Construction of Hangar with Media Centre and Double Storey Annexes for Aero India 2005 at Air Force Station Yelhanka – A Case Study

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1. ABSTRACT

1. Yelahanka Air Field is located at an altitude of 820 m above MSL in the out skirts of Bangalore city **"The Aviation & IT Hub of India".** The runway is oriented in 09-27 direction with parallel taxi-tracks on both northern and southern side, large dispersal and manoeuvring areas.

2. Air Force Station Yelahanka (AFSY) is a training base for transport pilots on AN-32 & DO-228 and helicopter pilots on MI-8 Aircrafts and has attained importance all over the world since 1996 when first International Aero India Exposition was conducted by Defence Exhibition Organization, Ministry of Defence on this base. A biennial International Aero exposition is regularly being held since then on this base, where a large number of International and National aviation companies participate. Wide varieties of air crafts from all over the world also visit and operate from this station during the Aero Show.

3. A large number of technical accommodation including hangars of varying sizes have been constructed in the station since its inception. The oldest of these hangars were constructed during 1965 for small sized aircrafts operating from this base at that time. Over a period of time the type and size of hangars in the station have grown from simple steel trussed structure to complex 70m span bowstring girder type and light weight steel tubular section structure. Requirement of hangars as covered exhibition space for aviation companies participating in Aero Show has increased many fold since 1996 when first Aero India Exposition was held at Yelahanka.

   Covered space available during 1996 was 4000sqm which has increased to 15000sqm by 2003 Aero Show. The participation level of national and international companies has increased from 10 numbers to 24 numbers during this period. Due to growing interest worldwide, participation level in AI-05 was expected to increase to 35-40 companies requiring additional covered space of approximately 4200sqm along with modern facility for conferencing and communication facilities for media coverage. A work was therefore initiated by Air Force Station Yelahanka through HQTC for **"Construction of Hangars with Annexe at Air Force Station Yelahanka"** for facilitating additional covered space for exhibition and other allied facilities.

4. Hangar project at Yelahanka was conceived with State-of-the-art concept of **Pre Engineered Building** using all modern materials and techniques which makes this an ideal project standing in the category of **A Complex Architectural and Engineering Marvel.** The project demanded use of modern techniques and materials with high degree of construction precision, excellent quality control, constant supervision through experienced executives and regular monitoring up to the highest level.

5. A/A was issued under Fast Track Procedure wherein tender action was completed based on go-ahead sanction by MoD and work was sanctioned and released on the basis of lowest tendered amount. The work commenced on 30 Mar 04 and was successfully completed on 20 Jan 05.

2. PROJECT MANAGEMENT TEAM

6. Responsibility for execution of the project along with other AI-05 projects was entrusted to CWE (AF) North Bangalore and GE (AF) Yelahanka under CE (AF) Bangalore. One AGE (I) Laboratory was placed at construction site for conducting all quality control tests independently.

7. Contract was awarded for an amount of Rs 11.08 crores to M/S Sukhdevraj Sharma Construction Co Pvt Ltd, Bangalore, a leading construction agency having adequate expertise in the field of building construction with MES as well as with other government departments.

3. BRIEF SCOPE OF WORK

8. Scope of work broadly consisted of construction of 60m x 70m x 10m clear size Hangar with no intermediate supports, flanked with Annexes on three sides and an electrically operated gate on the fourth side along with associated services. Annexes on two sides were to be in Double Storey and rear side was to house two auditoriums of 200 and 50 seats capacity each complete with Air conditioning, furniture and PA system besides a VIP lounge, a large Dining Hall and acoustically treated Class Room etc. Plinth Area of the Hangar and annexes put together was about 9000 Sqm. Roof of annexe on the Northern side was proposed to be the viewing Area for the Air Show. The flooring was to be generally of granite slabs, vitrified tiles and rectified ceramic tiles. Roads, Hard Standings, Water Supply, Electric supply, Stand-by Power Supply DG set with AMF panel of 250 KVA capacity etc were planned as external services. A site plan showing the location of proposed Hangar with reference to existing hangars "A" and "B" is given in Fig (1). Architectural plan and four side elevations of the Hangar are shown in Fig(2) & (3).

Fig. 1. Proposed Hangar Location

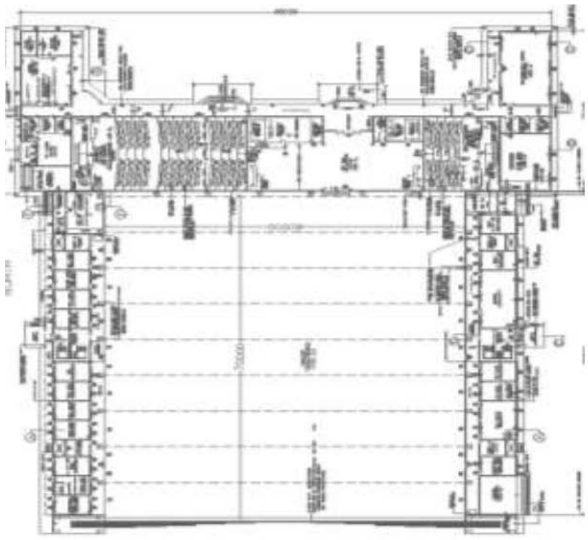


Fig. 2. Ground Floor Plan

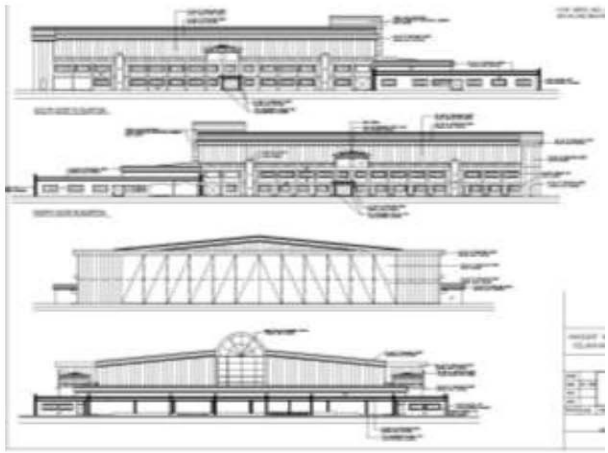


Fig. 3. All Four Side Elevations

4. PROJECT PLANNING SCHEDULE

9. As Go Ahead Sanction was accorded by MoD in 28 Oct 2003, time available for detail planning, preparation of architectural drawings, structural design, tendering, processing of all documents for issue of A/A and execution of work till completion was only 16 months. Based on the available crashed time, a schedule drawn for above activities is shown in Table (1)

TABLE 1: Time Schedule for Engineering Activities

SL No	STAGE	DATE	REMARKS
01	GO AHEAD	28 OCT 2003	PLANNING/ DESIGNING 45 DAYS.
03.	DIT	11 DEC 2003	TENDER ACTION 47 DAYS
04.	DRT	27 JAN 2004	
02.	ISSUE OF A/A	23 MAR 2004	ADMIN APPROVAL 55 DAYS
05.	COMMENCEMENT	30 MAR 2004	EXECUTION 290 DAYS
06.	COMPLETION	20 JAN 2005	

10. It was decided to provide "Pre-Engineered Building" structure for main hangar. Since the time available for all above activities was not enough for in-house preparation of drawings and carry out design, it was decided to outsource this activity through the tenderers to the manufacturers of PEB structure and other consultant with an explicit requirement of getting the design vetted from premier institutions like IIT's or IISc Bangalore. Apart from design and drawings of PEB structure, design and drawings of RCC structure, acoustics in Auditorium and Air-conditioning works were also outsourced through the tenderers. This approach could certainly reduce 2 – 3 months time in over all planning and tender action. With an aim to reduce the execution time entire structure was sub divided into five independent buildings/structures so that execution of these five buildings could be undertaken concurrently. These five buildings as shown in Fig (4) are as under:

    (i) PEB Hangar

    (ii) Double storey Northern Annexe in two parts with a crumple joint in between.

    (iii) Double storey Southern Annexe in two parts with a crumple joint in between.

    (iv) Rear annexe housing Media Centre, Communication Centre, Cafeteria.

    (v) Hangar Gate & Gate structure.

Fig. 4.

11. In the above planning, it was important to design the interface of two buildings keeping in view requirement of movement joints and over-lapping of roof projections so that water ingress could be prevented. All specifications with respect to finishes were frozen to the micro level by specifying even catalogue numbers for avoiding delay in decision / changes during execution. Important items where such detailed specifications were given are Flooring tiles, External finishes, Furniture (Featherlite & Durian), Acoustic Boards in wall & ceiling & PA Equipment.

12. In order to materialise above innovative ideas of planning, tender document was also framed suitably with relevant clauses to cater for out-sourcing of design of various structures / items and their verification. It was decided to conclude

only one tender for all activities including PEB structure, RCC Buildings, Gate structure, Air conditioning, Acoustics, Furniture and PA equipment. This was considered necessary for avoiding non co-ordination among contractors, at the time of execution which usually causes delay in such type of multidiscipline projects.

5. DESIGN CONCEPTS OF PEB STRUCTURE

13. "Pre-Engineered Building" Structure used in this project is comparatively a new concept in MES. In this type of structure, all structural elements like Columns, Beams, Purlins, Bracings, Base plates etc. are prefabricated in modular forms at modern workshops equipped with fully computerised machineries required for precision fabrication. Advantages of such structure over traditional steel structure are:

    (a) Quality control is par-excellence since fabrication work is through computerised plants. All members are cut to shape and tailor made as per structural requirement thus works out to be lighter and economical.

    (b) Elements are in Modular forms where each Module is of length not exceeding 10 M which can be transported easily.

    (c) Construction in faster and erection is easier.

    (d) Structure is maintenance free and aesthetically elegant

PEB ELEMENTS: RAFTERS

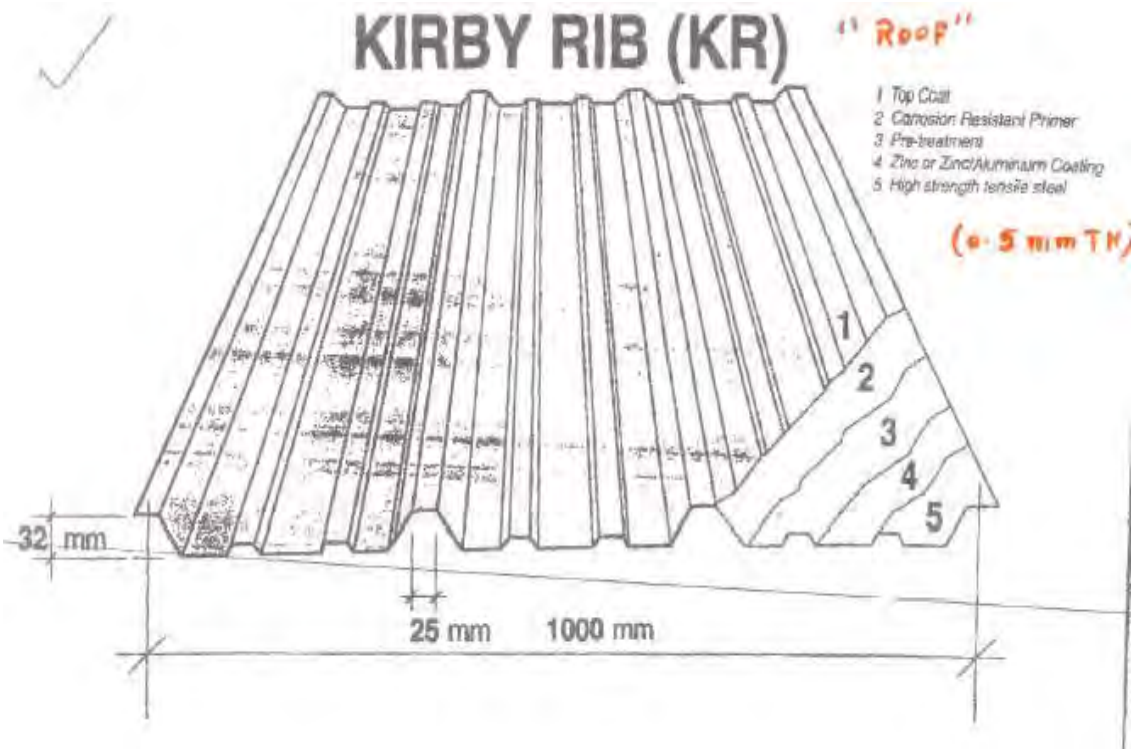
ERECTION OF RAFTERS

6. SPECIAL ARCHITECTURAL FEATURES AND NEW MATERIALS INTRODUCED IN THE PROJECT

14. Specifications of large span steel structures have seen advancements from heavy weight mild steel two dimensional traditional truss type structures over pylons or RCC columns to third generation Rigid Frame Pre-Engineered Buildings of profile commensurate to bending moment diagram to fourth generation three dimensional space, transigrity and tensile structures. It has been possible to develop such structures due to advancement in construction materials and techniques like High Strength Steel (Fe-510), large length Galvalume sheets as roofing and cladding materials etc. State-of-art building materials recently introduced in our country were effectively used in this work to their advantages. Description of some of the important materials are as follows:

(a) High Strength Steel PEB Structure: As already brought out in preceding paragraphs, Pre Engineered Building Structure fabricated from high strength steel plates were used for the hangar. All the materials used in PEB structures viz steel plates , cold formed sections, High tension bolts etc. were tested in quality control laboratory at manufacturer's end before fabrication. Quality assurance tests were also got carried out at IISc Bangalore as confirmatory tests for these materials.

(b) Galvalume Roofing System: A significant advancement in the field of metallic roofing system could be seen in the market from CGI sheets of maximum length 3.0m to GALVALUME and ZINCALUME sheets of 10m to 12m length. In this project GALVALUME high tensile cold rolled steel sheets conforming to AS 1397, coated with min 150 gms/m^2 of Zinc-aluminium alloy coating mass (class AZ150),and colour coating with oven baked paint applied to substrate manufactured by M/s Kirbi Building System India Ltd was used. Profile of sheets used is shown below.



15. Other new materials and important architectural features used in this work are;

(a) Alu-K-Bond Lining for Wall and Columns for improving aesthetics of the structure

(b) Cold Formed Section for Purlins, Girts as light weight secondary members in lieu of traditional open structural steel sections. Weight of CFS purlins of size 200Z2.0 used in this work is 4.8 Kg/m^2 as compared to ISMC 250 structural steel section of weight 15.6Kg/m^2.

(c) Vitrified and Rectified tiles have been provided in various rooms and corridors in lieu normal ceramic tiles as has been discussed subsequently.

(d) Structural Glass Façade in staircase mumty has been provided in lieu of PCC block masonry panel wall with an aim to improve side elevations and increase lighting level in staircase hall.

(e) Polycarbonate Double Walled Sheet Dome

7. METHOD OF PHYSICAL EXECUTION

16. Survey and Investigation: Prior to commencement of work, proper and accurate survey and investigation of existing soil and area of the plot was of paramount importance. Soil investigation was carried out by Karnataka Test House Pvt Ltd, Bangalore. Five bore holes were explored for this purpose and SBC reported was 13 T/m^2. North-eastern edge of the rectangular plot as shown in Fig(1) was appx 3.5m higher than the south-western corner. Total Station survey equipment was used to take the initial and final levels.

17. Architectural drawings and specification were prepared by CE (AF) Bangalore and design drawings were supplied by contractor. Pre Engineered Building was designed by M/s Kirby India, Hyderabad and other works by M/s Civil World, Bangalore.

18. Site Clearance and Foundation Work: Before commencement of excavation of earth all existing buildings were demolished. Ground was made level as hangar floor was required to be in level. Existing water pipes and cables passing through the area were diverted. Cutting of appx 20,000 Cum earth was involved.

19. Foundation of annexe was designed as raft foundation. Main Hangar was designed as Pre-Engineered structure with stanchions erected over RCC pedestals and fixed with anchor bolts. Foundation for pedestals was designed as strip footing. SBC of soil being low, soil was stabilized with sand cement (10:1) cushion 500mm thick. M 25 concrete was used for all RCC works and Ready Mix Concrete (RMC) with cement content of 340 kg/cum, was supplied by M/s ACC Ltd. Photographs below depict site clearance and foundation activities in the project.

20. PEB Structure: Primary members called stanchions and rafters were fabricated in the factory of M/s Kirby India Ltd in Hyderabad and were transported to site by road. The stanchions were single piece and rafters were in six pieces assembled with nut and bolts at site. These members were erected in a short span of 30 days. Erection was done with the help of derricks & cranes. All stanchions were erected first on the top of pedestals. The gap in pedestals and stanchions was filled with non shrinkable grouts. Thereafter rafters were put on stanchions. Erection manual of manufacturer was followed for safe erection. After erection of all members, roofing and cladding was done with Galvalume sheet 0.5mm thick. The sheet was fixed to purlins etc with the help of self driven screws. Roof of rear bay of the hangar was provided with polycarbonate sheet dome of 10 m span and 12 m height for better elevation and natural lighting. Polycarbonate sheet used was 6mm thick Multi wall marketed by M/s GE Corpn. Various activities of PEB structures viz individual members, erection work, connection and junction details, completed frames, fixing of Galvalume roof and wall sheeting could be seen in Photograph below

STRIP FOOTING BEING CASTED

FIXING STANCHION ON PEDASTAL

ERECTION OF END PORTALS

SETTING RAFTER OVER STANTION

A VIEW OF STRUCTURE

A VIEW OF PORTALS

21. Pavement Quality Concrete Floor: Pavement Quality Concrete designed for flexural strength of 45 Kg/Cm2 with cement content 395 Kg/Cum and water cement ratio of 0.38 with slump 25 to 30 mm considering compaction factor 0.82 was designed by ACC (RMC).

22. Concrete was manufactured under strict quality control from ACC Ready Mix Concrete plant brought in Transit Mixers to the site and discharged over WMM & Polythene sheet. Concrete was initially leveled manually and vibrated with the help of needle vibrators. Subsequently concrete was paved, compacted and leveled with "Mechanical Paver" (MULTI EQUIP)

WMM IN HANGAR FLOOR

POWER TROWELLING

23. Compacted and leveled concrete was allowed for its initial setting when concrete is still green (approximately after 20 to 35 minutes) non-metallic monolithic surface hardening compound NITOFLOR Hard top of M/s FOSROC Chemicals

was spread over the concrete surface at a rate of 3 Kg per SM. No "Vacuum-Dewatering" was not required since W/C ratio was too low to perform this activity.

24. After uniform spreading of hardner, concrete surface was "Floated" with tremix skim floater for top layer. Subsequent two passes of floating was carried out with floater at an interval of 1 to 1 1/2 hours. Once floating was completed, surface was "trowelled with power trowel three times at an interval of 2 to 2 1/2 hours depending upon weather conditions. Smooth finished surface was achieved in 10 hours of operation.

25. Electrically Operated Door Shutters: Main hangar has been provided with electrically operated door shutters, twelve numbers, each of size 10mx5m. These twelve doors were placed over guide rails at bottom and supported on guide channels fixed to steel wind girder at top. Total steel used was approx 45 MT. Gantry was fabricated at site in three parts. These three parts were then shifted at location and assembled with welded joints. Gantry was lifted en-block with two cranes of 100 Ton capacity and placed in position. Speed of movement of doors is adjusted for 10m per minute.

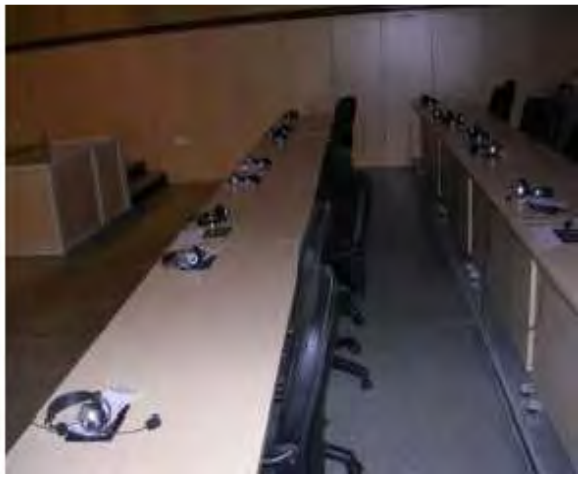
26. Double Story RCC Annexe: The conventional annexes on South and North were designed as framed structure with isolated footings. Panel walls were constructed with PCC Solid / hollow blocks. Floor finishes were with rectified ceramic, vitrified tiles and granite slabs in stairs. Railings on verandah were of stainless steel matt finish.

27. Media Center and Auditorium: The rear annexe was designed as Pre-Engineered Building structure of approx plinth area 2100Sqm to house two auditoriums of capacity 200 & 50, VIP lounge, class room, communication room, dining hall with kitchen, store and toilets. Auditoriums are provided with Air conditioning, acoustically treated and provided with state-of-art Public Address system centrally controlled from control room. Media centres were provided with Modern furniture manufactured by M/s Featherlite Industries and M/s Durian Ltd. Air conditioning was designed and erected by M/s Blue Star Ltd. Acoustic treatment was designed by renowned consultant, Prof B Ramakrishna. All toilets were provided with designer tiles, stainless steel doors and urinals with sensors. PEB stanchions and Columns are clad with ALUCOBOND cladding material for aesthetics.

STAINLESS STEEL DOORS IN TOILET

ENTRANCE HALL OF MEDIA CENTER

ALUCOBOND LINING



PA SYSYTEM IN MEDIA HALL

COMPLETED GATE STRUCTURE

MEDIA CENTER 200 SEAT CAPACITY

28. Important technical parameters of the completed hangar are given in Table below(3)

	PEB	**RCC**	**TOTAL**
PLINTH AREA	6071 SM	3150 SM	9221 SM
COST	Rs.640 LAKHS	Rs.160 LAKHS	Rs.800 LAKHS
PA RATE	Rs.10540/SM	Rs.5080/SM	Rs.8675/SM
TOTAL WEIGHT OF PEB MATERIALS :			890 MT
WEIGHT PER SM :			146 KG/SM
DETAILS OF PEB MEMBERS			
PRIMARY MEMBERS COLUMNS/RAFTERS :			310 MT
SECONDARY MEMBERS: PURLINS, STRUTS, BRACING ETC			57 MT
ROOF SHEETING 6717SMX0.005MX7850			264 MT
WALL CLADDING 6200SMX0.005X7850			244 MT
GUTTER, DOWN SPOUTS, BOLTS ETC			10 MT
BIRD PROOFING :			53 MT
DOORS			138 MT
TOTAL			1076 MT

8. DISCUSSION ON IMPORTANT TECHNICAL ISSUES

29. Smooth Concrete Floor: As per specifications given in the contract, hangar floor was to be of Pavement Quality Concrete designed for flexural strength of 45 Kg/cm^2 with rough broomed surface finish. This practice has been followed in MES in almost all the hangars constructed in the past. However it was pointed out by users that the rough surfaces in hangar floors cause maintenance problems with reference to cleaning of floor of grease / oil etc. and that all over the world, hangar floors are now being provided with smooth floor which attract less dust and are easy to clean, thus it was desired that hangar floor in this project should also be finished smooth. A detailed survey was carried out for ascertaining suitable techniques and material which could provide smooth finished floor without causing any shrinkage cracks. Subsequently trials were carried out over floor of existing hangars by M/s Fosroc chemicals, M/s Sika chemicals and M/s Berger Paints for self levelling epoxy floor coatings. All these products were appearing technically suitable but economically unviable. It was finally decided to obtain smooth surface by using power floats and trowels in combination with floor hardener applied @ 2.5 kg/sqm. This technique was found effective in achieving an excellent, smooth, high wear resistance floor finish without any shrinkage cracks.

30. Erection of Gate Structure: Gate structure was designed as an independent structure for the entire wind load over a large area of 60mX10m. This has necessitated wind girder depth and weight as high as 4.5m and 45 Tonnes respectively. Girder was fabricated at site in three parts. Erection of girder as one unit after connecting three parts was done carefully by using three cranes of 100 tons capacity with one crane as stand by. The gate supporting structure i.e. wind girder was fabricated out of tube sections RH 100 to RH 50 size and ISMC 250 sections with total weight of 45 tonnes. Similarly twelve number gate panels of size 10mx5m were fabricated out of ISMC 250 main frame with ISA 75x75x6 diagonal

bracing, each panel weighing to 2.5 tonnes. Since the wind girder was designed as structure independent of main hangar due to time constraints, its size with respect to depth, height and size of member is on higher side. The same could have been reduced if this structure was connected to the adjacent braced rigid frame. Similarly weight of gate panels could have been reduced if fabricated out of built-up section made out of 4 Nos ISA placed at 300mm c/c laced on all faces with 16mm MS rods. Due to time constraint the revision of design was not considered appropriate

WIND GIRDER ON GROUND

WIND GIRDER BEING ERECTED

31. **Polycarbonate Roof Panels and Dome:** Use of polycarbonate roof panels and dome has been found very effective in improving lighting level inside the hangar apart from improving the front elevation and overall aesthetics of the structure. Panels and dome can be seen in Photographs below.

COMPLETED DOME AND FRONT VIEW

CLOSE UP OF POLY CARBONATE DOME

32. Bird proofing panels fixed directly to flange of Portal Beam: As specified in the contract bird proofing panels made out of square tube section frame and weld mesh were to be fixed with suspenders at suitable intervals. It was observed that bird proofing in earlier hangars had developed sag at many places and got de-shaped over short span of time. It was therefore decided to fix these panels directly to bottom flange. This practice apart from imparting greater stability to bird proofing frame has rendered additional working height inside hangar.

BIRD PROOFING WITH SUSPENDERS

PANEL FIXED TO FLANGE OF RAFTER

33. Interface of Steel and RCC structure: As already brought out, main hangar is made of steel portal structure whereas double storey side annexes are of RCC framed structure. Structural and architectural detailing at the interface of two types of structures has been of paramount importance from structural and functional point of view. It was important to keep all elements of two types of structures at their interface separated adequately with movement / separation joints and at the same time it was desirable to take adequate care in detailing at such interface like overlaps and projection at roof level to avoid in-grace of rain water. These details can be seen in Photographs below.

FIRST FLOOR CORRIDOR

INTERFACE OF PEB STEEL AND RCC

34. An aerial view and front elevation of the completed project is shown in Photograph below.

AERIAL VIEW OF COMPLETED HANGAR

FRONT VIEW OF COMPLETED HANAGR

9. MONITORING OF WORK

35. The progress of work was being monitored right up to CE SC Pune in Engineer channel, by Air HQ in Air Force channel and by DEO in MoD channel. Regular meetings were being held at HQTC to monitor progress. Apart from many other

progress reports, a daily report up to CE's Office and a fortnightly progress report up to MoD was being initiated, intimating the latest progress of the work. Project was visited by several senior officials during the progress of work viz. Secretary (Defence Production), Govt of India, AOC-in-C HQTC, E-in-C AHQ, SOA HQTC,CESC etc.

10. QUALITY CONTROL

36. A well equipped laboratory was set up by contractor at the site of work immediately after issue of work order. One AGE (I) Lab assisted by one JE was made incharge of the laboratory under direct control of CE (AF) Bangalore. Most of the quality control tests were conducted in this laboratory in presence of Engineer-in-Charge and contractor's representatives. All field tests were also being carried out by AGE (I) Lab, contractor and executives jointly. In addition, Joint Director (Design) was tasked by CE (AF) Bangalore to verify the correctness of test results periodically for ensuring strict quality control.

11. CONCLUSION

38. Time was in true sense an essence of this project since dates for Aero India-2005 exhibition were fixed. In-spite of excessive rains and tight schedule the work could be completed in record time with excellent quality control to the entire satisfaction of Users. This was possible due to judicious planning, timely decisions, close interaction between Users and engineers and, of course, round the clock close supervision by executives. Technical knowledge and innovative approach applied in the work were quite effective in overcoming day to day problems encountered at site and in improving quality of work. User's interaction in technical accommodation like hangar is of paramount importance. In a way close liaison with Users has given important inputs enabling MES to deliver in achieving finished product to their entire satisfaction.