the estimated use of water is rather low compared with ordinary office buildings. The amount used per person per day is calculated at about 100 ℓ. With a maximum of five people using the facility, the estimated required amount is 500 ℓ per day.

3) Water Supply

Because of the heights of the tower, it would be desirable to use raised tanks. As the roof of the tower, however, is occupied by the radome and it will be uneconomical to build separate elevated tanks, pressure pumps with a tank will be introduced. Steel water supply pipes which are suitable for use with pressure pumps will be adopted, accordingly.

4) Drainage

a) Sewage

A sewage system will be made within the premises using septic tanks and soak pits as commonly adopted in Pakistan.

b) Drainage of Rain Water

As there are no public drainage systems at both sites, rain water from the roofs will be disposed of by natural seepage.

5) Sanitary Fixtures

Lavatories will be located next to Observation Room and Analysis Room and under the staircase on the ground floor and a set of water closet and wash basin will be installed in each of them.

6) Fire Extinguishers

1.5 kg dry chemical fire extinguishers will be installed in each room.

(3) Ventilation

Because of its special character, the tower will be an enclosed one and the window openings will be kept to a minimum. For this reason, except for airconditioned rooms, ventilation will be provided for all the other rooms as well as the radome. An outline of the ventilation in each room will be as follows;

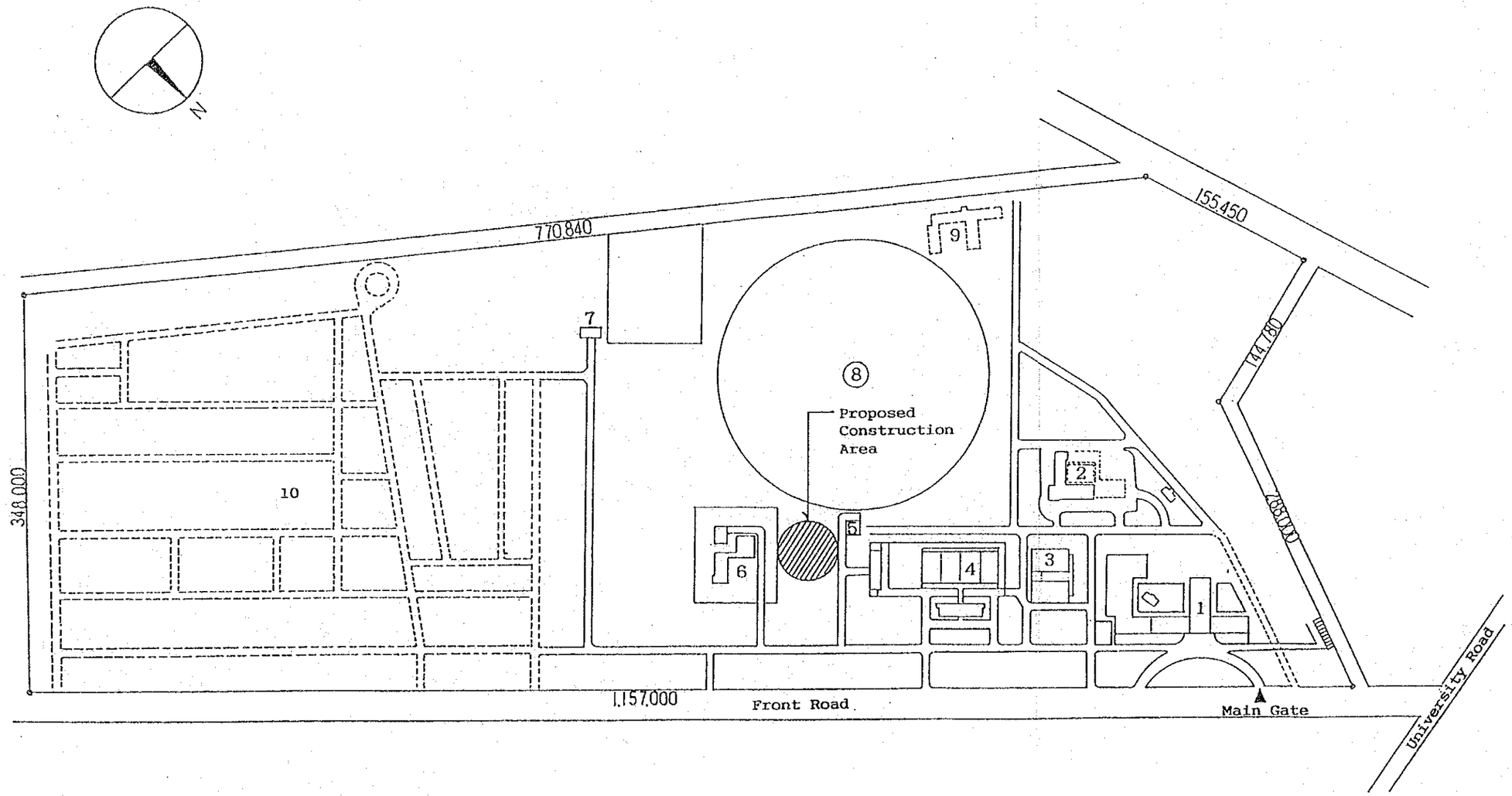
Room Name	Method of Ventilation	Frequency of Air change
(Radome)	MI + ME (*1)	10 times/hour
Analysis Room	NI + ME (*2)	5 times/hour
Data Room	NI + ME	5 times/hour
Maintenance Room	NI + ME	5 times/hour
Electricity Room	MI + ME	5 times/hour(*3)
Standby Generator Room	NI + ME	30 times/hour(*3)
Storeroom	NI + ME	5 times/hour
Lavatories	NI + ME	10 times/hour

(Remarks) *1:'MI+ME' means mechanical air intake and mechanical air exhaust.
*2:'NI+ME' means natural air intake and mechanical air exhaust.
*3: Actual figures will be determined in accordance with the heat dissipation of the equipment to be installed in the rooms.

Air intake for lavatories will be made through grilles from the adjacent room and air exhaust will be made with a ceiling fan and a duct. As for air intake for the other rooms, they will be protected with filters from dust intrusion. Ceiling fans, which are commonly used in Pakistan will be installed in the three rooms; Analysis Room, Data Room and Maintenance Room.

4-4 Basic Design Drawing

(1) Karachi Radar Tower / Site Plan
(2) Karachi Radar Tower / Site Layout Plan
(3) Karachi Radar Tower / Floor Plan
(4) Karachi Radar Tower / Elevation and Section
(5) Islamabad Radar Tower / Site Layout Plan
(6) Islamabad Radar Tower / Floor Plan
(7) Islamabad Radar Tower / Elevation and Section
(8) Layout Plan of the Radar Equipment

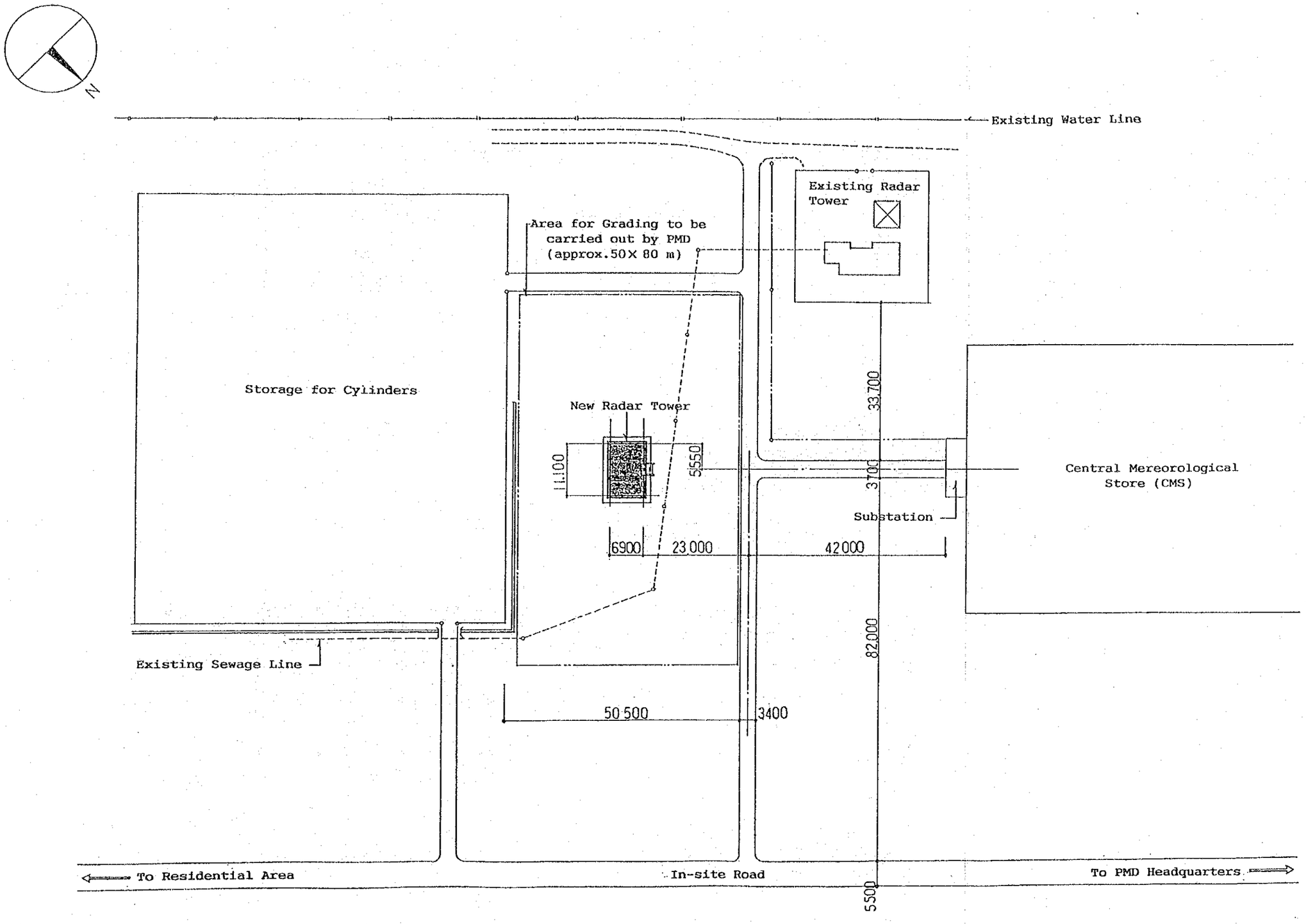


(Existing Buildings in PMD Headquarters Site)

1 : PMD Headquarters
2 : Institute of Meteorology & Geophysics (IMG)
3 : Meteorological Workshop
4 : Central Mereorological Store (CMS)
5 : Existing Radar Tower
6 : Storage for Cylinders
7 : Seismic Observatory
8 : Model Observatory
9 : IMG Hostel (Under Construction)
10 : Residential Area

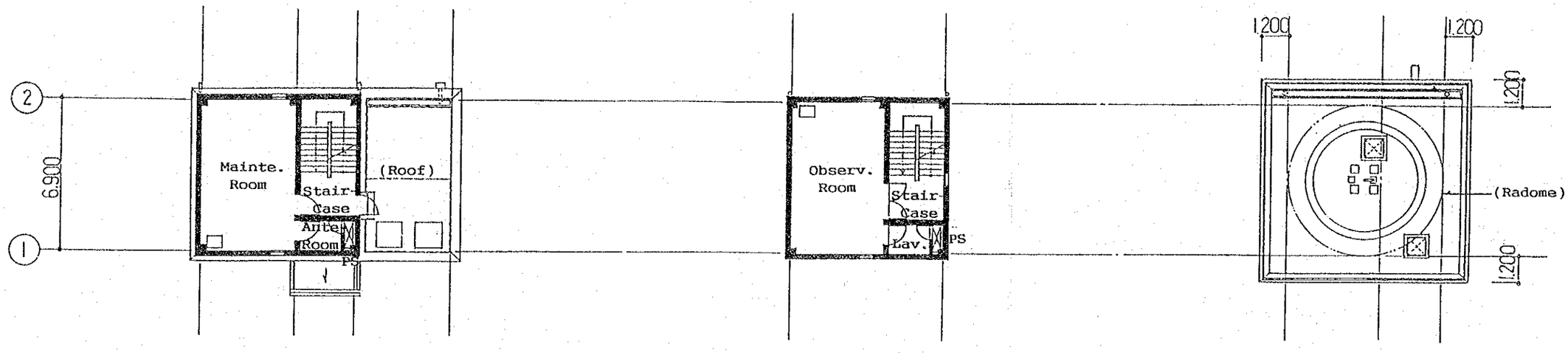
KARACHI RADAR TOWER / SITE PLAN SCALE 1:4000

01



KARACHI RADAR TOWER / SITE LAYOUT PLAN SCALE 1:800

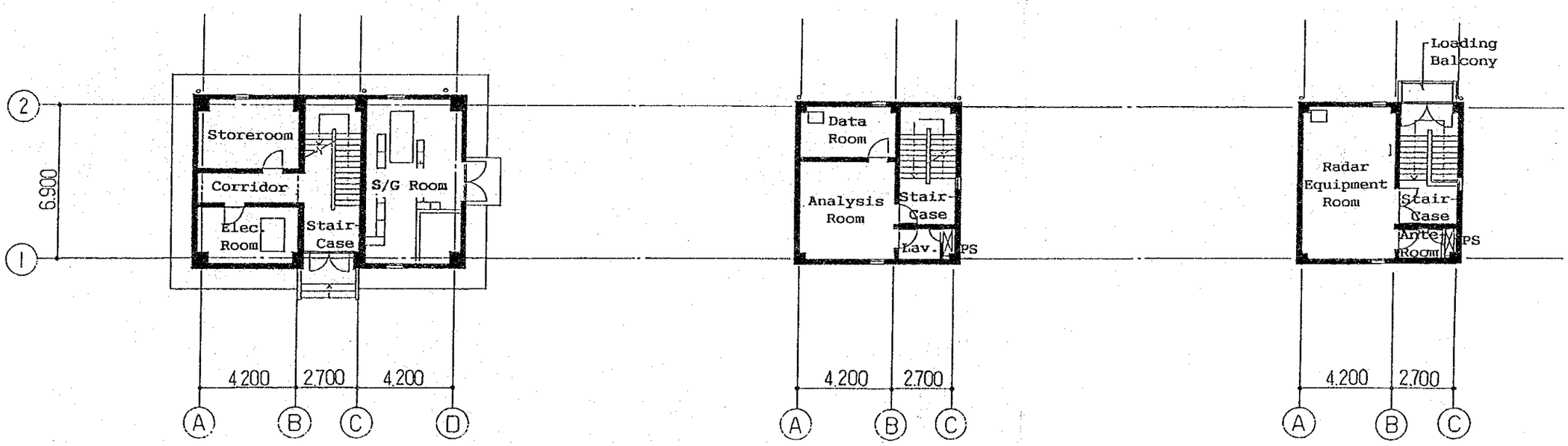
02



First Floor

THIRD FLOOR

Roof Floor

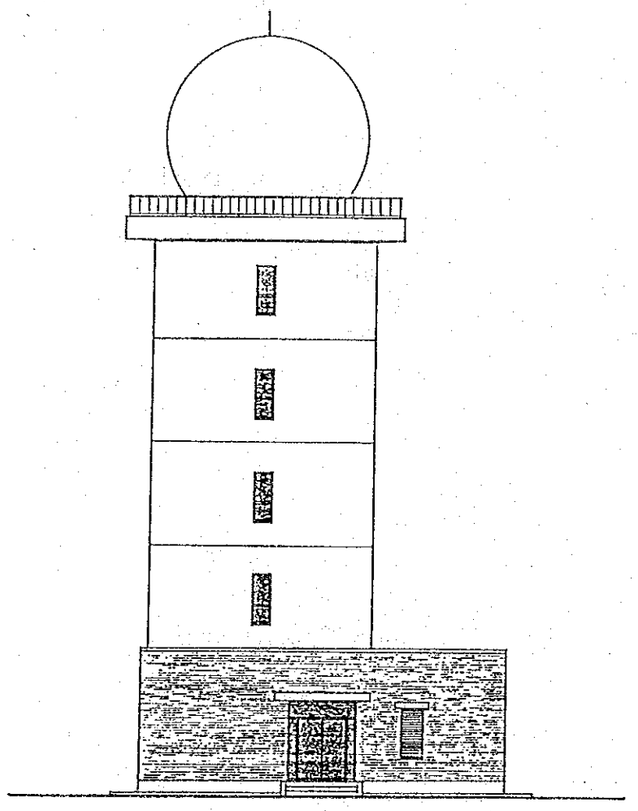


Ground Floor

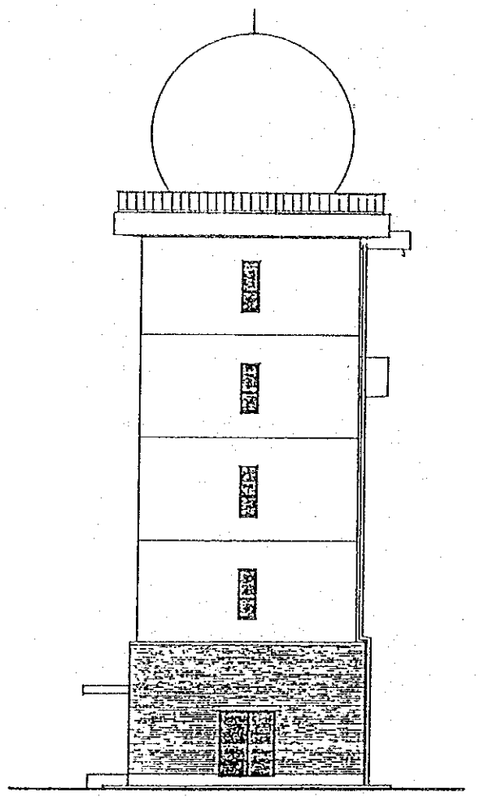
SECOND FLOOR

FOURTH FLOOR

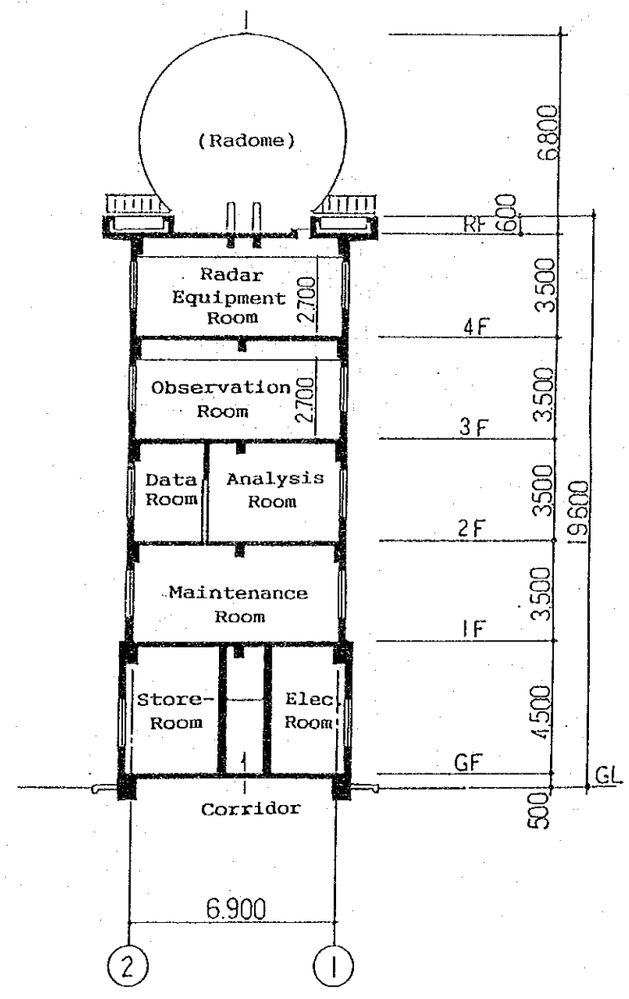
KARACHI RADAR TOWER / FLOOR PLAN SCALE 1:200



NORTHWEST SIDE ELEVATION

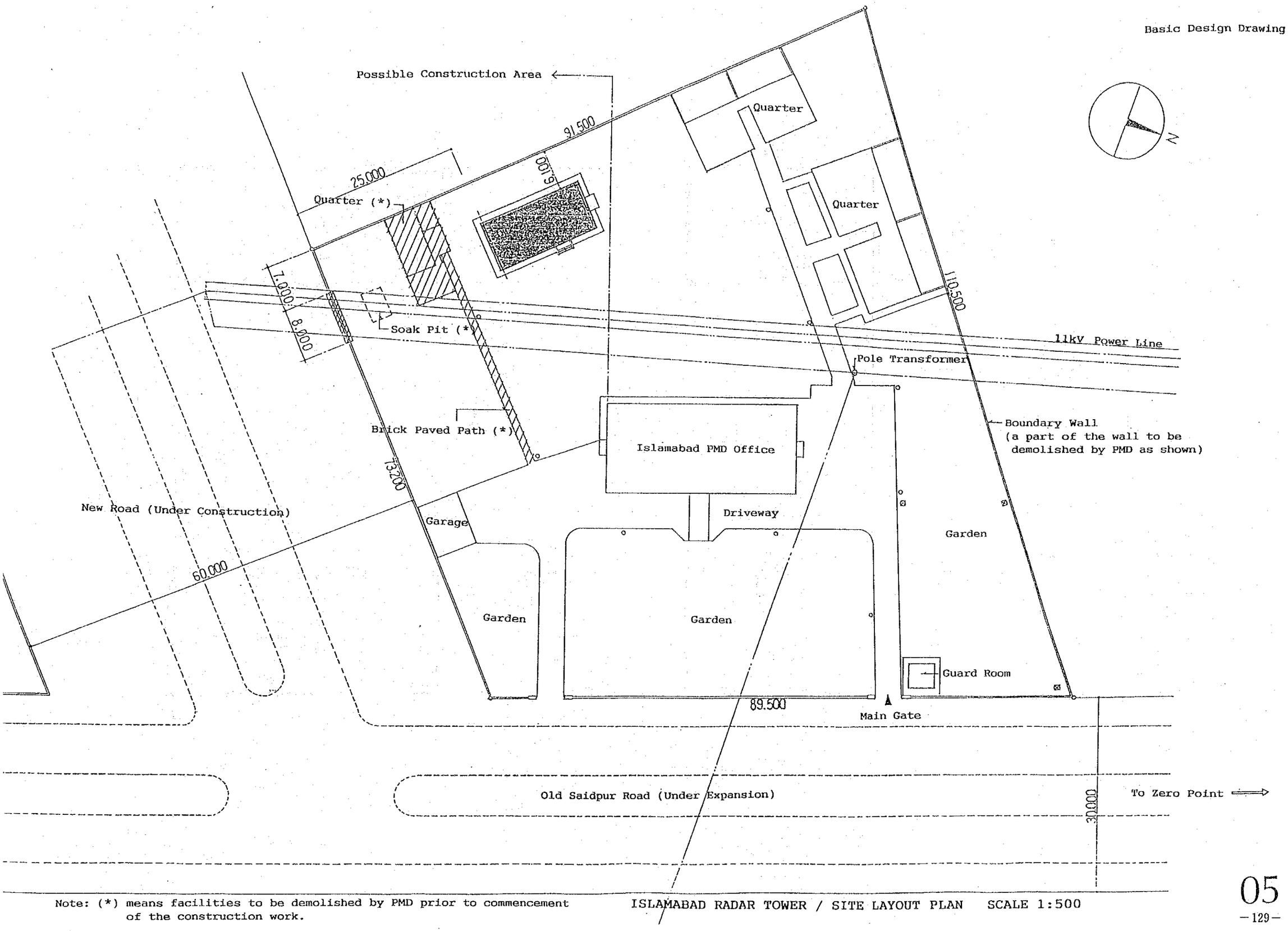


SOUTHWEST SIDE ELEVATION



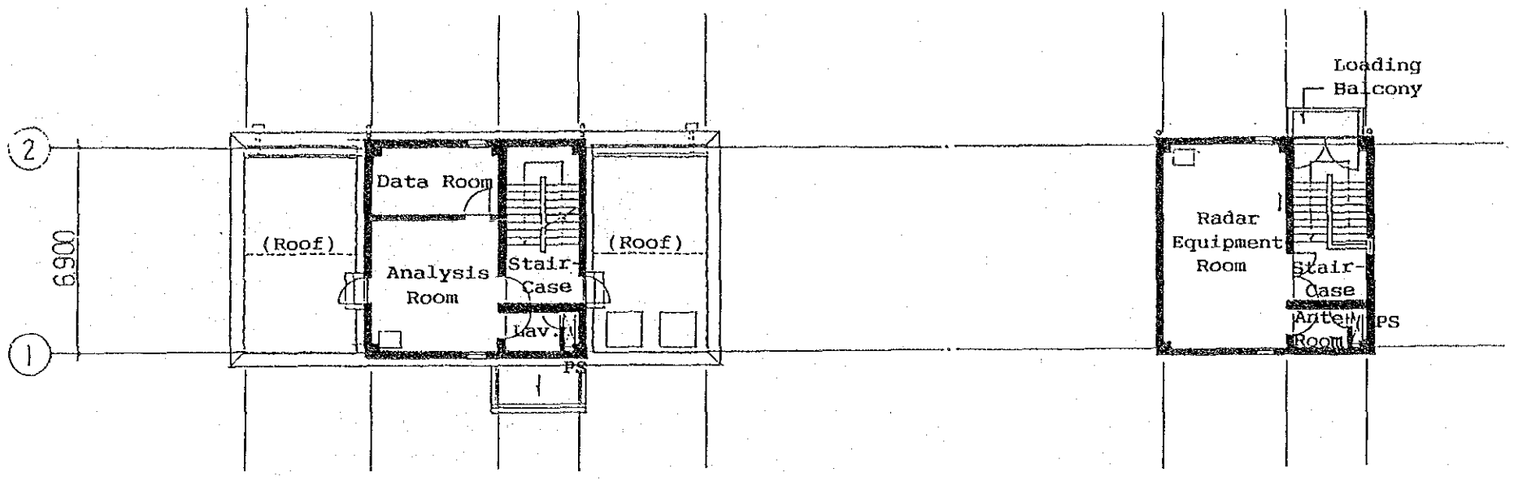
SECTION

KARACHI RADAR TOWER / ELEVATION AND SECTION SCALE 1:200



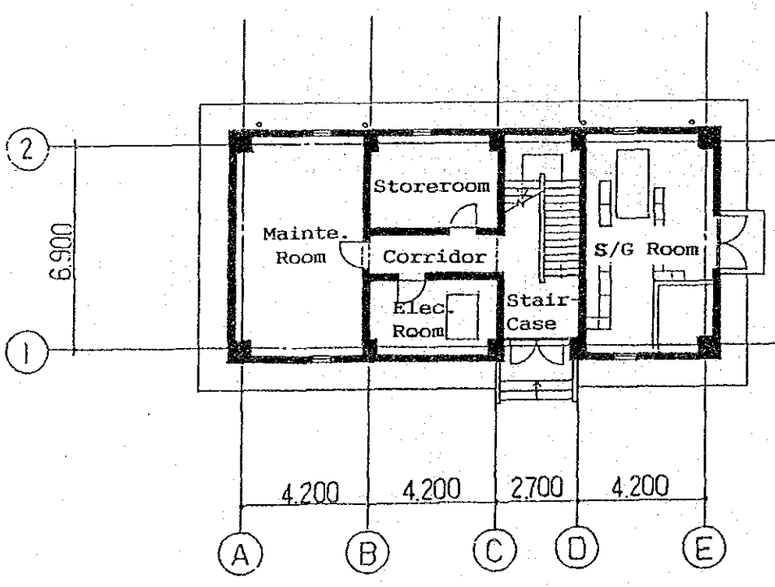
Note: (*) means facilities to be demolished by PMD prior to commencement of the construction work.

ISLAMABAD RADAR TOWER / SITE LAYOUT PLAN SCALE 1:500

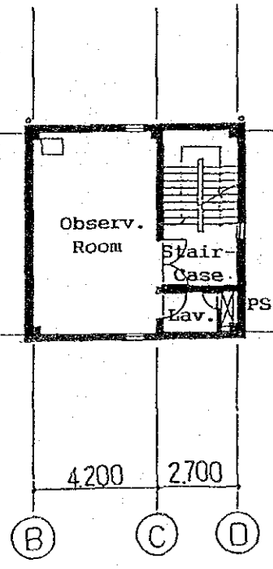


FIRST FLOOR

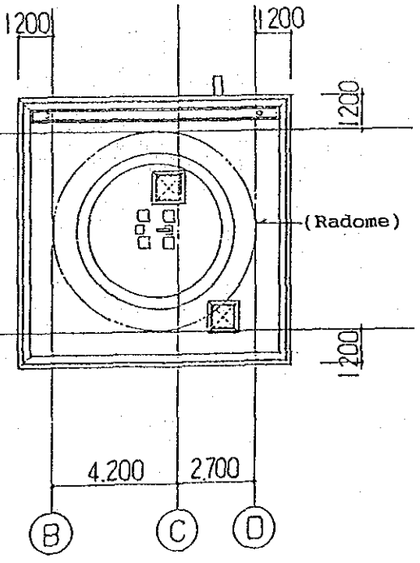
THIRD FLOOR



GROUND FLOOR

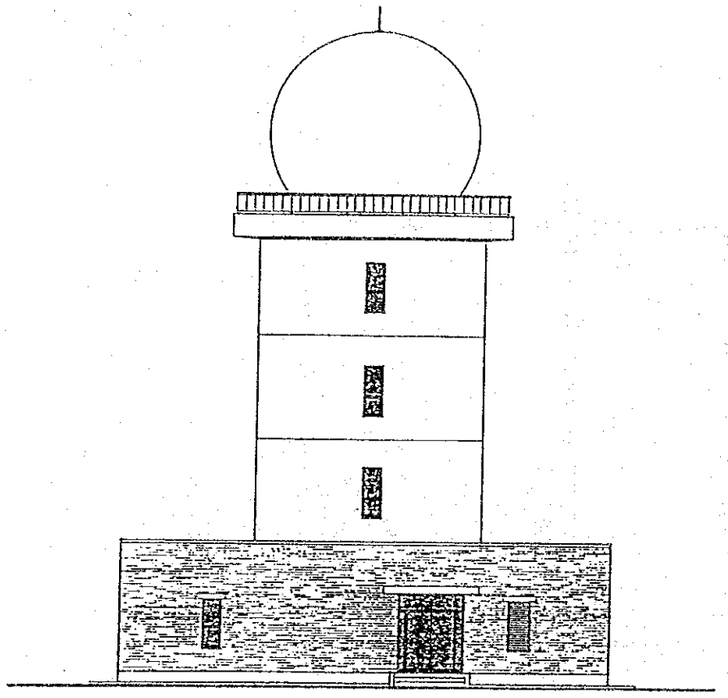


SECOND FLOOR

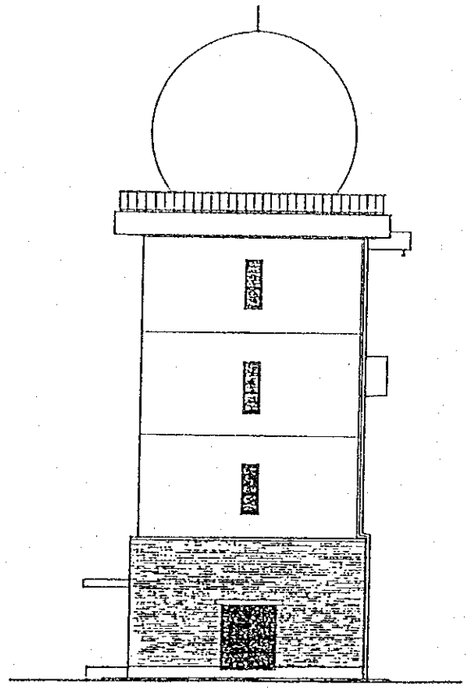


ROOF FLOOR

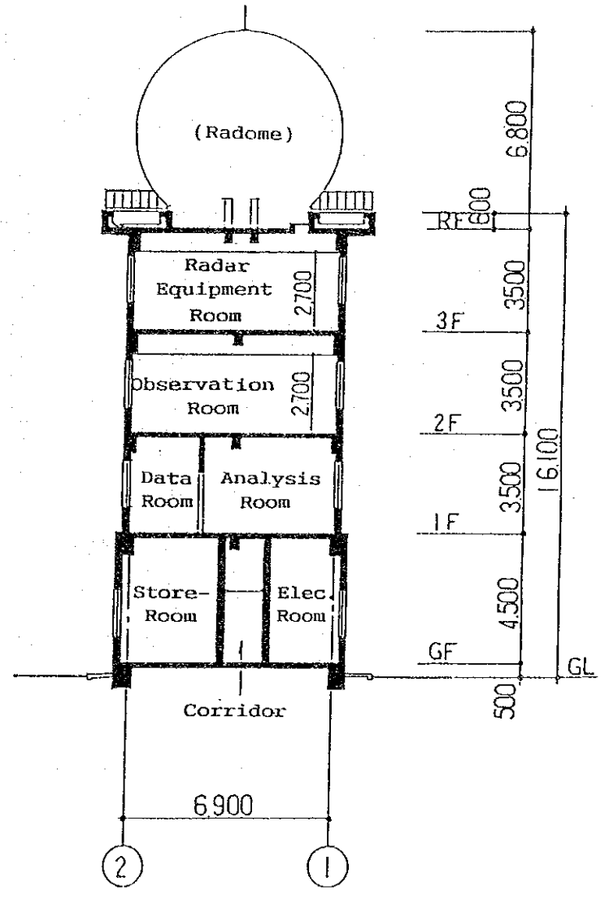
ISLAMABAD RADAR TOWER / FLOOR PLAN SCALE 1:200



NORTHEAST SIDE ELEVATION

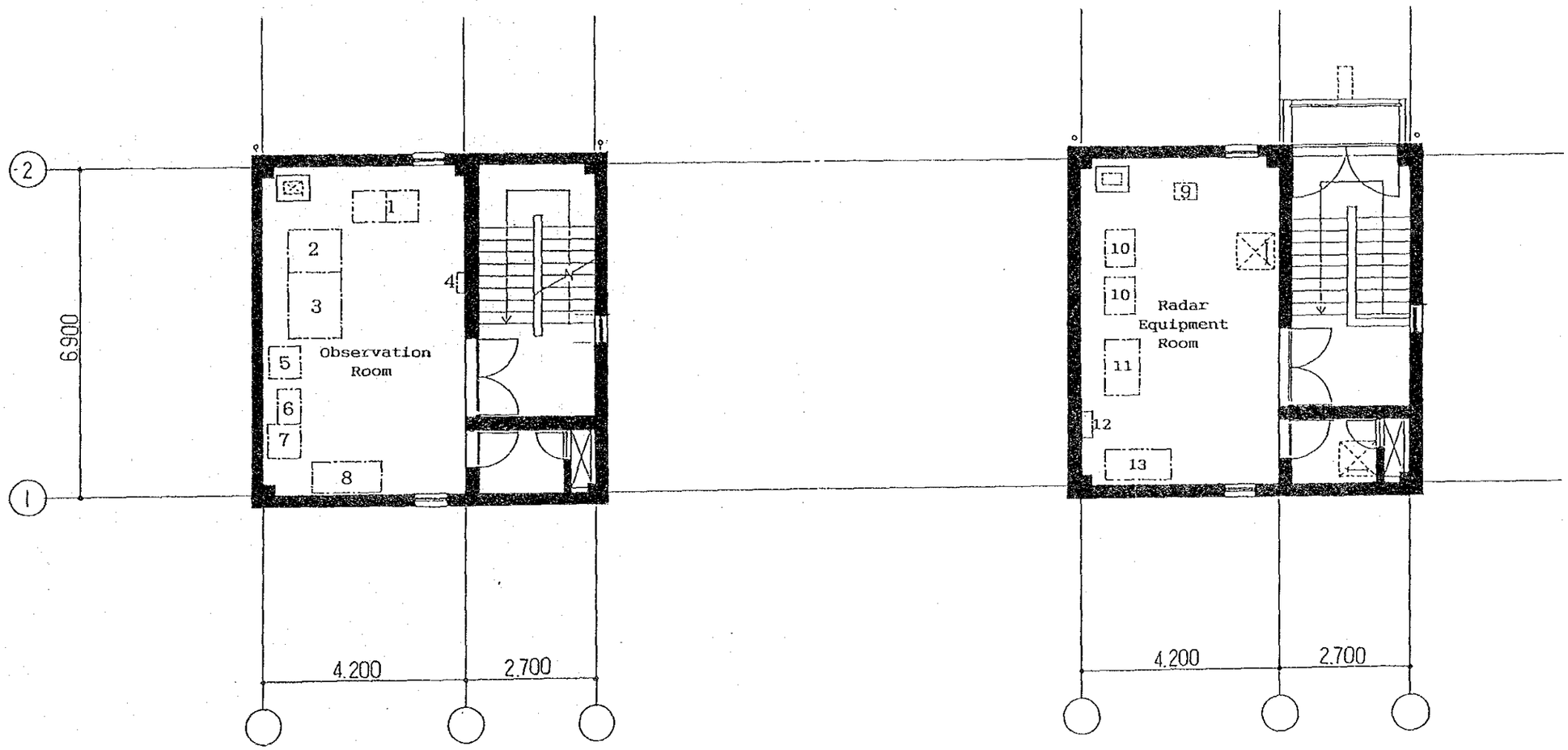


NORTHWEST SIDE ELEVATION



SECTION

ISLAMABAD RADAR TOWER / ELEVATION AND SECTION SCALE 1:200



(Radar Equipment)

1 :	Degital Video Integrator Processor (DVIP)	9 :	UHF-band Radio Equipment
2 :	Colour Monitor Display	10 :	Antenna Control Unit
3 :	Main Indicator (PPI)	11 :	Transmitter / Receiver (C-band, 250 kW)
4 :	Clock	12 :	Dehydrator
5 :	Uninterruptible Power Supply Unit	13 :	Air-conditioner
6 :	Power Distribution Board		
7 :	Automatic Voltage Regulator		
8 :	Air-conditioner		

LAYOUT PLAN OF THE RADAR EQUIPMENT SCALE 1:100

4-5 Implementation Plan

4-5-1 Principles of Implementation

(1) Special Characteristics of Construction and Plan of Execution Personnel

The project is to provide radars and to carry out replacement work and construction of radar towers for the installation of new radars. For this reason, the project involves both machinery work and construction work as well as the necessary adjustment.

The machinery work refers to the production of the radars in Japan, their transportation to the sites and installation at the sites, and the construction work refers to the construction of the radar towers.

As the construction will have to be carried out simultaneously at Karachi and Islamabad and the distance between these two cities is more than 1,000 km, a manager for the construction will be appointed at each site to supervise the work of construction from its commencement to its completion. A chief engineer will be sent by the manufacturer of the radars during the required period to supervise the construction at both sites.

(2) Basic Principles for Implementation

1) The personnel who are engaged in the machinery work and the construction works will take full responsibility for their respective areas, carry out their duties and maintain proper order and coordination.
2) Functions and capability in conformity with the specifications must be achieved in the machinery works.
3) Quality of construction materials and finish must be assured in the construction work.
4) Work must be carried out smoothly by maintaining constant communication with the Japanese side and with those involved in Pakistan.
5) Work must be carried out smoothly by maintaining excellent cooperative manners amongst the owner, the consultants and the constructors.

(3) Items of Note in Implementation

1) Drainage of the excavation surface and application of sufficient pressure to the bankings
2) Placement and curing of concrete during the hot weather season
3) Consultation and adjustment of the schedule concerning construction and commencement of the installation of machinery.
4) Protection of imported materials, especially electronic parts at the time of installation.