



## RADIO FREQUENCY SHIELDING OF A MULTI-STORIED BUILDING AT GMRT OBSERVATORY

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### Abstract

Engineering laboratories and auditorium build near a radio telescope facility require RF shielding to minimize the conducted and radiated emission from electrical and electronics equipment. The GMRT has built a six-sided RF shielded multipurpose building with an auditorium of 200-member seating capacity and four engineering laboratories. This paper presents the RF shielding design which encloses the entire two storied building in a Faraday Cage. A two-layer shielding mesh of stainless steel and copper is used for shielding and to isolate both the inner and outer shield to prevent the coupling and conductive path between the two shielding layers. The RF shielding uses waveguides for all pipe entry and exiting the building which includes HVAC, Utility pipe lines, fiber cables. The design uses separate power line filters for outer layer and individual power line filter for inner shielded layer of each laboratory which provides overall advantages to shielding effectiveness. The paper also talks about the proper grounding and bonding of the shielded enclosure to earth ground system, integration of mesh to steel bars at the plinth level during construction phase and protection of building from lightning. The careful in-house design of waveguide panels for HVAC and utility pipes, array of Earth pits for earth system, door frames and structures provided a cost-effective solution to achieve desired isolation. The paper presents the overall shielding effectiveness obtained as per specification of MIL-STD-285.

**Index Terms**— Radio Telescope, GMRT, RF Shielding, HVAC, MIL-STD-285.

### 1 Introduction

The Giant Meterwave Radio Telescope (GMRT) [1, 2,3,4,5] observatory consisting of 30 parabolic dish antennas each of 45 meter in diameter and spread over a 14 km radial distance. The antenna RF electronics system, computer network and electrical system are placed in the

shielded rooms or Faradays cage. The sub systems are further provided with individual, board levels shielding and are placed inside the shielded racks. The RF receiver system at the central electronics building is also placed inside the Faraday's cage and is placed inside the shielded racks. To meet the RFI free environment from self-generate RFI, shielded enclosures for air conditioning, Ethernet switches, DAQ cards, LED lamps, SMPS, UPS etc. have been designed to provide better RF isolation. [5].

### 2 Need of GMRT Observatory

The uGMRT provides seamless coverage from 50MHz to 1500MHz band with maximum instantaneous bandwidth of 400MHz. To test, measure the desired characteristics of receiver chain, digital correlator system and to carry our R & D activities there was need of additional laboratories.

Also an auditorium with exhibition area was also needed. Hence a shielded building was proposed to build near GMRT central square array that will incorporate an auditorium and additional laboratories without affecting any interference to the GMRT observatory.

### 3 Identification of shielded building requirements

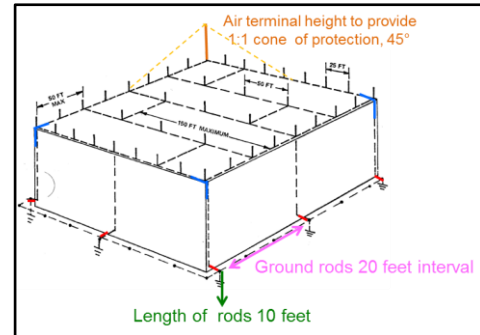
A two hundred seating capacity auditorium with exhibition area and four engineering laboratories requirement was estimated. The power requirement, lighting load, water facility, internet connection, room space required for R & D and air-conditioning requirement was studied for laboratories. For Auditorium and exhibition area requirement of AV equipment's, central air conditioning, lighting load, internet facility inside the auditorium was considered. After evaluating the overall shielding requirements a second level of shielding for engineering laboratories was proposed.

### 4 Design considerations of shielded building

Following points were considered for constructing shielded building,

- A building inside the Faraday's cage using six sided shielded SS mesh used for constructing the building.
- An equipotential / multipoint grounding made by connecting SS mesh to steel rebar's of each column of the building at the plinth level.
- Entire building to be bonded to the earth electrode system.
- Arrangement of lightening protection to the shielded structure around the building.
- Utility pipe entry inside the building.
- HVAC and Central air conditioning system for laboratories and auditorium
- Electrical power connection inside the building.
- Computer network and internet connectivity inside the laboratories and auditorium.
- Shielded double door for entry
- RFI free lighting lamps and shielded AV system for auditorium
- Fire safety measures with multiple doors for entry and exit.

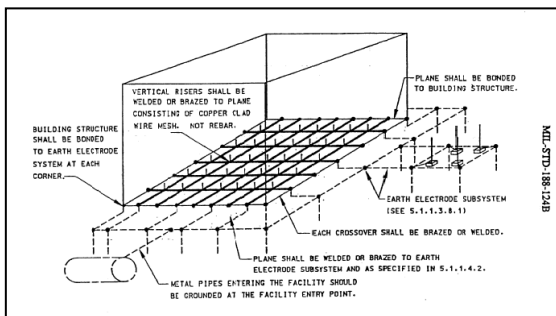
- They have been protected against mechanical damage.
- Spacing between two rods is kept two times the length of the buried rod as shown in green and pink colour respectively in figure 2.
- Earthing Rods are buried at a depth of 3 meter with watering facility.



**Figure 2.** Building structure lightning protection system [7][8]

#### 4.1 Equipotential or Multipoint Grounding to Earth electrode system for building

As shown in figure 1 equipotential / multipoint grounding made by connecting SS mesh to steel rebar's of each column of the building at the plinth level. Building structure is bonded to earth electrode system at each corner.



**Figure 1.** Equipotential / Multipoint gronding to earth electrode system [8].

#### 4.2 Building structure lightning protection using down conductors

- Down conductors bend have been made gradual and have a radius not less than 20cm (8.0 inch) as shown in blue colour line of figure 2[7][8].
- The angle of any bend kept not less than 90degrees.
- Down conductor bonded to earth electrode system within 1.8m (6 feet) from the structure as shown in red colour line of figure 2[7][8].
- All bonds between elements of lightning protection subsystem made by brazing.

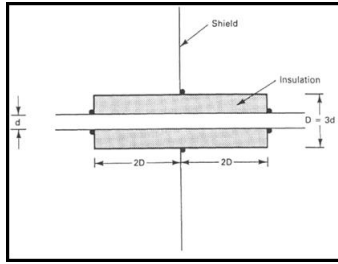
#### 4.3 Shielding of utility cables and water pipelines

- ¼"thickness of Brass / Steel entry plate used for mounting filter arrangement at the main entry point for building entry.
- Electrical power entry using power line EMI/RFI filter with insertion loss of 100dB, 150 KHz to 10GHz, MIL STD 220A and MIL PRF 15733 used.
- Power line filter is completely shielded with the filter case grounded.
- All the entry pipe are circumferentially welded.
- For water pipe line a rule of thumb is that length / diameter ratio of the in-room section should be > 7 with dielectric breaking outside the shielded area.

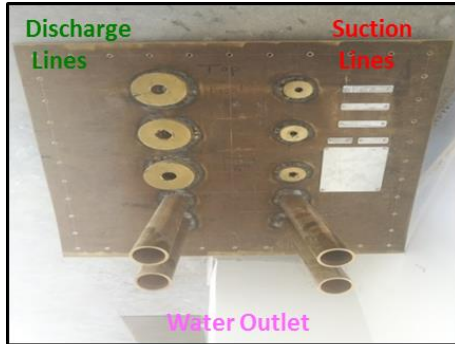
#### 4.4 Design for shielding of HVAC system for engineering laboratories

A special design of entry plate for HVAC lines inside the shielded area of engineering laboratories has been done as shown in figure 3[6]. It takes care of suction, discharge line and water outlet of the air conditioning system.

- Specially insulated (Teflon) with shielded pipes for hot and cold liquids circulation.
- Circumferentially welding joints for pipes.
- Waveguides used for water outlet.
- AC and DC filters implemented for outdoor unit
- Removable panel design arrangement for easy maintenance.



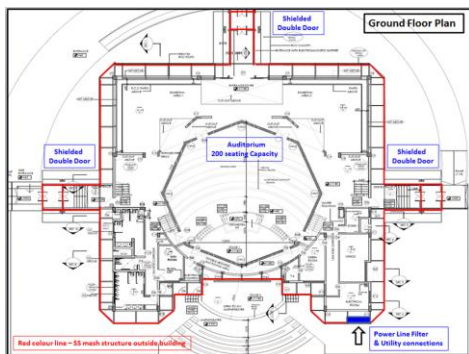
**Figure 3.** Design for Suction and discharge line of air conditioner system[6].



**Figure 4.** Design of Suction, discharge line, water outlet with AC and DC power line filter arrangement made for air conditioner system.

## 5 Measurement steps taken for main building as 1<sup>st</sup> level of shielding

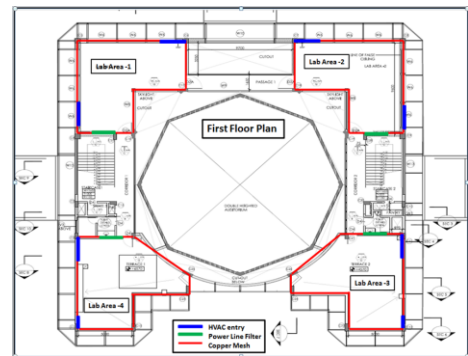
- Stainless Steel (SS) mesh 6mm x 6mm used for 1<sup>st</sup> level of shielding.
- SS mesh spot welded at each 6mm point with one inch overlap to establish electrical connectivity.
- SS mesh connected to columns rebar at plinth level.
- Earth plates were connected to the SS mesh.
- The SS mesh placed on all six sides of the building.
- A provision of RF shielded double door entry provided on three sides of the building.



**Figure 5.** Top view of ground floor plan with shielded double door entry on three sides and provision of shielded mesh as shown in red colour line.

## 5.1 Measurement steps taken for engineering laboratories as 2<sup>nd</sup> level of shielding

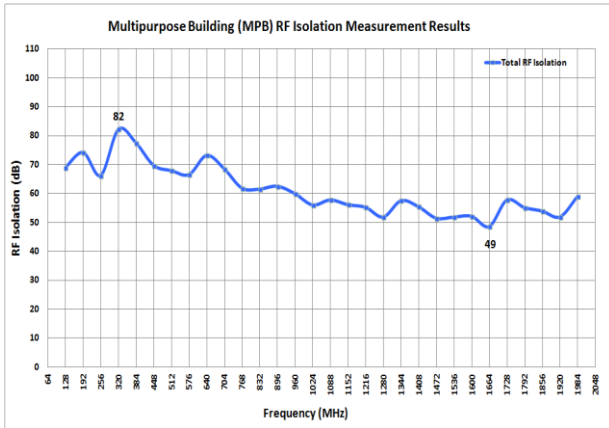
- Copper mesh with 1.5mm X 1.5mm X 29 gauge used for 2<sup>nd</sup> level of shielding.
- Copper mesh continuously soldered and installed on all six side of each lab.
- An independent AC power line filter entry provided to each lab which avoid coupling between labs.
- Air conditioning system with shielded and filtered panels for HVAC entry and exit made.
- Internet connectivity using waveguide arrangement for fiber optic cable entry.



**Figure 6.** Top view of 1<sup>st</sup> floor plan with provision of copper shielded mesh to the four laboratories as shown in red colour line. Blue colour indicated waveguide panel for HVAC and green colour line shows AC power line filter arrangement.

## 6 Measurement results and features of the building

- Area of the building 30.9 SQ.M X 30.9 SQ.M
- Total Buildup Area: 1478.99 SQ.M
- Auditorium: 200 seating capacity with Exhibition Area.
- The overall building shielding effectiveness was measured using IEEE 299 2006 std and found to be greater than 49dB up to 2GHz.
- Total Construction cost: 0.8 million USD ~



**Figure 7.** The RF isolation measurement result obtained using IEEE 299 2006 std [9].



**Figure 8.** Front side view of Multi purpose building (MPB) shielded structure .

## 6. Acknowledgements

We acknowledge our Civil, Mechanical, Electrical engineering team and workshop team of NCRA-TIFR and GMRT Observatory for their help in design and development, fabrication, and installation of shielded waveguides, earthing protection system. We also acknowledge the construction staff for their effort in erecting SS and copper mesh that meets RF isolation requirement.

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