Enclosure Design for the ARIES 3.6m Optical Telescope

A.K. Pandey[1], Vishal Shukla[1]*, Tarun Bangia[1], R. D. Raskar[2], R. R. Kulkarni[2], A.S. Ghanti[2]

[1]Aryabhatta research institute of Observational Sciences (ARIES), India

[2]M/s. Precision Precast Solutions Pvt. Ltd. Pune, India

Abstract

A 3.6-m, f/9 optical telescope is planned to be installed at Devasthal, India (Latitude:29° 21' 40" N, Longitude: 79° 41' 04" E, Altitude: 2450 m above msl). The telescope has Cassegrain focus and alt-azimuth mount. The design of the telescope enclosure and the auxiliary building includes a fixed base enclosure, a telescope pier, a rotating dome structure, an auxiliary building, ventilation and component handling systems. The design is optimized for thermal, mechanical, structural, as well as for telescope installation and maintenance requirements. The design aims to provide seeing limited images within the telescope enclosure. This paper presents design of the 3.6m telescope enclosure.

Keywords: Telescope enclosure, Auxiliary building, Ventilation system

1. Introduction

Aryabhatta Research Institute of Observational Sciences (acronym ARIES), an autonomous research institute under the Department of Science and Technology (DST), Government of India, has taken an initiative to establish a 3.6-m new technology Devasthal optical telescope (DOT) at Devasthal, Nainital. Belgium is also participating in the project under bi-lateral program of cooperation in science and technology with India.

The telescope is being installed at a good observing site Devasthal (Latitude:29° 21' 40" N, Longitude: 79° 41' 04" E, Altitude: 2450 m above msl) in India. Devasthal is about 65 km from Naintal and it has an added advantage of crucial geographical location for a number of time-critical observations of cosmic events. An extensive site characterization was conducted during 1980 – 2001[1]. Seeing measurements carried out over a period of two years close to ground level yielded a median ground level seeing estimate of about 1.1 arcsec; the 10 percentile values lie between 0.7 to 0.8 arcsec (mean = 0.75 arcsec) while for 35 percent of the time the seeing was better than 1 arcsec. The seeing measurements as well as number of yearly spectroscopic nights (~210), darkness of the per square arcsec sky (V ~ 21.8 mag) and other atmospheric parameters for Devasthal make this site comparable to international standards [2].

The f/9 configuration of the telescope has an alt-azimuth mount. It has Cassegrain focus fitted with a 30 arcmin wide field three-lens corrector, auto guiding unit and a derotator instrument interface. The telescope has two side ports and one main Cassegrain port[3]. The present contribution describes the design of the enclosure and other related building for the DOT.

*vishal@aries.res.in; phone +91-05942-233727; fax +91-05942-233439; www.aries.res.in

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1.2 Functional requirement of the enclosure

The design of enclosure and associated building for optical telescope is an important and challenging task as it involves the balancing of optical, thermal, mechanical and structural requirements. The `seeing' within the enclosure may be affected by thermal disturbances induced by the structure. The other challenge due to space constraint is designing of the enclosure of the DOT to provide facility for telescope installation and maintenance within the building. The main purposes of the enclosure and associated building are;

- Protection of the telescope from dust and inclement weather.
- Keep the air temperature in the optical path of the telescope as close to ambient as possible during observations.
- To provide isolated telescope pier for the telescope mount.
- Keeping instrument room at a stable temperature.
- Provision of facilities for operational and maintenance personnel.

1.3 Environmental condition at Devasthal

The enclosure and associated building are designed to meet all the required performances throughout the following range of environmental condition.

Normal conditions:

Temperature:	0 to 30°C
Variation in temperature during the night:	< 2 deg C
Relative humidity:	0 to 90%
Wind:	< 3 m/s (during 75% nights)
Peak gusts:	<13 m/s
Pressure	810mb (±10mb)

Survival conditions (Dome closed):

Wind gusts:		55m/s
Air temperature	max:	40°C
	min:	-20° C
Diurnal temperature	:	20°C
Seismic Ground Acceleration:		Zone V
Design Precipitation event:		35mm rainfall/hour with 10m/s wind.
Max Relative humidity:		100%
Snow		~ 4 to 5 feet on the ground level

2. Building design

The site for 3.6-m DOT is located at about 3 km from the State Highway and connected by a about 5 meter wide road. The enclosure and associated building plan is done by M/s PPS Pvt. Ltd Pune in close interaction with the ARIES scientists and engineers. The geotechnical investigation of the site was done by M/s Nagadi consultants Private Ltd. (India) and Civil department of Pantnagar University (India). The recommendations of these agencies were taken into considerations while preparing the design. Since the wind direction at Devasthal is from SE and SW during observing period, the auxiliary building housing is planned at about 15 degree north – east direction. The site plan is shown in Figure 1.

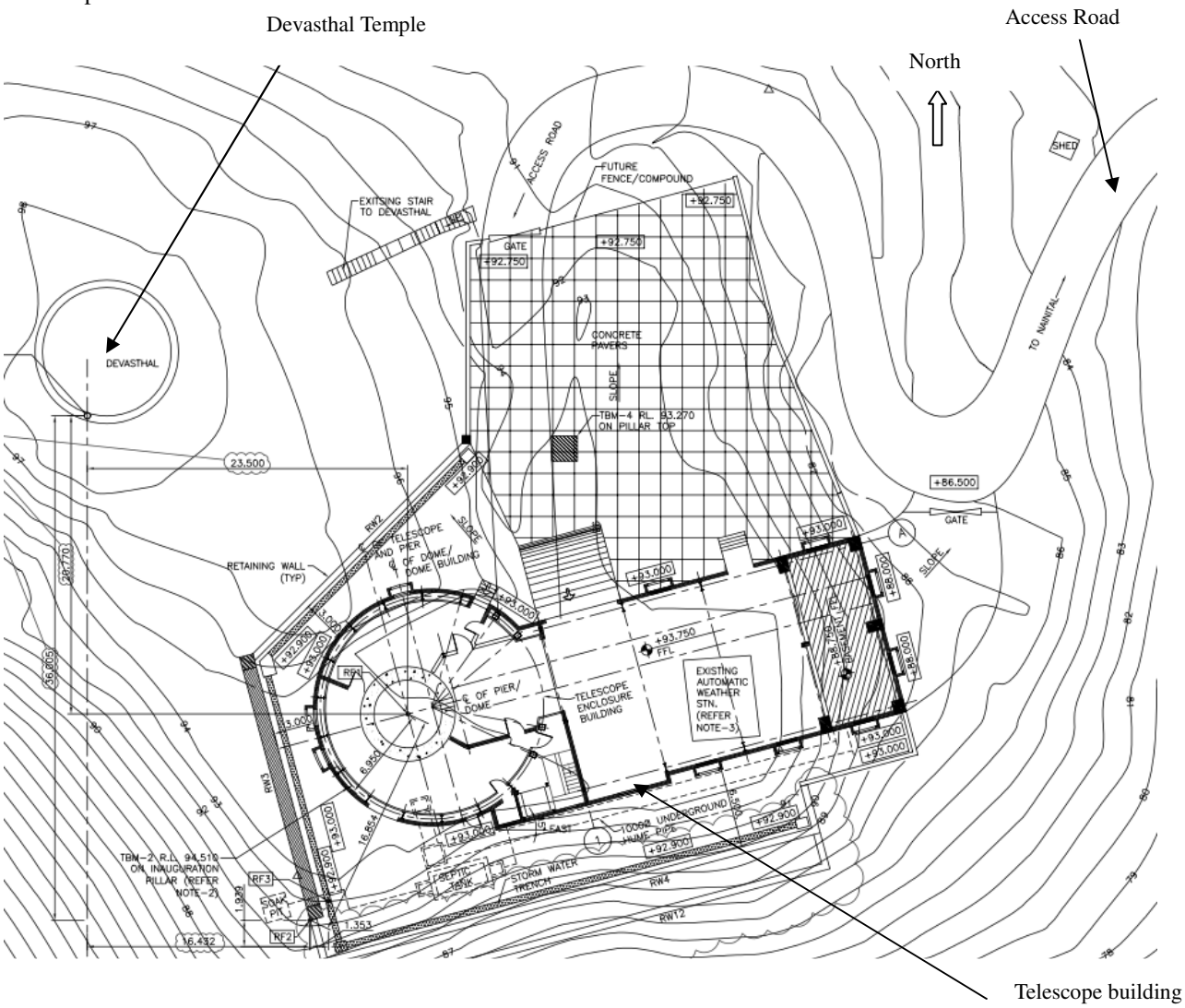

Figure 1: Devasthal Optical Telescope site plan showing telescope building

2.1 The layout of the enclosure and auxiliary building

The DOT facility consists primarily of interconnected but thermally isolated parts; telescope instrument room, control room, telescope pier, rotating dome and auxiliary building shown in figure 2. The ground level is divided into high resolution spectrograph, control and telescope accessories rooms. The auxiliary building contains space for mirror washing and coating. A rail system is included between the two buildings to facilitate a simple process for removing, cleaning, re-coating, and replacing the primary mirror.

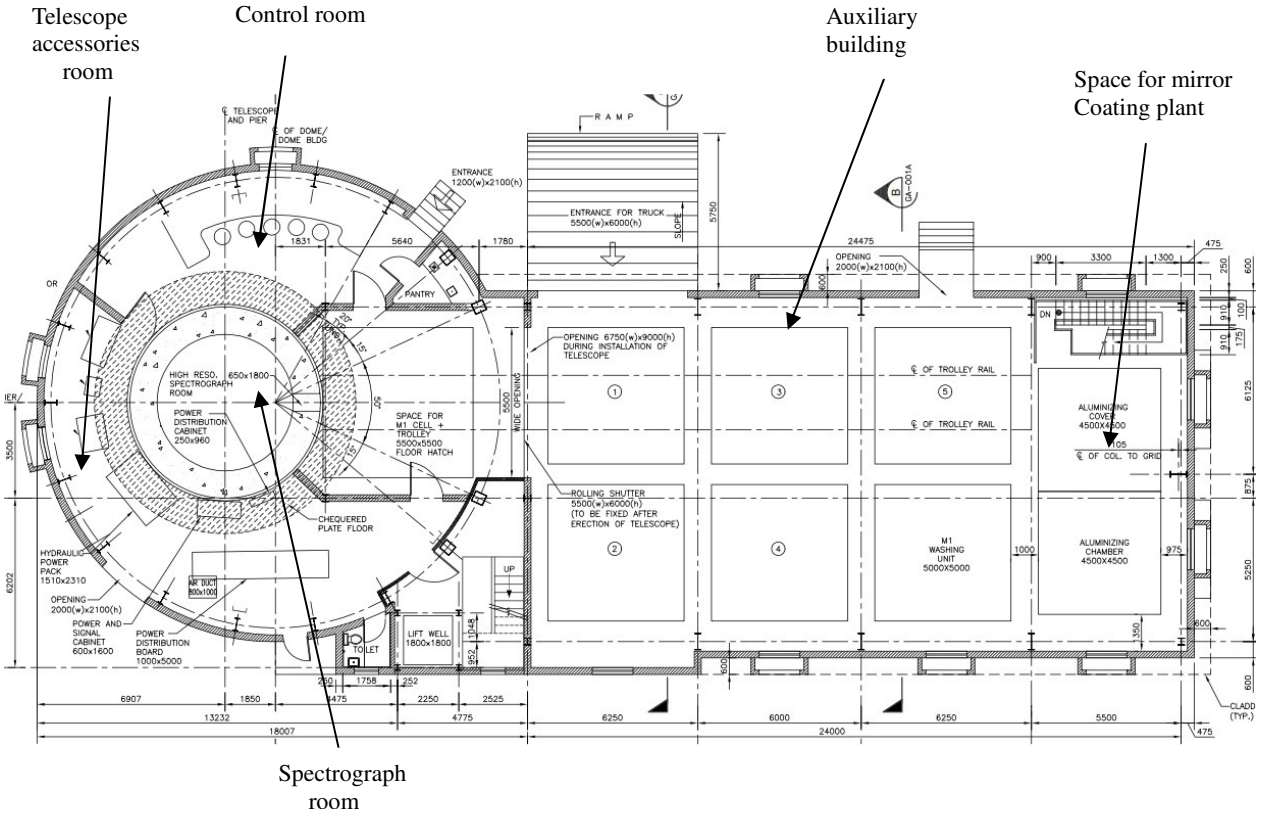

Figure 2: Floor plan at 0.0m level showing the auxiliary building, control room, telescope accessories room, spectrograph room, telescope pier

2.2 Telescope pier

A hollow concrete cylindrical pier will provide stable and rigid support for the 150 MT telescope mass at the top. The outer diameter of the pier is 7000mm and inner diameter is 5000mm. The top slab of the pier is 1000 mm thick. The base (foundation) of the pier is 9500 mm diameter and 1000 mm thick. The elevation of the pier is shown in Figure 3.The concrete grade for the construction of the pier is M25. The pier is completely isolated from other structures to avoid vibration transfer from other sources. Reinforced retaining wall all around the pier foundation with a clear gap of 150mm is provided to isolate the pier. The natural frequency of the pier and the telescope is 25.44Hz and 7.4Hz respectively. The combined frequency of the telescope and pier is 14.259Hz, which is significantly higher than that of the telescope to avoid the resonance.

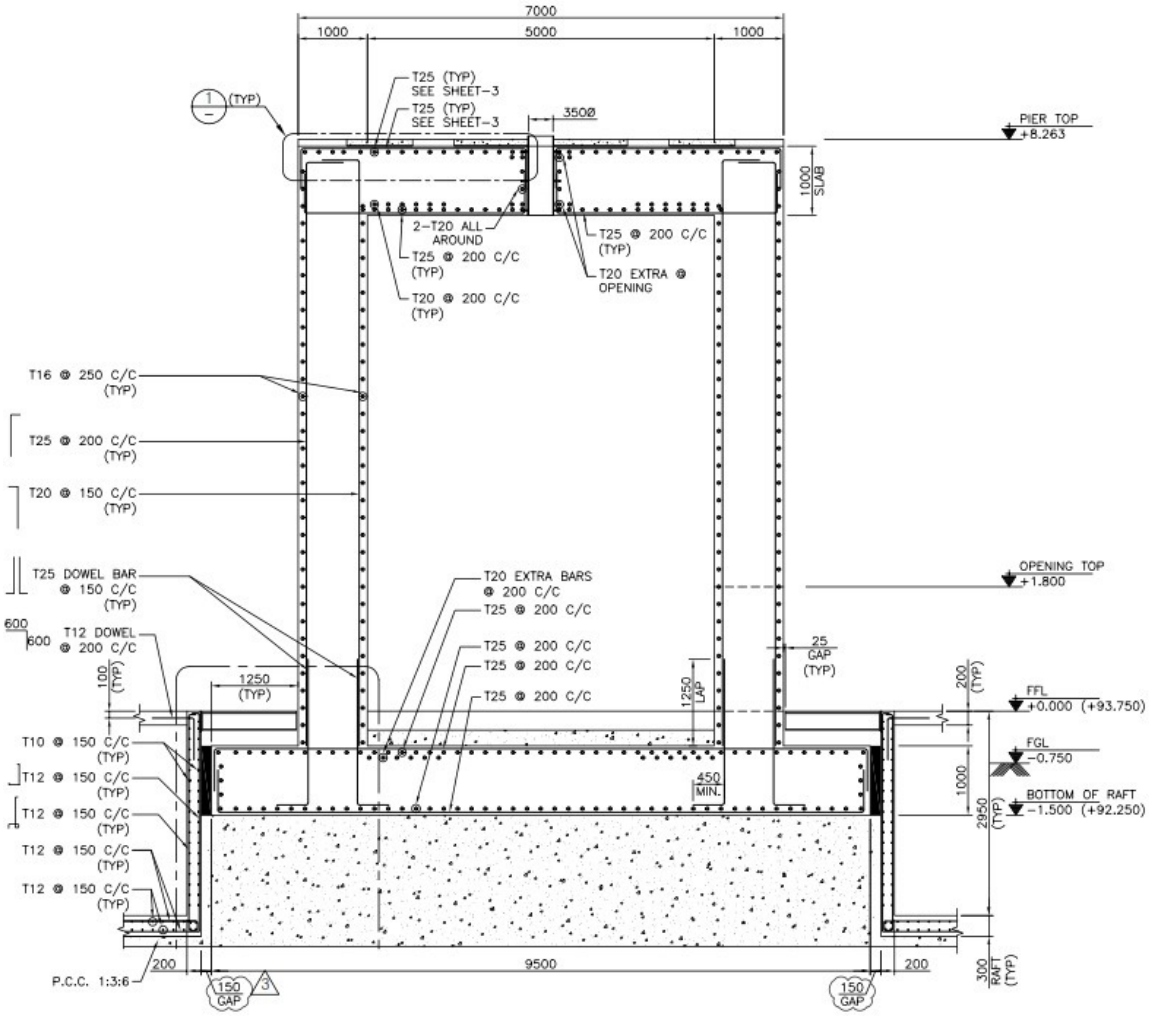

Figure 3: The pier elevation

2.3 The rotating dome and auxiliary building

The telescope enclosure building is separated in three parts (Figure 4) the dome, the non-rotating lower structure and an auxiliary building. The dome is the rotating insulated steel framed upper cylindrical structure with pitched roof. Considering the space limitation at the site an off-centered telescope pier has been planned to minimize the building size. Considering the gyration radius of the telescope (5749mm) and the space required for the assembly and future maintenance of the telescope, the diameter and height of the dome is kept as 16.5m and 13.0m respectively. A shutter opening is provided on dome surface to enable observations. Main structural components of dome are portal frames, the roof framing, slit shutter, dome ring beam. The rail and the wheels of the drive system are supported on bottom steel ring beam. The telescope floor level is at 11m height.

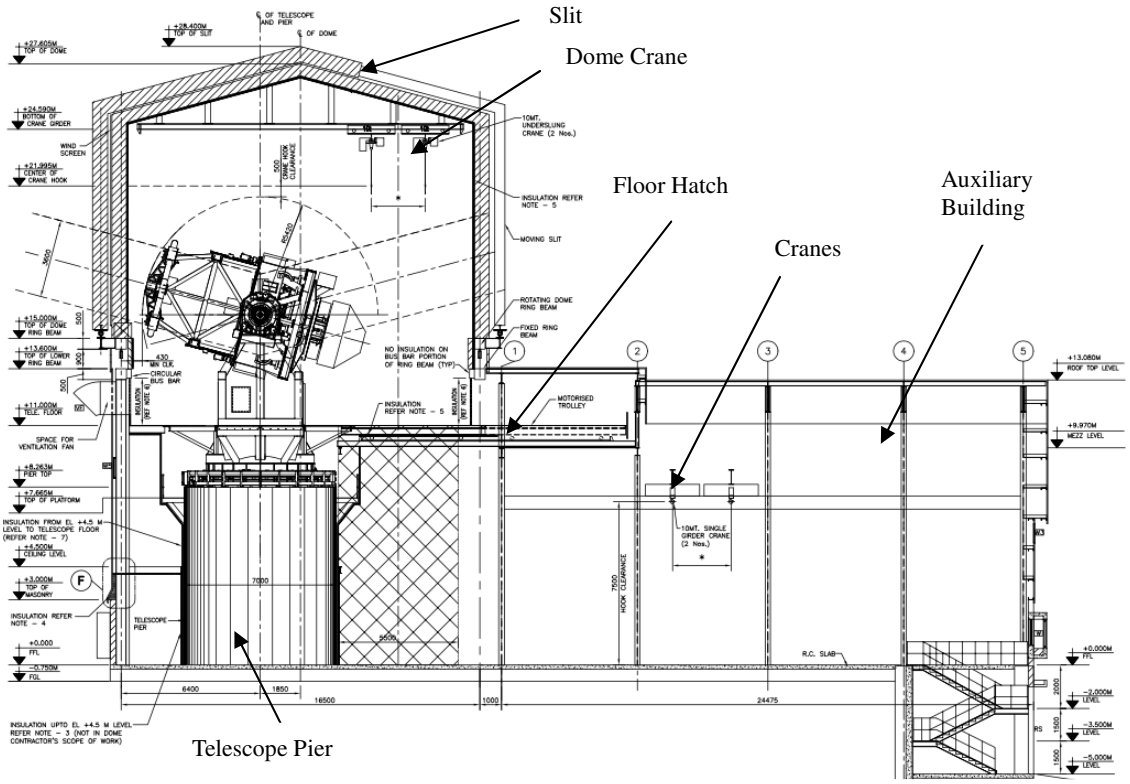

Figure 4: Telescope Building Section

The bottom ring beam is supported on the columns of a non-rotating lower steel structure which forms the second part of the building. In the present design the dome center-line diameter is 16.5m and the telescope pier is eccentric by around 1.85m with the dome center to get a space for a hatch of 5.5m x 5.5m to enable lifting of telescope parts from the ground floor. At ground floor there are various rooms viz. for equipment, control room, UPS systems etc (see figure 2). This building also houses a staircase and lift to have access on telescope floor.

The auxiliary building mainly accommodates aluminizing Plant, ventilation System and UPS room and component assembly & maintenance area.

3. Salient features of the enclosure

3.1 Dome drive

The proposed dome drive is of fixed type i.e. all the drive wheel assemblies and idler wheel assemblies are stationary and mounted on fixed ring beam. The rail is mounted on the bottom side of the rotating ring beam. The 170 MT dome will rest on 18 wheel assemblies. The dome will be rotated by 6 numbers of drive system. Other 12 wheel assemblies are idler wheel assemblies. The drive consist of variable- voltage, variable- frequency (VVVF) drive and a gear box to ensures smooth starting and stopping of the dome. Time taken to complete one dome rotation is 7.4 minutes. Interlocks are provided for dome drive system in such a way that dome drive motors shall not start when either dome is mechanically locked or overhead crane is in service. The salient features of the dome and drive system are given in Table 1.

Table 1: The salient features of the dome and drive system.

A	Mean dia of dome	16.5 m
B	Height of dome with slit	13.9 m
C	Total weight of dome	170 MT
D	Weight of Dome	140 MT
E	Weight of Slit	30 MT
F	Linear speed of dome	7 m/min.
G	Motor	1.5kW, 1395rpm
H	Gear box ratio	230
I	Wheel dia	400mm
J	Rail	CR 100
K	Spring Wire dia	48mm

3.2 Slit Cover Drive

The 30 MT slit cover is comprised of two parts moving in opposite direction. The slit is of inverted U shape as shown in Figure 5. Each part has two geared motors, thus there are total four drive motor limit switches provided on track of each slit to limit motion in either direction. Following interlocks are provided for slit cover operation; a) slit drive motors shall not operate when dome is rotating, b) if any of the four motor fails, the other three motors shall not start (we have to decouple the failed geared motor). Main design specifications of slit drive are given in Table 2.

Table 2: Main design specifications of slit drive.

A	Weight of the slit cover	30MT
B	Linear speed of the slit cover	6 m/min.
C	Travel length of rail	5.2 m on each side
D	No. of drive wheel assemblies	4 Nos.
E	No. of idler wheel assemblies	4 Nos.
F	Wheel diameter	200 mm
G	Motor	0.55 kW, 1360 rpm
H	Gear Ratio	138.4

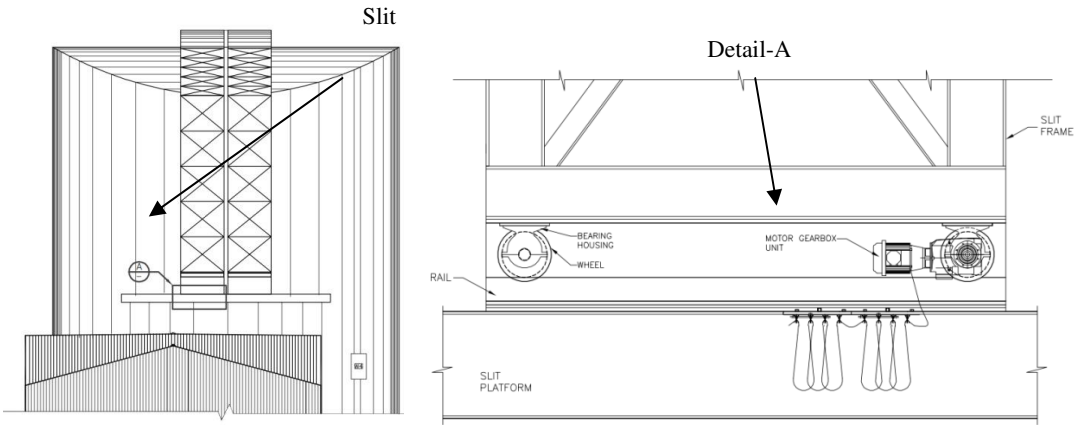

Figure 5: Arrangement of slit drive system

3.3 Hatch Cover

A hatch of 5.5 m x 5.5 m is provided on the telescope floor at 11.0 m level. It has a moving hatch cover. During erection period and thereafter during primary mirror aluminizing operation, this cover will be moved outside the circular structure on rails provided. The hatch cover shall move at 7m/min and stop at each end at desired location. The operation will be manual only with the help of control panel located on the telescope floor level. At all the four limits of the rail, limit switches are provided to control the desired motion of the hatch cover during opening or closing operation. When the overhead crane in the dome is in service the hatch cover drive shall not operate. The hatch cover drive consists of geared motors, wheel assemblies, electrical control panel, electrical and mechanical stoppers and other accessories as required for smooth functioning of the hatch cover motion. The main design specifications are given Table 3.

Table 3: Main design specifications of the hatch cover.

a	Speed of Hatch Cover	7 m/min.
b	Capacity of the Hatch Cover	15 MT
c	Self weight of Hatch Cover	6.5 MT
d	Travel Length	6374mm
e	Span	5900mm

3.4 Insulation

The entire dome structure, roof and slit will be insulated from inside with Phenotherm insulation panels having specifications as given in Table 4. The Phenotherm panels shall be CFC free and eco-friendly. The material is not easily ignitable and classified as per BS 476 – Part 5.

Table 4: The specifications of insulation panels

a	Material of Insulation	Phenotherm
b	Density	40 Kg/Cum
c	Thickness	75 mm and 50 mm
d	Compressive Strength	250 kN/Sqm.
e	Thermal Conductivity (K' Value)	0.018 W/M deg. K
f	Temperature Range	- 196 deg.C. To 130 deg.C.
g	Water Absorption	2% by volume
h	Panel size	about 1.2 m x 1.2 m

3.5 Wind Screen

A wind screen is provided to protect the telescope observation when wind velocity is more than 5meter per sec. It is located on the top of rotating ring beam of dome. The wind screen is similar to a rolling shutter but the shutter box installed at bottom and shutter moves in upward direction. The shutter movement is motorized with the facility to synchronize with telescope movement.

The wind screen shutter is made up of synthetic fabric with embedded strengthening bars or tubes. Two edges of the top end of the wind screen are connected to a dead weight. The motor and gear box will hold the wind screen from unwinding. The motor can rotate in both direction and release the screen. It will go up with the help of a

counter weight, and to take the screen down the motor will pull the counter weight (see figure 6). The motor shaft is provided with extension of shaft on non-drive end so that in future encoder arrangement to sense the location / opening of the wind screen can be provided. The major parameters of the wind screen are given in following Table 5.

Table 5: The specifications of wind screen.

a	Opening Size	4200 mm wide x 9000 mm height
b	Material of Wind Screen	Synthetic Fabric
c	Wind screen to withstand at	15 m/sec wind speed
d	Operating Speed	3-6 m/min.
e	Manual Operation	By Crank or Ratchet
f	General Motor Rating	415 V, 3 ph, 0.55 kW

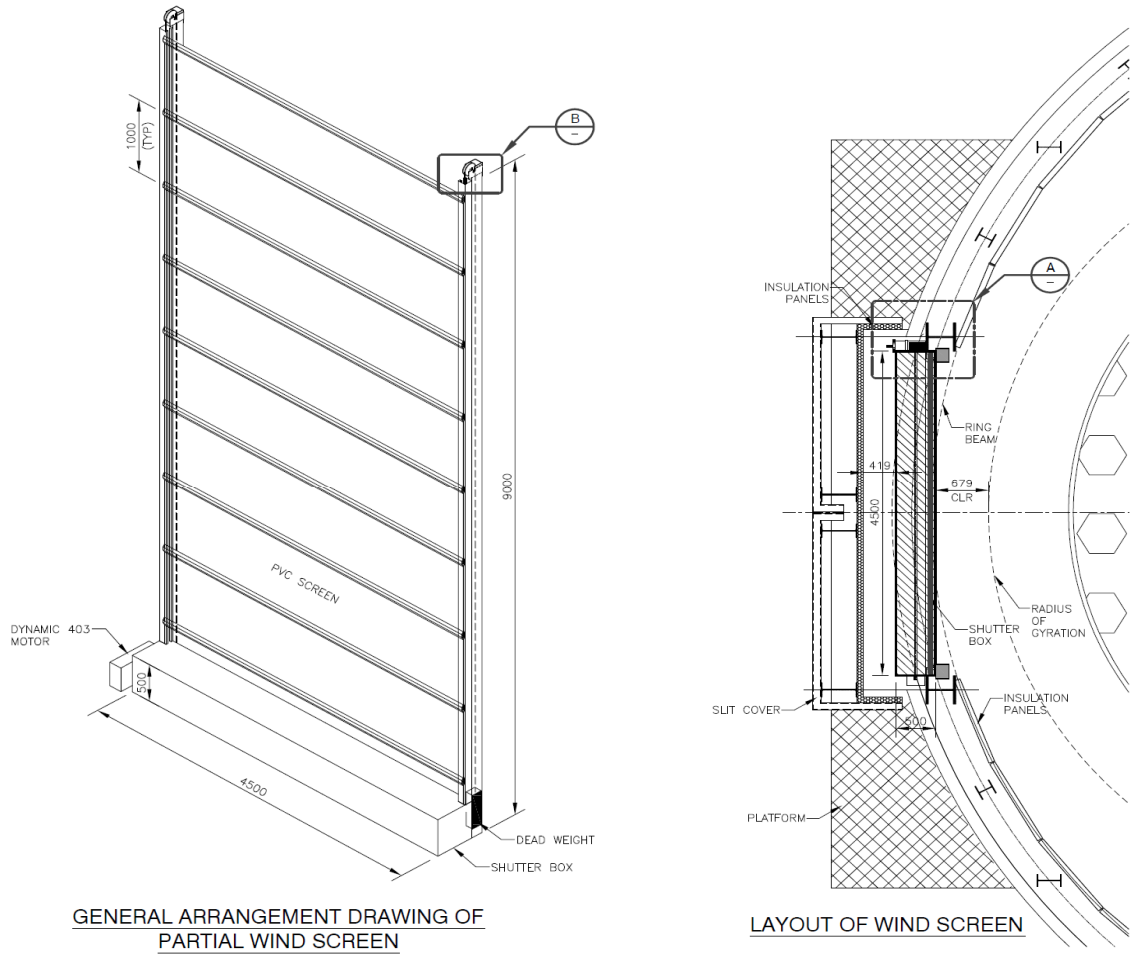

Figure 6: (Left) General arrangement drawing of partial wind screen. (Right) Layout of wind screen.

3.6 Telescope Floor and Building Temperature Control

To achieve best seeing inside the dome, the telescope enclosure must be designed to minimize the effects of convection, turbulence etc inside the dome. In order to achieve this goal a well ventilated telescope chamber, low thermal inertia construction, active ventilation using fans, and utilization of surface coating to control radiation losses etc are planned to be used[4].

The present enclosure and auxiliary building is designed using steel frame and metal clad panels so that the building can thermalise rapidly. The interior ventilation is designed to exhaust waste heat in prevailing downwind direction. Within the enclosure building the telescope floor and spectrograph room are properly insulated. The exterior of the building will be white in color to minimize solar heating. In spite of proper outside coating the inside area of the enclosure may get heated. Five numbers of ventilation systems are provided to remove hot air and maintain temperature equal to that of outside temperature. The ventilation plan is shown in Figure 7 and Figure 8.

3.6.1 Ventilation System for Telescope Accessories Room

There are number of equipment in the telescope accessories room such as Hydraulic Power Pack, Compressor, Air Dryer, Chiller, Electrical Control Panel etc. which generate heat during the normal operation. In order to exhaust the hot air from the room and release it at sufficient long distance from the telescope, centrifugal exhaust fans are located in the room at minus level in the auxiliary structure. Total heat generated in the telescope accessories room is estimated 35Kw, hence an air flow of about 15800 Cum/hr is required. There are 3 number of centrifugal exhaust fans (2 working + 1 stand-bye). From the telescope accessories room to ventilation room an underground hume pipe is laid. Two ventilation fans will suck the hot air from telescope accessories room and release it in the ventilation room. The capacity and static head of the exhaust fans are 7900 Cum/hr and 35 mm of WG (Water Gauge).

Three fans having capacity and static pressure of 13000 Cum/hr and 5 mm of WG are located near the hydraulic unit and chiller. These fans will assist in heat removal during any time / maintenance period. Eight exhaust fans having capacity and static head of 6000 Cum/hr and 5 mm of WG, respectively are provided in auxiliary building.

All the exhaust fans are provided with louvers which automatically close when fans are not working. The arrangement and construction of louvers is such that during rainy season water will not enter inside the room.

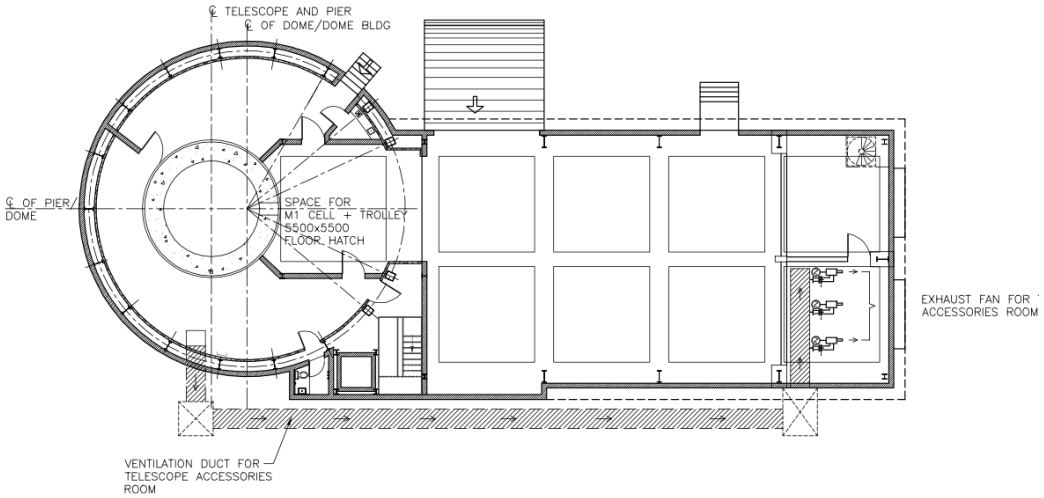

Figure 7: General arrangement of Ventilation system.

3.6.2 Ventilation System for Telescope Floor

During the day time the structure exposed to the Sun may get heated. The absorbed heat will be dissipated during night. Although dome is insulated from inside, some temperature difference is expected between atmospheric temperature and inside dome temperature. To remove the hot air from the inside of the dome and maintain the temperature equal to that of outside, 12 exhaust air fans (see Table 6) are provided on circumferential wall of the dome as shown in the Figure 8.

Table 6:The details for the exhaust fan

a	Type	Axial Flow
b	Capacity	75000 Cum/hr.
c	Static Pressure	3 mm of WG
d	Total Pressure	18 mm of WG

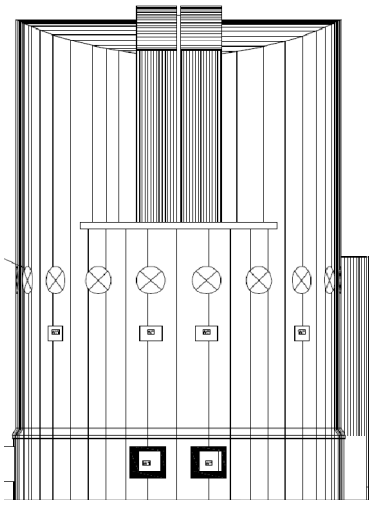

Figure 8: Ventilation system at telescope floor.

3.6.3 Centrifugal Blower for Pier

The high resolution spectrograph is planned inside the pier. Some electrical equipment may also be placed in the space inside the pier which may generate small amount of heat. The generated heat is proposed to be exhausted into telescope accessories room by exhaust fan. An opening of 300 mm is provided in the pier to exhaust the air from inside the pier. A centrifugal blower mounted on independent frame exhaust the air. Care is taken that blower vibrations are not transferred to the pier. The capacity and static head of the blower are 1300 Cum/hr and 10mm of WG, respectively.

3.7 Material Handling System

As per installation and maintenance requirements two 10 ton capacities under slung cranes are provided in the dome. The crane girder is suspended and supported from portal columns. Two 10 ton capacity single girder cranes operating in tandem in auxiliary structure are provided for loading/ unloading of telescope components, assembly operation and for loading component on the transfer trolley. After installation erection of the telescope these cranes will be utilized for maintenance purpose.

3.8 Schematic view of the enclosure

A schematic view of the enclosure described above is shown in Figure 9.

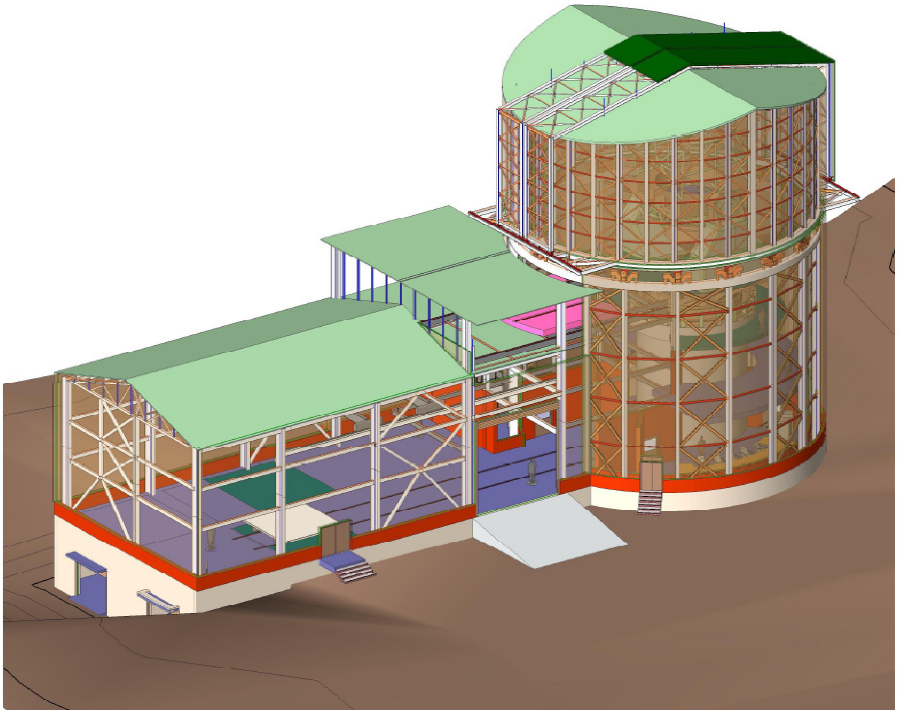

Figure 9: View of the enclosure building

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