Bird's eye-view of Terminal 2 complex, Mumbai airport

Project Challenges at T2 – Mumbai International Airport

Part 1 of 2

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Introduction

In this article, an attempt has been made to share the project management challenges faced in executing a mega HVAC project – Mumbai International Airport Ltd. Terminal 2 (Mumbai T2) at Sahar. This terminal, now operational, has set new benchmarks in aviation as well as airport HVAC systems. It has received LEED Gold certification.

Mumbai T2 is one of the biggest and most modern airports in India, with covered area of 4,39,000 sq m. The terminal building can accommodate 40 million passengers per annum. It was acknowledged as one of the most iconic developments in recent times on the Discovery Channel show *Building Now*. The scope of air conditioning work of the terminal building, including design, execution, testing, commissioning and integration with other services, is the largest of its kind in India's HVAC history, qualifying it as a mega HVAC system.

The HVAC contractor was awarded the *Most Safety Conscious Contractor Award* for 2011, out of over 40 contractors with a cumulative strength of more than 15000 workers at the project site.

It would be interesting to understand the job quantum and various project challenges faced in HVAC execution especially in the utility plant room, MEP rooms, etc., along with details of the building – levels, HVAC layouts, various work categories, automated tools and tackles, and productivity improvement measures implemented at the site.

Concept-wise the old airport terminal T3 at Sahar was ⌒ shaped, i.e. it had a single air side. The new ✕ shaped T2 has 92% utilization of space – the air side contacts on three sides mean a 3.5 fold increase in contact space. The number of aerobridges has been augmented from 9 to 29, for 2 aircraft each. There is a multi-storied building with four fold increase in space for baggage handling, arrivals, departures, check-in and retail, to cater to air

About the Author

Ketan Soni graduated in mechanical engineering from L. D. College of Engineering, Ahmedabad in 1983, and has more than 30 years of experience in the field of HVAC project management at Blue Star, including engineering, project planning, testing and commissioning, sales and marketing and overseas assignments. He is a BEE qualified energy auditor and an active life member and past president of ISHRAE Vadodara Chapter. He has presented papers at CII, National Productivity Council and IGBC platforms, and delivered lectures in various engineering and architectural institutes. He has written several articles for magazines.

HVAC System for Mumbai International Terminal T2

Fact File

Check-in area at Mumbai T2

- 15,000 TR cooling capacity from 6 centrifugal VFD chillers and cooling towers of 2,500 TR each.
- 3.1 lakh sq m ducting of various categories running 110km in length.
- 2.8 lakh sq m of various types of insulation.
- 27 km of piping with sizes upto 1300mm dia, including pre-insulated pipes 1100mm onwards.
- 21 pumps of capacity 7500 USGPM/335 HP onwards.
- 80 AHUs, some with HRWs of 4600mm dia, delivering 31 lakh cfm air with 1.2 lakh cfm fresh air.
- 521 ceiling suspended units, handling 5.5 lakh cfm.
- 1450 VAVs.
- Over 350 ventilation fans.
- Integration with BMS and other services.
- Energy saving measures including condensate recovery of 1.36 lakh USGPM for cooling tower make-up water and chemical dosing system.
- Skilled manpower strength peaking at 1100, sourced through 68 business associates.
- Procurement of about 2250 types of material for HVAC work.

traffic of 40 million passengers per annum. It has a modern architectural concept with multilevel structural design.

HVAC Design Highlights

The design highlights mentioned below would serve to underline the size and complexity of the assignment.

- Strategically located plant room and MEP room for better space management.
- Centralised MEP rooms at seven places.
- Utilisation of staircase core for other MEP services.
- 1.20 lakh sq m covered area spread over 52 zones per floor.
- 208 zones on four floors, plus 7 MEP rooms.
- Connected through trenches and utility corridors with plant rooms.
- Electrical BMS integration.
- More than 21 AutoCAD operators with 6 engineers spent 65,000 man-hours.
- *Good for Construction* (GFC) drawings prepared with section details for dif-

Photo 1: 2500TR centrifugal chillers with interconnecting piping

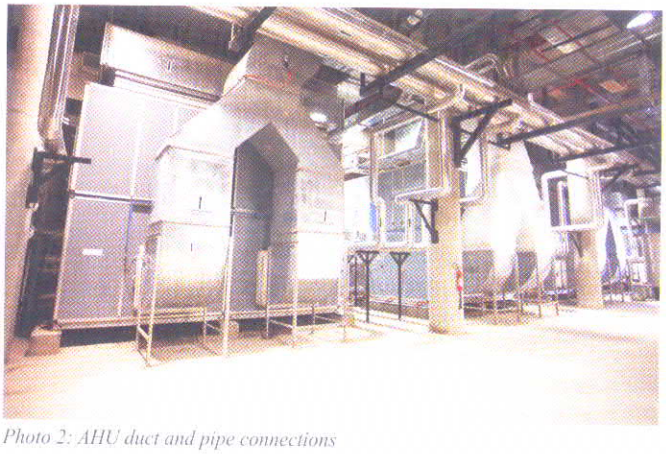

Photo 2: AHU duct and pipe connections

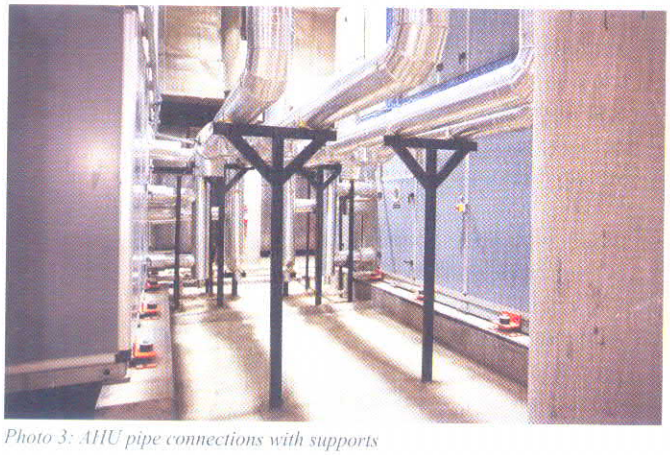

Photo 3: AHU pipe connections with supports

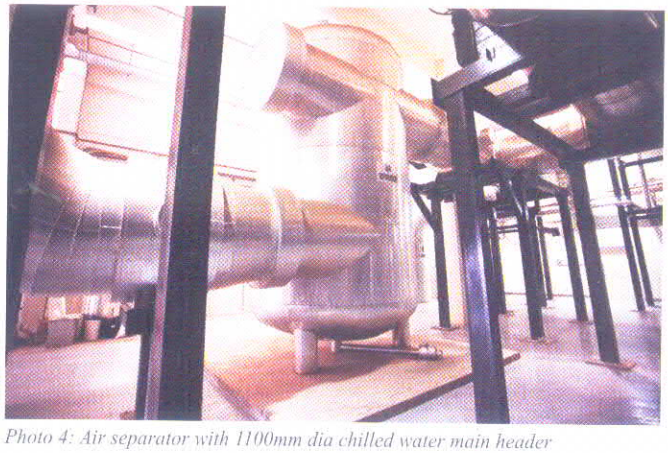

Photo 4: Air separator with 1100mm dia chilled water main header

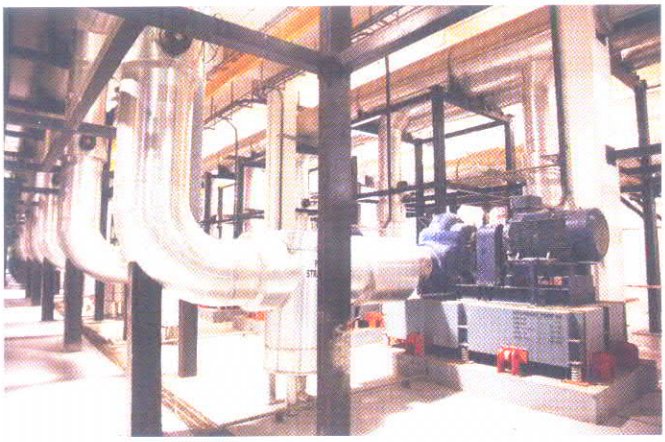

Photo 5: Chilled water pumps with 1100mm headers

Photo 6: Condenser water pumps with 1300mm headers

Photo 7: Cooling tower cells 2500TRx6

ferent categories: ducting, insulation, piping and equipment – totalling 3400 drawing details.

- GFC drawings released for construction with approvals from project management consultant, structural consultant, seismic consultant, architect and HVAC contractor's designer.
- Seismic analysis.

Resource Management

The responsibility for executing such a mega project calls for efficient resource management, viz. analysing resource requirements and identifying and organising their availability at the right time and place at the site synchronising with front clearance demand. The integration of front clearance demand of the resources vs. their site availability is very important to avoid crises and delays in the project and integrated work fronts. The site demand of resources is based on the customer's front clearances from civil and architecture viewpoint of various buildings, floors, plant room, trenches (underground and over-ground), racks, false ceilings, roofs, trusses, other service integration like fire-fighting, safety, interiors, electrical, etc. At this site, such demand of work went up to 70 to 80 locations at a time for various trades of HVAC work (like various types of ducting and insulation adhering to different specifications, under-deck insulation, piping, equipment installation, electrical, tray work etc.), which makes an average of 5 trades of work per location, i.e. resources at 400 work fronts were required to be managed on any given day.

The resources required are listed below:

- Approved drawings released for construction integrated with other services and fronts (*engineering and procurement management*).
- Material availability at site stores along with all C class ancillary material as per specifications, duly ready after third party inspection with test certificates (*site stores management and materials*).
- Movement of the above material at all locations during each work-day (*site transport management*).
- Tools, tackles, scaffoldings, scissor lifts, generators etc. (*auxiliary support management*).
- Continuous construction power at 80 work locations (*power and water management*).
- Safety compliance at all fronts with necessary gadgets (*EHS management*).
- Work permits from clients and relevant authorities.
- Drinking water and sanitation at points near working locations.
- Adequate manpower for all trades of work based on the quantum of work front and agreed time period of completion of part or full activity (*manpower management*).
- Monitoring and supervision of the above work at respective locations individually.
- Managerial reporting of work progress to the client and interaction on hindrances, if any.

Photo 8: An air tower with jet nozzle outlets in the security hold area

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- Site quality assurance of all resources and approvals (*quality management*).
- Crisis management of resource scarcity beyond control.

Thus such a mega HVAC project poses multiple site challenges like several work front clearances, resource scarcity, manpower management, power and water management, safety management, stores management, materials management of ABC classes as per specification, business associate management, supervision/ site construction planning management, quality management, extended hours/ night shift management, EHS management, material handling/ site transport management, scaffolding/ rigging management, worker attrition issues, punctuality/ working hour discipline coupled with work output demand based on site clearance vs. work force deployment in various shifts, residential worker colony management, site instructions, meetings, client reports and complaint escalation management.

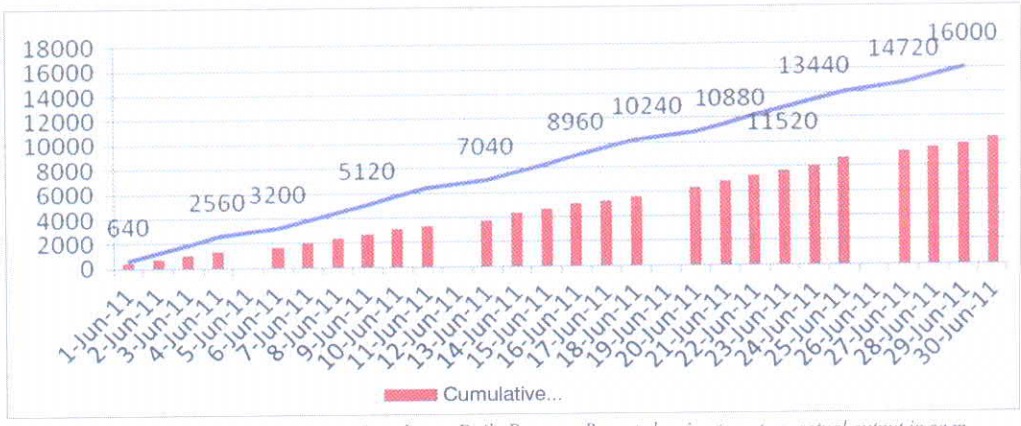

Figure 1: Indicative ducting output monitoring chart – Daily Progress Report showing target vs. actual output in sq m

Power Management

12 to 14 DG sets of various capacities from 2KVA to 65KVA were deployed at various floors and zones upto the site office, managed by two engineers and five electricians with daily diesel logistics, consumption and power utilization management.

Manpower Management

- For ducting of four types of specifications in 208 zones adding to 2.84 lakh sq m, 260 men were deployed.
- For insulation of five types of specifications in 208 zones adding to 2.75 lakh sq m, 140 men were deployed.
- For 27 km piping spread over 4 sq km area, manpower deployed was 210.
- For installation of about 1200 pieces of equipment, manpower deployed was 110.
- For cabling, electrical work and BMS adding to 27 km, 60 men were deployed.
- For structural fabrication totalling 350 metric tonnes, 55 people were deployed.
- At the site workshop, 15 people were deployed.
- For rigging work, 656 people were deployed.
- For housekeeping, manpower deployed was 70.
- Security was manned by 25 people.

To monitor this manpower, a site management team of 44 qualified skilled engineers was deployed with different responsibilities and reporting structure to the floor manager.

Asking Rate – Dynamic Manpower Demand Calculation

Table 1: Sample manpower estimation based on the balance scope of work

Sr. No.	Equipment	Completed quantity	Balance quantity	Unit	Skilled/ installation man-hours	Unskilled/ rigger man-hours
	Duct and Accessories					
1	Ducting	62000	133411	sq m	320186	32019
2	Fire ducts	11050	24145	sq m	57948	5795
3	MS ducts	1240	5754	sq m	23016	2762
4	Duct testing	56020	163310	sq m	130648	78389
5	Sound attenuators	121	768	sq m	13816	6908
6	VCD/FD/MFD/collars	108	2707	sq m	32487	8122
7	Grilles/diffusers	121	806	sq m	9676	2419
8	Jet nozzles	112	3020	nos.	6040	1208
9	Linear diffusers		2611	rm	3133	1044
10	Flexible ducts	121	4282	rm	2569	1028
11	Flexible connections	23	500	sq m	300	240
12	VAV boxes	211	1833	nos.	7332	2200
				Total man-hours	**6,07,152**	**1,42,133**
	Piping and Equipment					
1	Piping	17400	172969	inch m	207563	36035
2	Pumps		21	nos.	4032	1344
3	Condenser pumps		6	nos.	144	96
4	Expansion tanks		3	nos.	192	96
5	Air separator		1	nos.	96	144
6	Valves/strainers		14935	inch dia.	26882	11948
				Total man-hours	**2,38,909**	**49,663**

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Table 2: Manpower calculation for the balance work, with 6 months (150 days) remaining

Average man-hours per day demand		
Average manpower per day (12 hours working)		
Activity	**Skilled manpower**	**Unskilled manpower**
Ducting	4048	948
	337	79
Insulation	633	38
	53	3
Piping and equipment	1593	331
	133	28
Air equipment	415	132
	35	11
Electrical	505	169
	42	14
Total	**7194**	**1617**
	599	**135**

Total manpower demand per day: 734

Based on manpower estimation of work quantum of the project (*Table 1*), the project manager is required to estimate the work activity of each trade in terms of man-hours, and based on the project duration one can estimate the per manpower demand w.r.t. front clearance and other resource availability. It becomes very important for the project head to holistically look at the demand vs. supply network of manpower along with resource management to avoid the end crisis of the project. It is also important to deploy the right trade of manpower for each type of work for better output per person per day. It becomes economical to plan for material handling and site transportation along with rigging activities to separate the skilled manpower demand.

As summarized in *Table 2*, if the balance duration of the project is 6 months or 150 days, backward calculation leads us to the manpower demand of 734 at the site working for 12 hours.

Photo 9: Ducting and insulation work in progress in immigration area with battery operated scissor lifts

This would dynamically keep on revising daily based on the presence of workforce at site and the expected output.

Material Handling and Site Transport Management

Material handling and site management facilities included:

- A 25 metric tonnes crane
- A 5 metric tonnes JCB forklift
- Twelve battery operated scissor lifts of 22 metre height
- 3000 m² scaffolding
- Twelve DG sets with DG tanker facilities
- Security staff
- Canteen and pantry
- Three fully furnished site offices
- Stores/ warehouse
- Scrap removal vans
- Airside transport truck
- Two jeeps

Photo 10: Total station for marking universal axis on latitude/ longitude for locating grilles and outlets

Use of Advanced Techniques

A number of advanced technical and project management tools were used to ensure project quality and smooth progress:

- Laser levelling and alignment tools
- Implementation of survey stations for locating grills and diffusers numbering more than 7000 (see *Photo 10*)
- Productivity improvement plans with time and material study
- Employment of industrial engineers
- Water and power requirement with distribution network

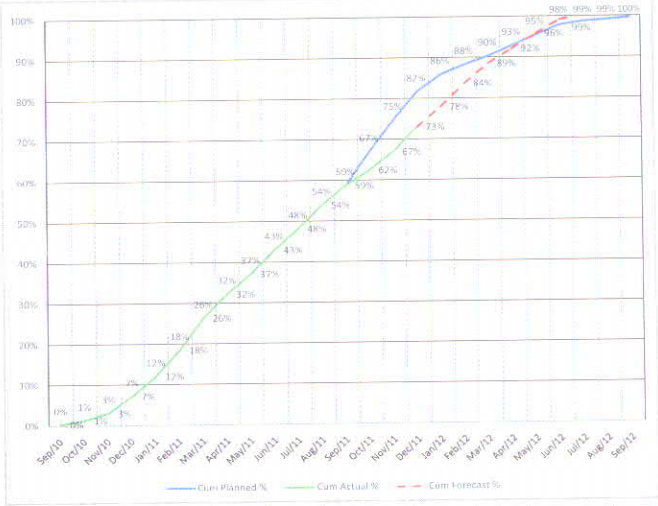

Figure 2: Monitoring of actual vs. planned work completion for overall work output through Primavera

- Productivity monitoring systems like Primavera (see *Figure 2*) and MS Office.

In Part 2 of this article, to be published in the May - June 2014 issue of the Journal, we will look at commissioning activities.