REPORT ON

ANALYSIS OF CAPITAL EXPENDITURE ON EXPANSION OF DELHI INTERNATIONAL AIRPORT LTD. (PHASE-3A)

Prepared for

Airport Economic Regulatory Authority (AERA)

Prepared by

KITCO
the consultants

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Abbreviations

DIAL	Delhi International Airport Limited
IGIA	Indira Gandhi International
AAI	Airport Authority of India
OMDA	Operation, Management & Development Agreement
ICAO	International Civil Aviation Organization
LCC	Low Cost Carriers
OOG	Out of Gauge
MMPTA	Million Metric Tonnes Per Annum
IMG	Inter-Ministerial Group
ILS	Instrument Landing System
GSE	Ground Support Equipment
MRO	Maintenance Repair & Overhaul
MAP	Million Annual Passenger
RET	Rapid Exit Taxiway
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
LOS	Level of Service
ATM	Air Traffic Movement
CAGR	Compound Annual Growth Rate
NTP	North Terminal Precinct
STP	South Terminal Precinct
ROT	Runway Occupancy Time
ATC	Air Traffic Control
ADRM	Airport Development Reference Manual
ECT	Eastern Cross Taxiway

EXECUTIVE SUMMARY

Indira Gandhi International Airport (Delhi Airport) is the primary civil aviation hub for India and the National Capital Region of India. It is spread over an area of 5106 acres (2066 Ha), situated in Palam, South-West of New Delhi. IGI Airport is the busiest airport in India in terms of passenger traffic and second busiest in term of cargo traffic. The overall airport infrastructure has the capacity to handle 62 MAP and Cargo handling capacity of 1.5 MMTPA.

Keeping in account of the present aviation demand and growth rate, DIAL has now proposed to expand the existing Terminal and Airside facilities along with associated facilities to enhance the passenger handling capacity of IGIA from current 62MAP to 109MAP and Cargo handling capacity 2.2 Million Metric Tonnes Per Annum (MMTPA) from 1.5 MMTPA as per demand forecasted. The proposed expansion project by DIAL will be carried out in three phases with the expansion plans as Phase 3A, Phase 3B and Phase 4.

In this context, AERA assigned KITCO Ltd. to carry out the analysis of capital expenditure of expansion of Delhi International Airport on Phase 3A proposed by DIAL. Accordingly, KITCO has carried out the following:

1. *Examined the proposal of the Airport and has assessed the need for the proposed project and its capacity, with reference to passenger growth/cargo volumes/air traffic movements and also has suggested cost effective alternatives.*
2. *Examined whether the building standards and designs are in line with IMG/IATA/ICAO norms.*

3. *Analysed the reasonableness of the proposed cost with reference to the tentative ceiling decided by the Authority based on the details of the rates and quantity as per Govt./Industry approved norms.*
4. *Reviewed the designs and specifications proposed, wherever the costs were excessive in the case of projects already in progress or where the contracts are already awarded. It was also examined whether proper procedures have been followed in the award of work.*
5. *Reviewed and justified the reasonableness of time schedule of completion of the work proposed by DIAL.*

The major components of the proposed capital expenditure is planned in 5 tender packages under the following heads:-

Packages	**Estimated cost by DIAL**
Expansion of Terminal 1	2,513.00
Airfield works including 4th Runway & Eastern Parallel Cross Taxiways	4,681.00
Landside / Connectivity works	366.00
Modifications to Terminal 3	167.00
TOTAL	7,727.00
Others	905.00
GRAND TOTAL	**8,632.00**

The components in various packages are as below:-

PACKAGE 1 - Expansion of Terminal 1 and Apron

- *Expansion of departures/arrival buildings with a new architectural façade on the city side and integrating with existing Terminal buildings.*
- *Construction of node building & Pier with 22 PBBs*
- *Reconstruction of Apron with 82 aircraft parking stands.*
- *Redesign of existing drainage facility.*

- *Redesign of MEP systems to meet the requirement of the new terminal building and its associated facilities.*
- *Special Airport systems*

PACKAGE 2 - Airfield Works

- *Construction of 4th runway and associated Rapid Exit Taxiways*
- *Construction of North Parallel Taxiway for existing Runway and related Rapid Exit Taxiways (RETs)*

PACKAGE 3 - Landside Works

- *Kerb widening of Terminal 1*
- *Northern Access Road widening*
- *Widening of Central spine road*
- *Realignment of Radisson road and its integration with proposed eastern cross taxiway underpass.*

PACKAGE 4 - Eastern Parallel Cross Taxiways

- *New Eastern Parallel Cross Taxiways*

PACKAGE 5 - Modifications to Terminal 3

- *Construction of additional transfer area for I-I (international to international).*
- *Installation of 7th check in island along with its Baggage Handling & screening systems.*

For assessing the existing scenario and future requirements the following data shall gathered and reviewed.

Master plan report 2016 for IGIA (Delhi) prepared by Landrum& Brown;

MDP reports , Bill of Quantities, Drawings of 5 Packages submitted by DIAL

Order No. 07/2016-2017 dtd. 13th June 2016 issued by AERA in the matter of Normative Approach to Building Blocks in Economic Regulation of Major Airports- Capital Costs Reg.

Report of the Inter Ministerial Group (IMG) – Norms & Standards for Capacity of Airport Terminals

Operation, Management and Development agreement between Airport Authority of India and Delhi International Airport Private Limited for Delhi Airport

Master Plan Report 2006 for IGIA Delhi prepared by Mott MacDonald.

The methodology adopted for the evaluation of capital expenditure is summarized as below:-

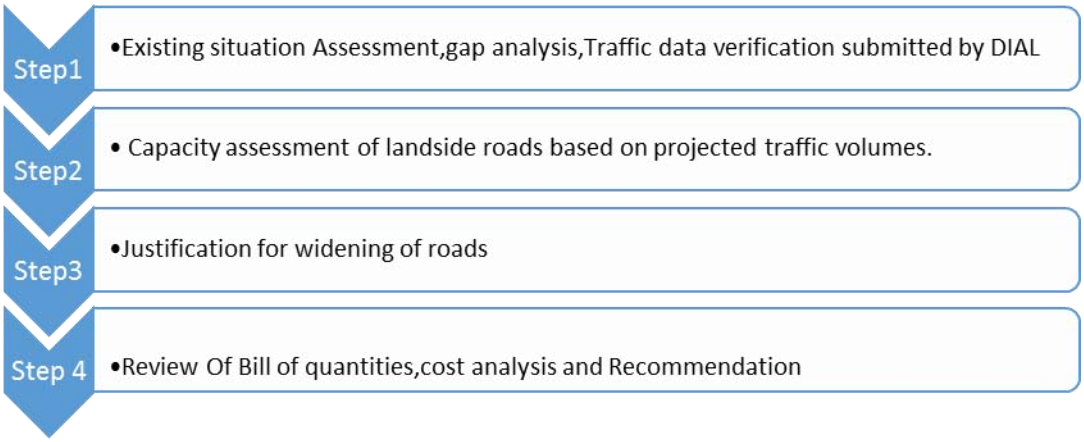
Package 1

- Step1: •Existing situation Assessment,gap analysis,Traffic projection verification :-Data collection of Passenger Traffic ,Trend based projection & analysis ,Verification of the forecast projected by DIAL .
- Step2: •Individual Process Area Assessment Based on ADRM calculation and survey inputs
- Step3: •Peak hour calculation based on IMG norms & Cross Verification with the peak hour surveys conducted at IGIA
- Step 4: •Apron Capacity Calculation based on ADRM and Design assumptions.
- Step5: •Review Of Bill of quantities,cost analysis and Recommendations

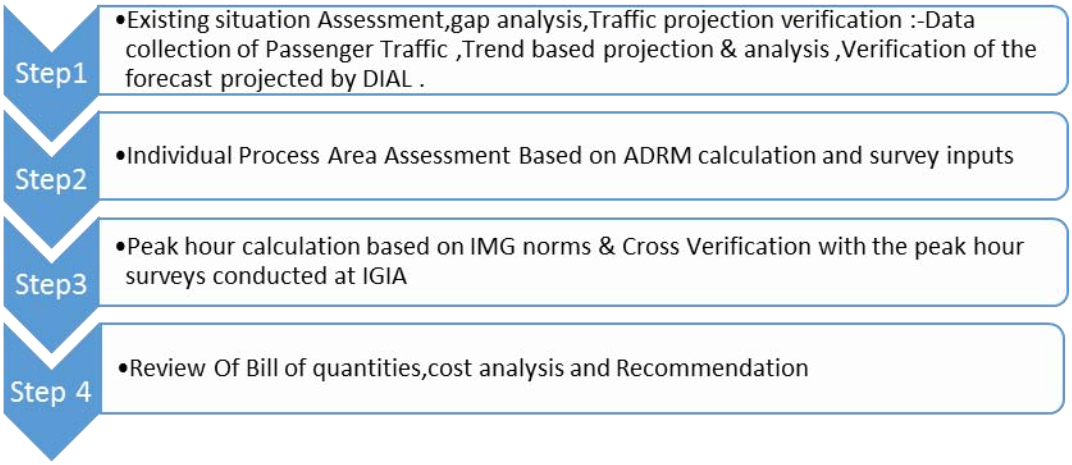
Package 2 &4

- Step1: •Existing situation Assessment of Air side.
- Step2: •Verification of ATM forecast,Assessment of Runways & Taxiways constraints.
- Step3: •Need for new Runway ,Eastern Cross taxiway & Link taxiways
- Step 4: •Review Of Bill of quantities & cost analysis and Recommendation

Package 3



Package 5



The summary of the exercises performed by KITCO is briefed as below:-

1. *The traffic projections have been verified by means of Trend based Projection using Data collected from Year 2006-2016. Design year in which the 35MAP in T1 & 40 MAP in T3 are achieved is found from the traffic projections.*
2. *The correlation with the forecast projected by DIAL is verified and differences highlighted.*
3. *The peak hour capacity based on IMG norms is verified and validated.*
   It is cross checked with the peak hour surveys conducted at IGIA and peak hour projections based on collected data and found to be matching with the IMG norms.

4. *The total area required as per IMG norms per PHP is calculated and the terminal areas proposed are justified.*
5. *Each process area is evaluated based on ADRM calculations with survey inputs and LOS C expectations and found matching with what is required for the projected PHP*
6. *Area allocations for other ancillary facilities are also cross checked and found well within the industry standards and best practices.*
7. *ATM forecast is also verified in line with the PHP forecast*
8. *Apron capacity is calculated based on ADRM calculations and design assumption to provide 30% spare active stands is as per L&B master plan 2016.*
9. *The night parking stand demand is verified as per L&B master plan and validated as per the Airline demand*
10. *The area shown for GA apron is deducted from the total Apron area and the cost variation due to area variation is highlighted*
11. *Taxiway proposals are assessed in detail and evaluated based on the need to enhance the efficiency of the airside.*
12. *The need for aircrafts in T1 Apron including GA aircrafts to use Runway 11/29 is verified and validated based on ATM data and runway curfews and the need to connect T1 to Runway 11/29 using eastern cross taxiway, which reduces the travel time to T1 apron substantially is justified.*
13. *The need for a northern parallel taxiway for Runway 10/28 is highlighted to avoid crossing of aircrafts to T1 and is justified, as DIAL has decided to retain the T1 location.*
14. *Rapid exit taxiways from Runway 10/28 and all linkages to apron and runways are cross checked and found justified.*
15. *The drawings are verified as per ICAO standards and the area requirements for taxiway are validated and cross checked with the quantities considered for estimate preparation.*

16. *Need for new runway 11/29 is assessed based on the combined runway capacity of existing 3 runways. AAI has calculated the combined capacity of the 3 runways, keeping in mind the restrictions in airspace, approach, obstacles, existing taxi network etc. as 67 ATM/ peak hour. L&B has reviewed the permutation/ combinations and has recalculated peak hour ATM of 84 based on simulations. IGIA has operated 84 ATMs per hour based on the standard of operations, prepared by L&B.*
17. *The ATM forecast is reviewed and found exceeding the combined capacity of 3 runways and therefore the need for fourth runway is justified.*
18. *The capacity assessment of land side roads has been done on the basis of existing and projected traffic volumes. Based on the capacity analysis, widening of roads is justified to maintain the desired level of service (LOS).*
19. *Capacity enhancement proposed by DIAL for the land side and airside works is for the design year 2035-36 whereas the T1 expansion is for the year 2025-26 and T3 enhancement is for year 2021-22. This is justified based on the fact that infrastructure developments can only be done on a long term basis, whereas buildings can be augmented with minimum interference with operational activities.*

KITCO reviewed the cost estimates submitted by DIAL based on the information provided by DIAL and Govt./Industry approved norms. The revision to total capital cost is recommended as below:-

(Amount in Rs. Crore)

Packages	**Estimated cost by DIAL**	**Recommended cost By KITCO**
Expansion of Terminal 1	2,513.00	2,431.00
Airfield works including 4th Runway & Eastern Parallel Cross Taxiways	4,681.00	4,320.00
Landside / Connectivity works	366.00	366.00

Packages	**Estimated cost by DIAL**	**Recommended cost By KITCO**
Modifications to Terminal 3	167.00	167.00
TOTAL	7,727.00	7,284.00
Others	905.00	685.60
GRAND TOTAL	**8,632.00**	**7,969.60**

An attempt has also been made to compare the cost incurred for the new International Passenger Terminal Building at Cochin, Expansion of the Terminal Building at Hyderabad and the Terminal at Kolkata constructed by AAI with the proposed Terminal expansion at Delhi. The comparison is given in the following table.

Comparison of cost

	Cochin			Hyderabad			Kolkata			Delhi			Cost Difference from Cochin (Rs./Sqm)		
Sub	Cost Rs. Cr	%	costper sqm	Cost Rs. Cr	%	costper sqm	Cost Rs. Cr	%	costper sqm	Cost Rs. Cr	%	costper sqm	Delhi	Hyderabad	Kolkata
Civil Works	401.47	47%	26765	335.43	23%	32566	957.16	43%	48173	442.81	18.21%	22945			
Spl finishes	70.26	8%	4684	191.6	13%	18602	56	3%	2818	366.00	15.06%	18965			
External Façade	47.98	6%	3199	117.12	8%	11371	167.12	8%	8411	67.82	2.79%	3514			
Roofing System	Incl.		Incl.	104.54	7%	10150	161.76	7%	8141	368.4	15.15%	19090	29,866	38,041	32,896
HVAC	121.5	14.31%	8100	56.64	4%	5499	144.88	7%	7292	180	7.40%	9327			
Electrical system				74.38	5%	7221	193.54	9%	9741	310	12.75%	16063			
Plumbing & Drainage				17.18	1.2%	1668	71.74	3%	3611	21	0.86%	1088			
Fire fighting system				10.18	0.7%	988	27.8	1%	1399	7	0.29%	363			
Fire detection				5.83	0.40%	566				15	0.62%	777	19,518	7,843	13,942
Vertical & Horizontal transport	207.95	25%	13863	536.92	37%	52128	424.72	19%	21376	653	26.86%	33837	19,974	38,265	7,512
PTB furniture															
Airport system															
Special works															
Total cost	849	100%		1450	100.0%		2,205	100%		2431.0	100.00%				
Area	150000			103000			198692			192985					
Cost Rs./sqm	56,611			140759			110962			125970			69,359	84,149	54,351

	Cochin	hyderabad	Delhi
Airside works			
Apron and taxiway for Code E + partly for Code F	Rs.4336per sqm		Rs.9042/sqm (for code F)
Runway		Rs.5705/sqm	Rs.5978/sqm

Chapter 1 - Introduction

1.1 Background

Delhi International Airport (P) Limited (DIAL) is operating, managing and developing the Indira Gandhi International Airport (IGIA) . DIAL is a Joint Venture consortium between GMR Group (64%), Airports Authority of India (AAI) (26%) & Fraport AG (10%) and is head quartered in New Delhi, India. In January 2006, the consortium was awarded the concession to operate, manage and develop Indira Gandhi International Airport (IGIA), following an International Competitive Bidding process. DIAL signed the Operations, Management and Development Agreement (OMDA) with the AAI on April 4, 2006 for an initial Concession term of 30 years, with the option to extend the term for an additional 30 years.

Indira Gandhi International Airport (Delhi Airport) is the primary civil aviation hub for India and the National Capital Region of India. It is spread over an area of 5106 acres (2066 Ha), situated in Palam, South-West of New Delhi. IGI Airport is the busiest airport in India in terms of passenger traffic and second busiest in term of cargo traffic. The overall airport infrastructure has the capacity to handle 62 MAP and Cargo handling capacity of 1.5 MMTPA.

The airport has best in class facilities and infrastructure compatible with International Civil Aviation Organization (ICAO) standards and practices to handle largest of aircrafts and International traffic. At present, there are three active passenger terminals, in which Terminal 1 and Terminal 3 operates for scheduled aircraft services and the Terminal 2 currently supports in Haj Terminal service .It also has two main cargo Terminals to support cargo service demands. Terminal 1C & 1D is used only for Low Cost

Carriers(LCC) arrival and departure respectively with a total floor area of 64,140 m^2

The integrated domestic and International Terminal 3 have 5.4 million sq ft. area with a design capacity of 34 MAP serves all international and full service domestic carriers. The 9 level passenger terminal building has 2 piers each 1.2 km long having 78 Passenger Boarding Bridges (including 3 Passenger Boarding Bridges for A380 or similar sized aircraft), 95 Immigration counters (49 Outbound and 46 Inbound Immigration counters), 6 Common check-in islands -168 check-in counters, In-line Baggage Handling System with capacity to handle 12,800 bags per hour, 12 Baggage reclaim belts including 2 belts for Out of Gauge (OOG) bags, 6.7 million sq ft. of apron area, 100 room Transit Hotel for Domestic and International passengers (68 rooms for domestic transit and 32 rooms for international transit), 96 automatic travelators /walkalators (Longest one being 118 mts in length), over 20,000 sq mtrs. of retail space, Multi-Level Car Park to accommodate 4300 cars, 7 MLD Water Treatment Plant and 15 MLD Sewage Treatment Plant (total quantity for entire airport, treatment plant inside airport premises only). The modular integrated Cargo Terminal-1 is spread over 70,000m^2 and Cargo Terminal 2 is 48,500 m^2. There is an exclusive apron adjoining it that can accommodate Code-F aircraft.

IGI Airport has total 3 runways out of which two are main runways and one is a secondary runway. The two main runways are runway 11/29, 4,430 m × 75 m (14,530 ft × 200 ft) with CAT IIIB instrument landing system (ILS) on both sides, runway 10/28, 3,810 m × 45 m (12,500 ft × 151 ft), and the secondary runway is 09/27, 2,813 m × 45 m (9,229 ft × 148 ft).

There are four certified ground handlers that handle the foreign flag carriers. The T1 Apron has 3 GSE staging areas in total about 12,155m^2. The T3 precinct has 40 areas designated for GSE storage totaling about 59,735 m^2. Three of the four MRO sites at IGIA contain maintenance hangars. The General Aviation

facilities are located in the T1 precinct in the north east corner of the airport having 28 code B aircraft parking stands.

Keeping in account of the present aviation demand and growth rate, DIAL has now proposed to expand the existing terminal and airside facilities along with associated facilities to enhance the passenger handling capacity of IGIA from current 62MAP to 109MAP and Cargo handling capacity 2.2 Million Metric Tonnes Per Annum (MMTPA) from 1.5 MMTPA as per demand forecasted. The proposed expansion project by DIAL will be carried out in three phases with the expansion plans as Phase 3A, Phase 3B and Phase 4.

In this context, AERA has assigned KITCO to carry out the analysis of Capital Expenditure on Expansion of Delhi International Airport Ltd. for Phase-3A)

1.2 Scope of Work

AERA has awarded the work of consultancy services for analysis of Capital Expenditure on Delhi International Airport Ltd. for second control period (01/04/2014 to 31/03/2019) to ***KITCO*** *vide letter dtd. 28.12.2017.*

The proposal for analysis of Capital Expenditure towards expansion of Delhi International Airport Ltd. comprises of the following packages:

i) Expansion of Terminal 1 and Apron
ii) Airfield works including 4th Runway
iii) Landside/ Connectivity Works
iv) Eastern Parallel Cross Taxiways
v) Modifications to Terminal 3 and associated facilities

The scope of services assigned to KITCO include

i) To examine the proposal of the airport and assess the need for the proposed project and its capacity / scope with reference to Passenger growth/Cargo volumes/Air Traffic movement and also to suggest cost effective alternatives.

ii) To examine the building standards and designs proposed by the airport operator in line with IMG norms/IATA/ICAO norms.

iii) To analyze the reasonableness of the proposed cost with reference to the tentative ceiling decided by Authority vide order no 7 dated 13/06/2016 based on the details of the rates and quantity as per government / industry approved norms and advise the Authority on the justificaton of the costs.

iv) To review designs and specifications proposed in case the costs are assessed to be excessive where the Projects are already in progress or the contracts are already awarded. Further to examine whether proper procedures have been followed in the award of work.

v) To assist AERA in case any litigation arises in future in connection with the reasonableness of the cost estimates.

vi) To review and justify the reasonableness of time schedule of completion of work of proposed by DIAL

vii) To perform any other duties as may be deemed necessary and specified in the award letter.

viii) To assist AERA in Stakeholder Consultation process.

Chapter 2 - Phase 3A Expansion Proposal by DIAL

Currently the expected annual throughput has grown more than 60 million passengers. The major development projects would be the expansion of Terminal 1, fourth runway, eastern cross field taxiway, aprons, MROs and other airfield improvements, improvements to central spine road and northern access road, reconfiguration of Terminal 3. A series of airfield improvements will be implemented with the existing runway system to maximize existing capacity. The development of 4th runway 11L-29R will be in the southern part of the airfield adjacent to existing runway 11R-29L. Terminal 1 will be expanded to handle a demand of 35 MAP, along with improvements to the landside and apron. Other scope of Phase 3A expansion and improvements are:

- *Expansion of Terminal 1D (Departures);*
- *Extension of Terminal 1C (Arrivals);*
- *A new airside concourse building to provide contact aircraft parking stands;*
- *An expanded and redeveloped aircraft apron serving Terminal 1;*
- *New General Aviation (GA) Aprons;*
- *New parallel taxiway to existing Runway 10/28;*
- *A new fourth runway(Runway 11L/29R) with Rapid Exit Taxiways(RETs);*
- *New eastern cross-field taxiways linking the southern and northern parts of the airfield;*
- *Various other taxiway/airfield layout improvements;*
- *Various landside road and tunnel improvements;*
- *Various ancillary/support facility improvements; and*
- *Modifications to the transfer passenger facilities at Terminal3*

Terminal 3 will be reconfigured to handle 40 MAP international passenger traffic & domestic passenger traffic. Internal bottlenecks of emigration and immigration

will be resolved to facilitate a high level of service for international passengers. At the same time, domestic passengers will have direct access to domestic Pier C and D through an infill between the south face of the terminal and Pier C/D.

The northern access road corridor will continue to be main corridor for traffic arriving from central and northeast Delhi to the south terminal precinct.

- *Northern Access Road Corridor Widening: Expanding the corridor-from the Central Spine Road running north to the tunnels-to 5+5 lanes*
- *Roadway Widening: Widening the roads to the north of the existing tunnels to accommodate 5+5 lanes. The central spine road will be widened towards the median from current 4+4 lanes to 6+6 lanes.*

The proposed expansion works of IGIA constitute the 5 packages and the details of these packages are elaborated in the succeeding section.

2.1 Brief About the Proposed Packages

The submission made by DIAL has been forwarded to KITCO by AERA. The major components of the proposed capital expenditure is subdivided in 5 packages under the following heads:

Table 1- Abstract of cost

Packages	***Estimated cost in cr.***
1 - Expansion of Terminal 1 and Apron	*2,514.00*
2 - Airfield works including 4th Runway	*3,561.00*
3 - Landside / Connectivity works	*366.00*
4 - Eastern Parallel Cross Taxiways	*1,118.00*
5 - Modifications to Terminal 3	*167.00*
TOTAL	*7,727.00*
Others	*905.00*
GRAND TOTAL	***8,632.00***

PACKAGE 1 - Expansion of Terminal 1 and Apron

- *Expansion of departures/arrival buildings with a new architectural façade on the city side and integrating with existing Terminal buildings.*
- *Construction of node building & Pier with 22 PBBs*
- *Reconstruction of Apron with 82 aircraft parking stands.*
- *Redesign of existing drainage facility.*
- *Redesign of MEP systems to meet the requirement of the new terminal building and its associated facilities.*
- *Special Airport systems*

PACKAGE 2 - Airfield Works

- *Construction of 4th runway and associated Rapid Exit Taxiways*
- *Construction of North Parallel Taxiway for existing Runway and related Rapid Exit Taxiways (RETs)*

PACKAGE 3 - Landside Works

- *Kerb widening of Terminal 1*
- *Northern Access Road widening*
- *Widening of Central spine road*
- *Realignment of Radisson road and its integration with proposed eastern cross taxiway underpass.*

PACKAGE 4 - Eastern Parallel Cross Taxiways

- *New Eastern Parallel Cross Taxiways*

PACKAGE 5 - Modifications to Terminal 3

- *Construction of additional transfer area for I-I (international to international).*
- *Installation of 7th check in island along with its Baggage Handling & screening systems.*

Chapter 3 - Methodology Adopted for Evaluation

3.1 References

The detailed site study has been conducted for assessing the existing scenario and future requirements. Series of discussions with DIAL for understanding the proposal in detail was also carried out.

The following data has been gathered and reviewed:

- *Master plan report 2016 for IGIA (Delhi) prepared by Landrum& Brown;*
- *MDP reports , Bill of Quantities, Drawings of 5 Packages submitted by DIAL*
- *Order No. 07/2016-2017 dtd. 13th June 2016 issued by AERA in the matter of Normative Approach to Building Blocks in Economic Regulation of Major Airports- Capital Costs Reg.*
- *Report of the Inter Ministerial Group (IMG) – Norms & Standards for Capacity of Airport Terminals*
- *Operation, Management and Development agreement between Airport Authority of India and Delhi International Airport Private Limited for Delhi Airport*
- *Master Plan Report 2006 for IGIA Delhi prepared by Mott MacDonald*
- *Other Clarifications provided by DIAL.*

3.2 Methodology

The methodology adopted for the evaluation of Capital Expenditure for proposed expansion at Delhi International Airport is enumerated below:

Package 1

- **Step1** •Existing situation Assessment,gap analysis,Traffic projection verification :-Data collection of Passenger Traffic ,Trend based projection & analysis ,Verification of the forecast projected by DIAL .
- **Step2** •Individual Process Area Assessment Based on ADRM calculation and survey inputs
- **Step3** •Peak hour calculation based on IMG norms & Cross Verification with the peak hour surveys conducted at IGIA
- **Step 4** •Apron Capacity Calculation based on ADRM and Design assumptions.
- **Step5** •Review Of Bill of quantities,cost analysis and Recommendations

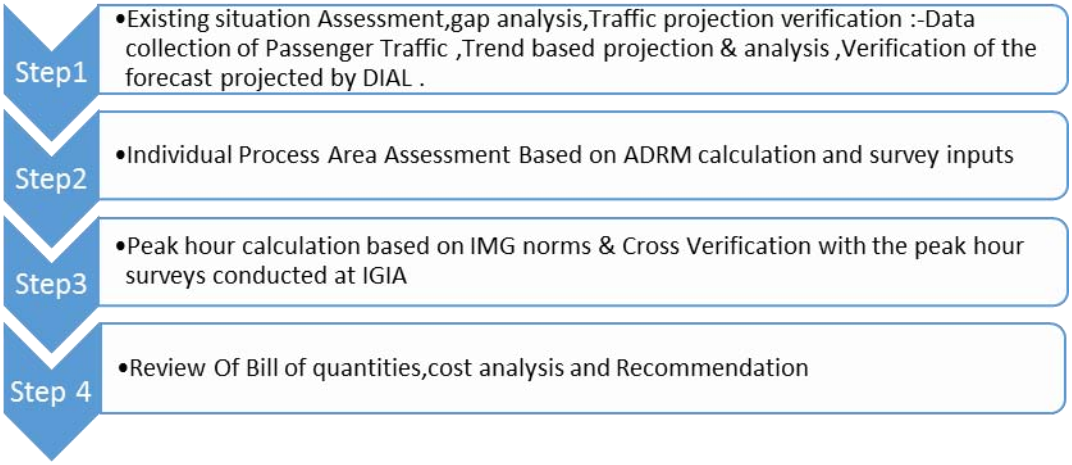
Package 2 &4

- **Step1** •Existing situation Assessment of Air side.
- **Step2** •Verification of ATM forecast,Assessment of Runways & Taxiways constraints.
- **Step3** •Need for new Runway ,Eastern Cross taxiway & Link taxiways
- **Step 4** •Review Of Bill of quantities & cost analysis and Recommendation

Package 3

- **Step1** •Existing situation Assessment,gap analysis,Traffic data verification submitted by DIAL
- **Step2** • Capacity assessment of landside roads based on projected traffic volumes.
- **Step3** •Justification for widening of roads
- **Step 4** •Review Of Bill of quantities,cost analysis and Recommendation

Package 5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•Peak hour calculation based on IMG norms & Cross Verification with the peak hour surveys conducted at IGIA
Step 4
•Review Of Bill of quantities,cost analysis and Recommendation

Chapter 4 - The Capacity Assessment

4.1 Expansion of Terminal 1 (Package 1)

4.1.1 Existing Scenario

Performance or Level of Service (LOS) criteria is the primary driver for various functional elements in a Terminal. International benchmarks and best in class practices were adopted for assessing terminal requirements. The current status of various aspects of IGIA has been studied in detail and the bottle-necks were identified in the existing facilities. These areas are used beyond their capacity to maximise existing utility.

Table 2 -Estimated Terminal Demand

Year	Daily ATMs			Annual ATMs		
	NTP	STP	TOTAL	NTP	STP	TOTAL
2013/14	335	474	809	116374	164660	281034
2015/16	376	556	932	130500	192900	323400
2020/21	538	783	1321	186700	271700	458400
2025/26	678	1011	1689	235400	350900	586300
2030/31	678	1279	1957	235400	443700	679100
2033/34	678	1415	2093	235400	491000	726400
2013/14	43035	70455	113490	13983621	22893365	36876986
2015/16	50352	83597	133949	16183000	26868000	43051000
2020/21	74966	120752	195718	24167000	38928000	63095000
2025/26	98201	161958	260159	30000000	53950000	8395000
2030/31	98201	212237	310438	30000000	70224000	100224000
2033/34	98201	240382	338583	30000000	79339000	109339000

source- L&Breport

Facilities at Terminal 1 would have to accommodate up to 35 MAP by 2025-26 from about 14 MAP in 2013-14. The study also addressed the needs of additional facilities such as Check-in, Security & Emigration & Immigration etc. Table No: 2 shows the daily ATM growth, annual ATM growth, daily passengers and annual passenger growth in the listed years.(source –L&B report)

4.1.2 Existing Terminal 1 Facilities:

Terminal 1 complex consists of two separate operational terminal buildings: Terminal 1D (T1D) for departures and Terminal 1C (T1C) for Arrival. Terminal 1D is operational since 2009 whereas Terminal 1C is an older building which was constructed in 1970s. Terminal 1A is located to adjacent to Terminal 1D but is not operational. Overview of the existing facilities provided in T1 D & T1C for various processes and functions are tabulated below in Table No:3.

Table 3- Existing Facilities

Description	*Existing*
Capacity	*24 Million*
Total Area (Dep+Arr)	*64,140 m²*
Entry Gate	*8 Gates (16 CISF Positions)*
Check in Gates	*4 Islands*
CUSS	*12*
Self-Baggage Drop	*Nil*
Hand Baggage X-rays	*18*
Hand Baggage (per machine)	*160- 180 Bags/ Hr*
Screening Capacity	*2,880 – 3,240 Bags/ Hr*
Contact Stands	*Nil*
Bussing Gates	*15*
BMA	*4 Baggage Carousels*
Baggage System	*Airline wise*
Arrival Baggage Belt	*8 Nos of 52m each*
Arrival Terminal	*Separate T1C*
Arrival Area	*8,000 m²*

4.1.3 Existing Passenger Traffic & Future Projections

Current domestic & International traffic handled during the years 2005-06 to 2016-17 has been collected from DIAL which is tabulated below in Table-4.

Table 4-Existing passenger traffic

Sl.No.	Year	T3 Intenational Total	T3 Dom Total	T1 Dom Total	TOTAL
1	2006-07	6653366	6646867	7143211	20443444
2	2007-08	7342075	10604170	6025417	23971662
3	2008-09	7769313	9887517	5186585	22843415
4	2009-10	8314211	10940410	6870074	26124695
5	2010-11	9275774	11953318	8713795	29942887
6	2011-12	10750009	13568420	11563536	35881965
7	2012-13	11566102	9917302	12885007	34368411
8	2013-14	12681309	10271008	13924669	36876986
9	2014-15	13534424	11592945	15858186	40985555
10	2015-16	14152172	15429243	18842750	48424165
11	2016-17	15497384	18198673	24007039	57703096
12	2017-18	17437372	22005642	25982699	65425713

From the table it can be seen that in coming years the terminal is expected to become capacity constrained. There is an unprecedented growth witnessed in the passenger movement.

From the actual number of passengers handled in the listed years trend based projections were made up to 2025-26 which is tabulated below in Table No: 5.

Table 5- Traffic forecast by KITCO based on trend based projection on historical data collected from DIAL(2006-2016)

Sl.No.	Year	T3 Intl. Total	T3 Dom. Total	T1 Dom. Total	Total
1	2006-07	6653366	6646867	7143211	20443444
2	2007-08	7342075	10604170	6025417	23971662
3	2008-09	7769313	9887517	5186585	22843415
4	2009-10	8314211	10940410	6870074	26124695
5	2010-11	9275774	11953318	8713795	29942887
6	2011-12	10750009	13568420	11563536	35881965
7	2012-13	11566102	9917302	12885007	34368411
8	2013-14	12681309	10271008	13924669	36876986
9	2014-15	13534424	11592945	15858186	40985555
10	2015-16	14152172	15429243	18842750	48424165
11	2016-17	15497384	18198673	24007039	57703096
12	**2017-18**	**17437372**	**22005642**	**25982699**	**65425713**
13	2018-19	17471329	18735848	25050780	61257958
14	2019-20	18428797	19682190	26891888	65002874
15	2020-21	19386264	20628532	28732995	68747791
16	2021-22	20343731	21574874	30574103	72492708
17	2022-23	21301198	22521215	32415210	76237624
18	2023-24	22258666	23467557	34256318	79982541
19	**2024-25**	**23216133**	**24413899**	**36097426**	**83727457**
20	2025-26	24173600	25360241	37938533	87472374

Terminal (T1) presently has passenger capacity of 24MAP which is projected to grow up to 35MAP ahead of the year 2025-26.

The Landrum & Brown Master plan 2016 Report also indicates that maximum capacity of future Terminal 1 is 30MAP. The strong passenger growth experienced at Terminal 1 in recent years gives a clarity that a passenger throughput of 30MAP will be achieved significantly in advance of the date originally forecasted

in the Landrum and Brown Report 2016.ie, in 2025-26. Therefore DIAL believes that it would be prudent to base the phase 3A works on a higher forecast at 35MAP. In the trend based projection made by KITCO, the 35 MAP is projected for the year 2024-25.

FY	Total Passengers		
	Dom	Int'l	Total
2013/14	24,195,677	12,681,309	36876986
2014/15	26,633,000	13,309,000	39942000
2015/16	28,726,000	14,325,000	43051000
2016/17	31,293,000	15,582,000	46875000
2017/18	33,880,000	16,813,000	50693000
2018/19	36,677,000	18,025,000	54702000
2019/20	39,581,000	19,242,000	58823000
2020/21	42,592,000	20,503,000	63095000
2021/22	45,643,000	21,788,000	67431000
2022/23	48,663,000	23,068,000	71731000
2023/24	51,627,000	24,339,000	75966000
2024/25	54,507,000	25,553,000	80060000
2025/26	57,248,000	26,702,000	83950000
2026/27	59,821,000	27,778,000	87599000
2027/28	62,199,000	28,772,000	90971000
2028/29	64,405,000	29,777,000	94182000
2029/30	66,403,000	30,794,000	97197000
2030/31	68,403,000	31,821,000	100224000
2031/32	70,402,000	32,858,000	103260000
2032/33	72,396,000	33,904,000	106300000
2033/34	74,381,000	34,958,000	109339000

YEAR	PAX (L&B)	PAX (ACTUAL)
2015-16	43.1 M	48.4M
2016-17	46.9 M	57.7M
2017-18	50.7 M	65* M

*Projected

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AECOM IDA

Figure 1: Traffic forecast by L&B

The above figure 1 shows the traffic forecast study conducted by L&B in 2016 master plan report. Projected traffic in the year 2017-18 is 65 MAP and this matches with the actual passenger traffic data also.

The actual and forecasted airport traffic data indicates that there is a significant increase in aircraft movement and passenger traffic in IGI Airport and the same is expected to increase further in the coming years. The existing facilities are inadequate to cater services of handling increased volume of aircrafts and passenger traffic .Thus the need for the airport capacity enhancement with

respect to aircrafts and passenger growth is justified. The drastic change in traffic growth indicates that an extensive expansion is needed to accommodate future demands of 35MAP for T 1.

The new Terminal's design caters to meet the future requirement of 35MAP and provides 13 remote gates and 22 contact stands which is accommodated in the pier. The current terminal is operating in excess of 24MAP and served only by 13 remote gates.

The aesthetics and façade is improved by integrating the Terminal 1 into a new single architectural element.

4.1.4 New Terminal

The New Terminal comprises of 4 levels including basement.T1 C is demolished and rebuilt to integrate with T1 D and new terminal T1 is evolved. From the detailed structural assessment of T1C done by AECOM and considering the following factors leads to the culmination that T1C shall be demolished and rebuilt.

1. *Generally Life span of a building is 50 years and the building T1C is reaching the limit within 5 years*
2. *Characteristic compressive strength of existing concrete is in the range of 11 to 18 MPa, whereas the minimum concrete strength should not be less than 20MPa for a reinforced concrete structure as per IS:456-2000*
3. *Difficulty in assessing the strength of foundation due to the non availability of drawings. Delhi being in a very sensitive seismic zone, it is essential to follow the seismic provisions as well as ductile detailing as per IS 1893:2016 and IS 13920:2016, which is not followed in T1C structure.*
4. *Aesthetics of the Terminal in totality not up to the mark.*

The salient features of the new Terminal is given in Table 6.

Table 6- Salient Features of New Terminal

Description	Existing	Proposed
Total Area (Dep+Arr)	64,140 m^2	1,92,985 m^2
Entry Gate	8 Gates (16 CISF Positions)	13 Gates (26 CISF Positions)
Check in Gates	4 Islands	5 Islands
CUSS	12	108
Self-Baggage Drop	Nil	36 (1 for every 3 CUSS machines)
Hand Baggage X-rays	18	20 (Expandable to 25)
Hand Baggage (per machine)	160- 180 Bags/ Hr	250 – 300 Bags/ Hr (ATRS)
Screening Capacity	2,880 – 3,240 Bags/ Hr	5,000 – 6,000 Bags/ Hr
Contact Stands	Nil	22
Bussing Gates	15	13
BMA	4 Baggage Carousels	9 Baggage Carousels
Baggage System	Airline wise	Flight wise (Flexible)
Arrival Baggage Belt	8 Nos of 52m each	10 Nos of 70m each
Arrival Terminal	Separate T1C	Integrated T1
Arrival Area	8,000 m^2	18,000 m^2 (New)

Based on the design assumptions given in Table No-7 and the basis of planning followed as per figure 2, individual area assessments were validated as per IATA calculations and the functional areas provided as per standards. Table 8 shows the individual area calculations and remarks.

Table 7-Design Assumptions based on Survey reports

Sl.No	Description	Design Assumptions
1	T1D Door entry Check	12.5 seconds
2	Self check-in kiosk	60 seconds
3	Baggage Drop-in	82 seconds
4	Airline Check-in	90 seconds
5	Security Screening	24 seconds

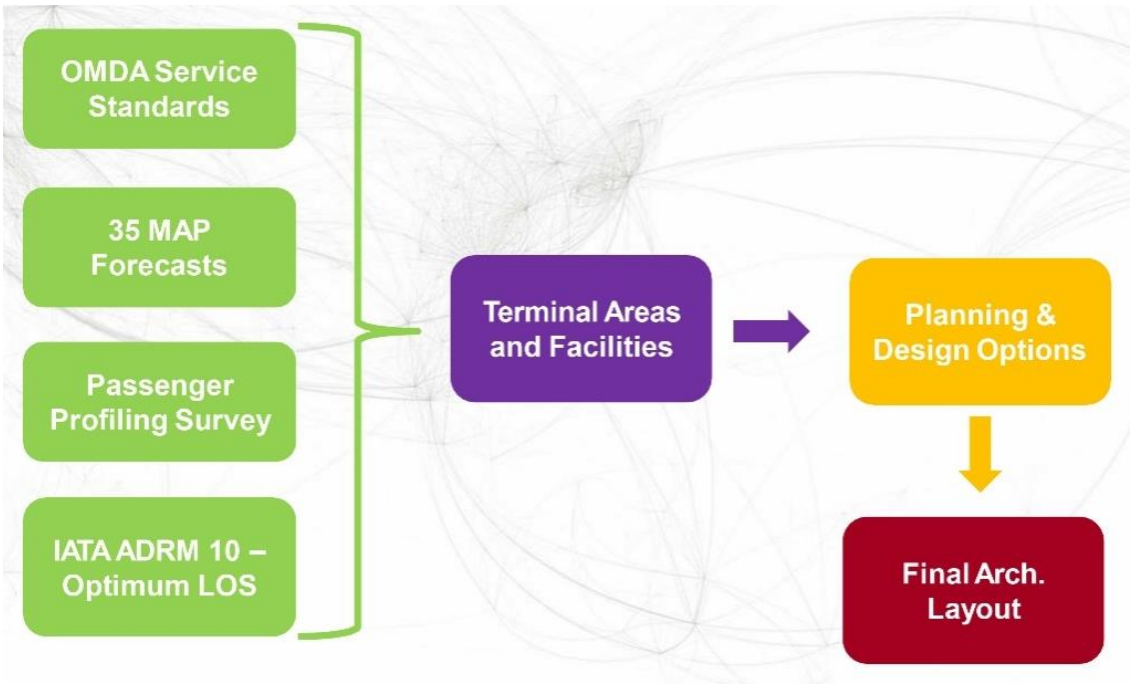


Figure 2: Planning Basis

Table 8- Individual area calculations

Total Terminal Area	***GMR***	***Remarks by KITCO***
Terminal Entry Chk & Space for fare wellers	*2314sqm*	*As per ADRM*
Check-in Hall	*8437sqm*	*-do-*
Departure Security	*6528sqm*	*-do-*
Transfer security	*2127sqm*	*-do-*
Contact gates (22no)	*6135sqm*	*-do-*
Remote gates (13 no)	*4733sqm*	*-do-*
Departure baggage make up area	*9043sqm*	*-do-*
Baggage reclaim & Arrival hall	*9300sqm*	*-do-*
Arrival meet & greet area	*3313sqm*	*-do-*
	51,930 sqm	
Toilets	*5464sqm*	*10% of total process area Found nominal*
Airport offices	*5798sqm*	*-do-*
Airline offices	*5141sqm*	*-do-*
Ramp accommodation	*7535sqm*	*-do-*
Circulation/MEP/structure	*95,298sqm*	*49% of total area, acceptable based on unit area/PHP*
Commercial areas	*22503sqm*	*12% of total area, Within the IMG norms i.e. 20% of overall area*
BOH Area	*1349sqm*	*acceptable*
TOTAL AREA	***192985sqm***	*Justified*

4.1.5 Validation of Peak Hour Assessment with IMG norms

Peak hour calculations are assessed as per IMG norms and the area required for each process is analyzed and all assumptions are validated.

Passenger Busy Hour rates obtained from DIAL is as given below in Table No- 9

Table 9 - Peak Hour Pax

Description	Annual Pax(MAP)	Peak Hr Ratio	30th Busy Hr
Departure	17.5	0.0285%	4998
Arrival	17.5	0.0274%	4795

Corresponding to the passenger traffic forecast of 35MAP, the total peak –hour passenger has been estimated as 9,793 based on the above 30th busy hour rate.

The area provided /Peak hour pax
- *1, 92,985/9793*
- *19.7sqm which is within the limit as per IMG norms.*

Table No-10 shows the comparison with IMG area norms (Annexure-IV)

Table 10- Comparison with IMG area norms

Terminal	Area provided	Planned Capacity/ annum	Approx. Peak hour pax	Area provided/ PHP	Area Norm as per IMG Area/php
Terminal 1	1,92,985sqm	35MAP	9793	19.7sqm	**20 sqm**

Thus the total terminal area of 1,92,985 sqm provided by DIAL is within the IMG norms and it can be concluded that this area caters to the projected traffic of 35MAP. A comparison of terminal area/PHP with the standards or AAI, IATA, IMG is shown in Figure No-3.

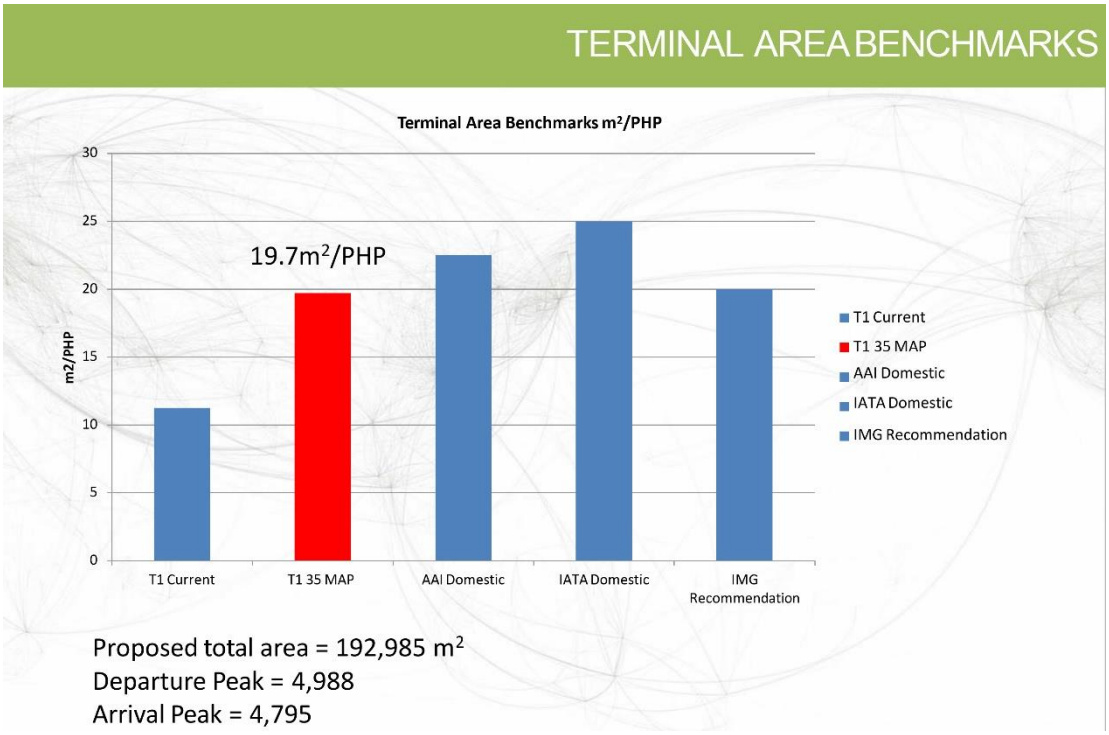


Figure 3: Terminal Area Benchmark

4.2 Apron Development (Package-1)

4.2.1 Existing scenario assessment of Aircraft Stand Demand and other Facilities:

T1 Apron presently has 71 stands out of which 55 aircraft stands is fit for Code C aircraft for Scheduled operations and another 28 stands for General Aviation aircraft. Since there are no contact stands currently all aircrafts are remotely parked and therefore bussing operations of passengers between the terminal and the aircraft are significant. DIAL has proposed 22 contact stands for the T1 apron. The Apron currently has an area of 2,82,000 sqm. The proposed apron area development by DIAL is 7,16,288 sqm. It has been observed that an area of 86,750sqm is considered for General Aviation aircraft which can be deducted from the proposed area.

As per ADRM, the no. of operational apron stands is calculated using the following formula.

Apron Stands, S = (Ti/60) X Ni+ a = 42 stands required for operational purpose in T1

Ti = gate occupancy time in minutes of aircraft group code (60 mts)

Ni = No. of arriving aircraft during peak hour (32 projected equivalent to 35MAP)

a = No. of spare stands (30% spare assumed)

*As 4 Airlines is using IGIA as a hub, the request for night parking facility corresponds to **40** stands matching 35MAP. Hence the total requirement is **82** Code C stands T1 Apron. Since the night parking facility is a revenue generating segment for airport operators, this shall be captured for revenue generation. Proposed apron layout is shown in Figure 4.*

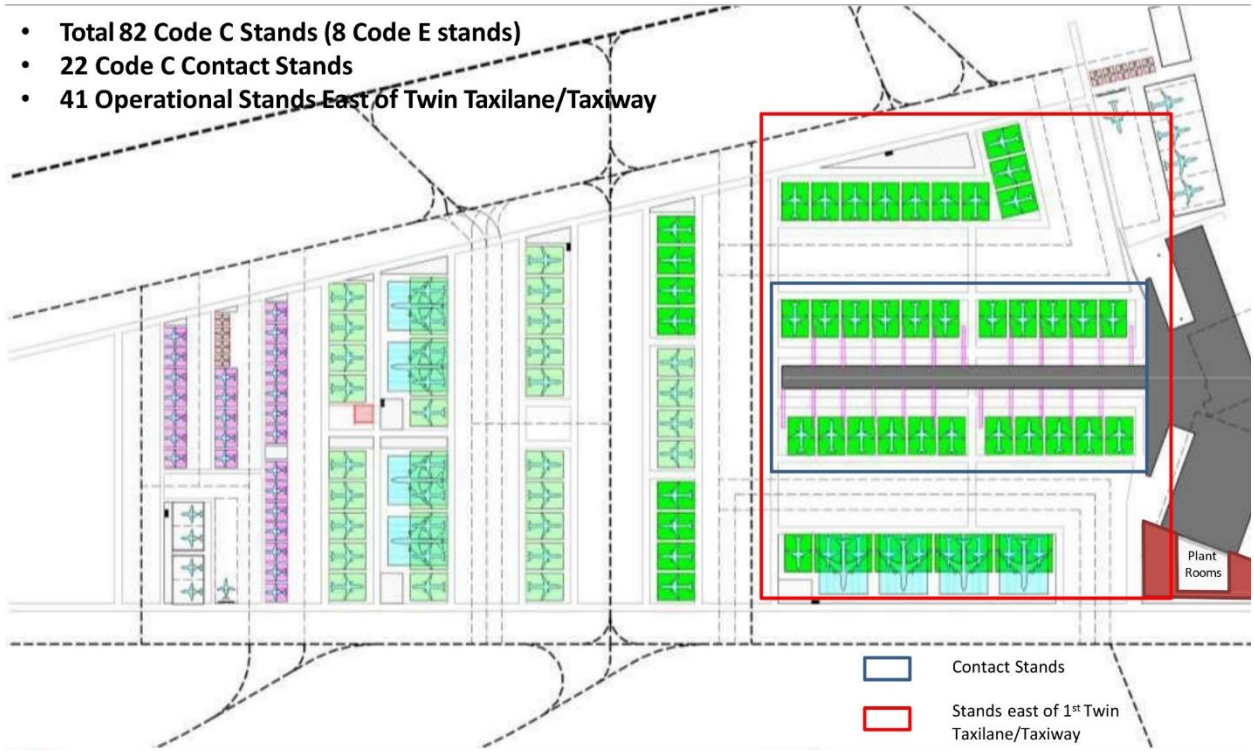


Figure 4: T1 Apron layout

4.2.2 Inference on Terminal & Apron (Package-1)

T1Terminal area requirement is justified with respect to IMG norms as detailed in the preceeding section.

The Apron area proposed by DIAL includes the General Aviation area also. It is recommended that this area (86,750 sqm) can be deducted from the total area.

Thus the total apron area gets reduced from 7,16,255 sqm to 6,29,685 sqm.

Existing T1 apron pavement is of varying age and for various design parameters. Therefore, it is recommended to redo the entire pavement area (operational stands & night stands area) for the optimum design layout.

4.3 Airfield Works (Package 2 & 4)

4.3.1 Aircraft Movements

The airport had a CAGR of 7.9 percent for the period 1995-96 to 2015-16. IGIA handled 344 thousand schedule movements in FY2015-16 registering a growth of 14.4%. It is expected that average aircraft sizes and load factors will increase over time. The passenger aircraft movement is projected to grow from 281,034 movements in 2013/14 to 726,400 movements in 2033/34.

4.3.2 Existing Scenario Assessment

4.3.2.1 Airside Capacity

The North Terminal Precinct NTP (Runway 9-27 and 10-28) serves primarily Code C aircrafts and the South Terminal Precinct STP (Runway 10-28 and11-29) handles other larger aircrafts. Though Runway 11/29 has a length of 4430 mtr, approach 29 is limited due to the existing Shiva Statue. With a view to plan for future airside facilities, the design aircraft for the NTP will be Code E and for the STP will be Code F. Sometimes Code B or C standards are also used for planning specific elements of the airside and other facilities.

Under both east and west flow conditions, which could vary throughout the day, the ATC uses the IGIA's runways dynamically to maximize operational efficiency and to balance the available capacity with arrival and departure demands. Currently, across the year, the airport operates in west flow for about 68.3% and in east flow for 31.7% of the time. Based on the application of existing ATC procedures and the use of current ATC technology, the peak hour runway capacity was estimated for the existing 3-runway system. The estimated capacity of the current airfield was 75 ATMs per hour based on the analysis of IGIA flight strip data though the airfield has operated at a higher capacity at times.

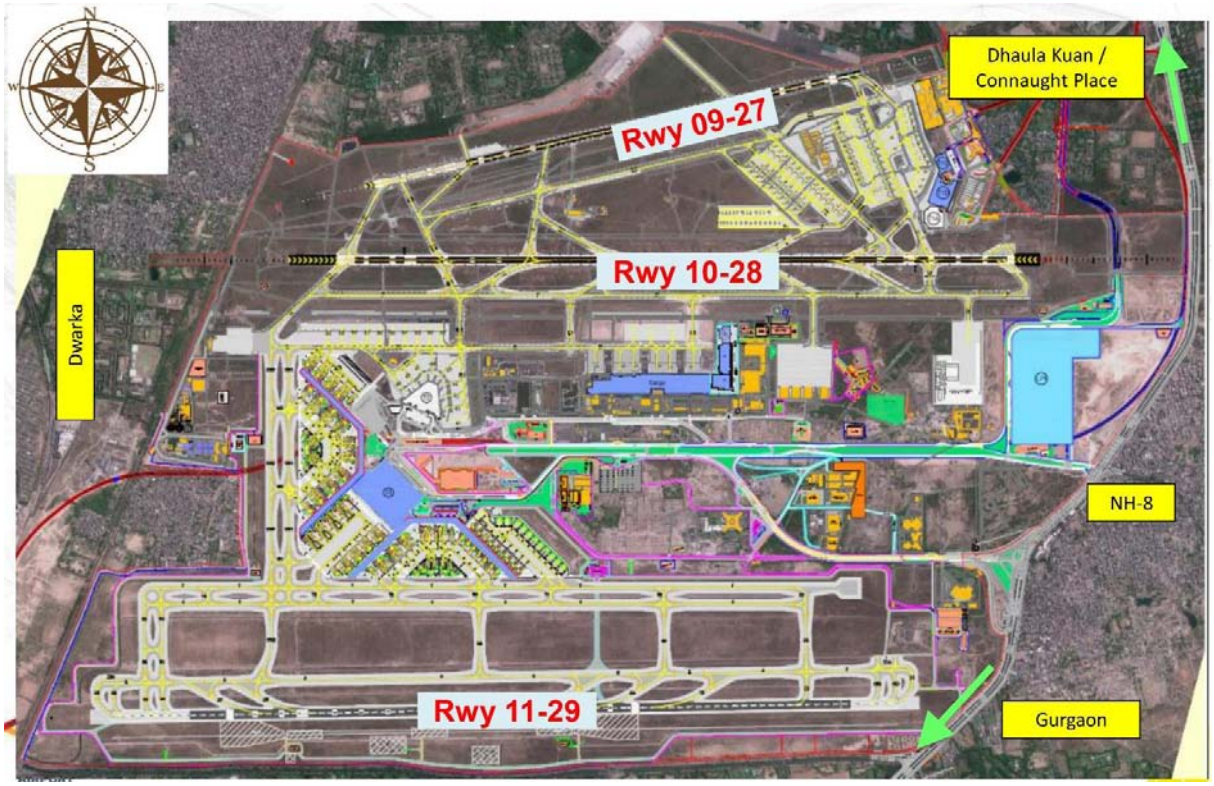


Figure 5: Existing Runway Locations

4.3.2.2 Runway Capacity

The existing runway system (Figure 5) along with taxiway improvements would serve 86 ATMs per hour, using a highly dynamic runway use strategy. The 3-runway system with ATC and taxiway improvements would be able to handle

between 593,500 and 620,500 annual ATMs at a delay of 10 to 15 minutes per ATM, a portion of which would be attributable to ground infrastructure. The declared peak hour capacity of the three runway system at IGI Airport is 67 but presently, it is being operated at a peak of 73 ATM/hr under the profiled schedule.

This forecast is equivalent to 77.5 MAP to 81.8 MAP based on the aviation activity forecast. Therefore, the 3-runway system would accommodate the growing demand at IGIA through 2024-25. The 4th runway in the southern part of the airport along with the taxiway improvements would accommodate 776,000 to 790,500 annual ATMs or 108 to 110.7 MAP based on the assumed delay target. This 4-runway system would accommodate the projected demand at IGIA up to the year 2033-34.

DIAL has proposed the following to cater this demand which were analyzed by KITCO

- *4th Runway (code-F compliant) and associated taxiway connection /links.*
- *New parallel taxiway to existing runway 10/28 and associated taxiway connection/links to suit Code E aircraft operations.*

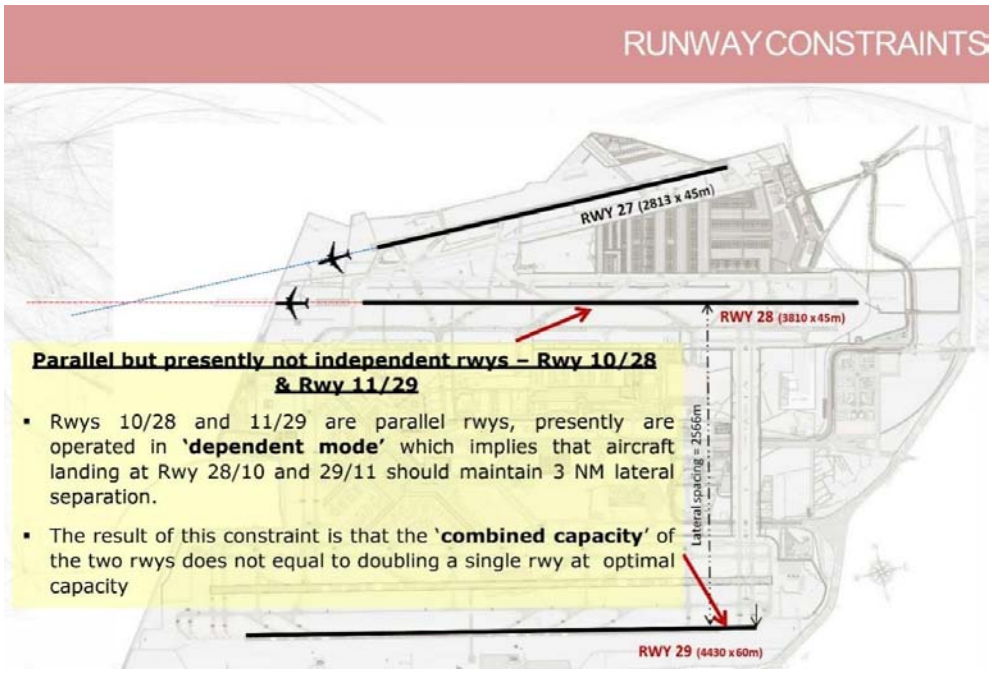


Figure 6: Runway

Existing runway constraints is depicted in Figure No-6. As per ADRM, maximum combined capacity of two dependent close parallel, mixed mode runway is 97 ATM/hr under optimum conditions and the efficiency is reduced to 84 ATM/hr in IGIA due to following factors

Runway 09/27 - Restriction on use by GA/ Non-scheduled flights due to VIP Residential area (Approach 27 almost fully discarded)

Runway 10/28 - Efficiency affected by crossing of aircrafts to & from T1

Runway 11/29 - Efficiency affected by GA/ Non-scheduled flights (ROT high & 7nm wake vortex separation as per ATC)

And obstacle of Shiva Statue with threshold displacement on Rwy29

Table 11 – Runway utilization – January 2018

	APR&DEP	***ARR***	***DEP***
09	*5.2%*	*-*	*10.3%*
27	*13.5%*	*26.76%*	*0.2%*
10	*11.4%*	*18.1%*	*4.64%*
28	*23.3%*	*7.62%*	*39.1%*
11	*15.3%*	*13.8%*	*16.9%*
29	*31.2%*	*33.64%*	*28.8%*

As per the table no-13, it is seen that Hindon Military Airspace (VIR-155A) on East is restricting use of Rwy 27,28,29

.Apart from the factors affecting ATM forecast like VVIP operations requiring shutdown at that part of airport even during peak hours & Night Curfew, there are certain other parameters that affect the peak hr. ATM which are as follows:

Rwy 9/27 – Arriving aircrafts are more as taxiing time to T1 apron is less
Rwy 10/28 – Handles 44 % of total departures
Rwy 11/29 – Handles 47% of both departures & Arrivals in the airport
Achieved peak hour ATM's for the year 2013 to 2018 is shown in figure-7
Though IGIA has handled 82 ATM/hr, as per L&B report based on simulation, the maximum ATM's that can be handled is not more than 84 ATM/hr. Therefore, fourth runway is required if the airport has to handle more than 84 ATM/hr.

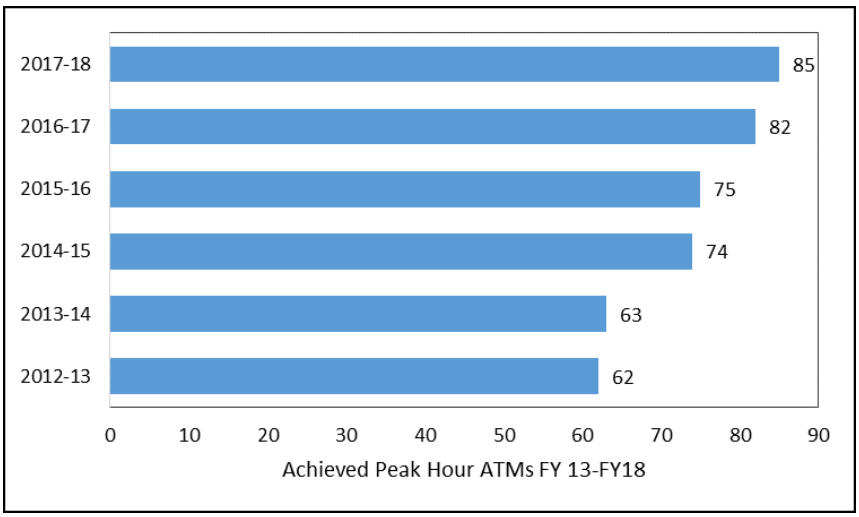


Figure 7: Achieved Peak Hour ATMs FY13- FY18 9source-L&Breport)

KITCO also reviewed the 2006 masterplan report by Mott mac and 2015 masterplan report prepared by L&B. It has been observed that no realignment of Rwy 09/27 is possible until 2034. Subsequently the Rwy 09/27 shall be made non functional in due course when the new runway becomes operational. Hence a full reconstruction of this runway is not recommended and DIAL could consider

to overlay the affected portion to strengthen. This would reduce the cost and avoid working at close proximity to active runway.

4.3.2.3 Existing Capacity Assessment of Taxiway Configuration

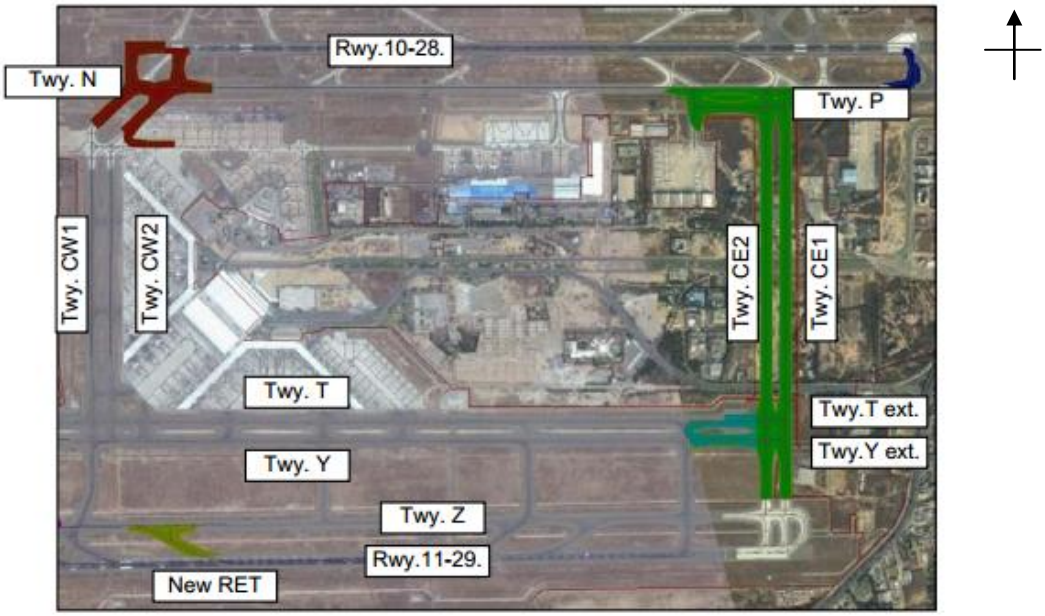


Figure 8: Taxiway Location

Absence of a parallel taxiway on the north side of the Runway 10/28 is increasing the taxiing time of the low cost aircrafts to T1.

The existing cross taxiway on the west is so far away from the T1 that the taxiing time required for aircrafts from the existing Runway 10/29 to T1 Apron is 17.7 minutes.

Rapid exit taxiways from existing Runway 10/28 & new 11/29 improves the runway occupancy time and adds to the overall efficiency factor.

DIAL intent constructing cross taxiway, parallel taxiway and RETs to compensate the above deficiencies. These proposals were reviewed by KITCO.

The objective is to:

- *Reduce the taxi distances for aircraft, thereby saving precious time fuel, emissions and ultimately increasing the capacity of the airport.*
- *Provide flexibility to the Air Traffic Controllers in managing the aircraft movements.*
- *Allow for optimal use of both runways for departing and arriving aircraft from both the Terminal 1 & Terminal 3 areas.*

The proposed parallel eastern cross-taxiways ET-1 and ET-2 are approximately 2.1km long. The width of each taxiway is 60m both being separated by an open space of 37.5m width. While connecting the runways 11-29 and 10-28, these taxiways shall cross the Radisson Road, the Central Spine road and the proposed Cargo Road. Hence taxiway crossings are required at all these three locations. The width of each taxiway crossing shall be 84m and both the parallel structures shall be separated by an open space of 13.5m.

Separate structures shall be provided for the crossing of the service roads which run parallel to the cross taxiways. These structures will be situated at 57.5m from the taxiway centerlines. The width of these structures will be between 10m.

Based on the existing levels of the runways and the existing roads and permissible gradient of the taxiway, an underpass is proposed at the crossing of the Radisson Road.

The Central Spine road is located approximately 1150m and 850m from the southern and northern limits of the proposed cross taxiway respectively. Hence it is apparent that sufficient length of gradient is available to elevate the taxiway and cross the spine road by a flyover.

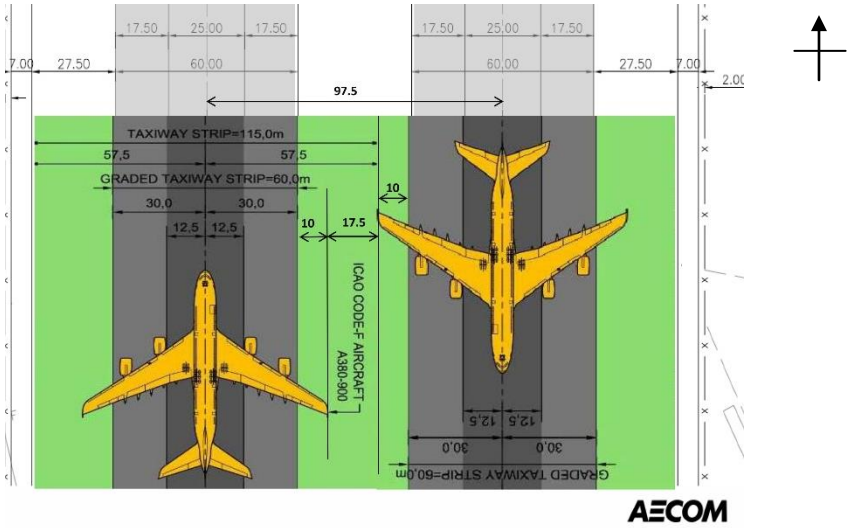


Figure 9: Eastern Cross Taxiway Configuration

4.3.3 Inference on Airfield Works (Package 2 & 4)

Need for new runway 11/29 is assessed based on the combined runway capacities of existing 3 runways & review of ATM forecasts .It is found that that the forecast is exceeding the combined capacity. Hence the fourth runway is justified.

Taxiway proposals are assessed in detail and evaluated based on the need to enhance the efficiency of the airside.

The need for a northern parallel taxiway for Runway 10/28 is highlighted to avoid crossing of aircrafts to T1 and is justified, as DIAL has decided to retain the T1 location.

For runway 09/27 , it is recommended to do the overlay for strengthening the affected portion instead of full reconstruction.

4.4 Landside Works (Package 3)

The projected increase in air traffic and terminal expansion, necessitates the augmentation of land side connectivity and other terminal kerb side facilities.

Northern Access Road, Central Spine Road and Radisson road are the three major access roads to the airport. The northern access road connects to Central spine road which is the primary access to the Terminal 3 and Radisson road provides access form NH 8. Figure 11 shows the key plan of existing land side road networks.

Scope of land side work includes:

- *Recommendations detailing out proposals for improving terminal facilities such as kerb arrangements for pick up and drop offs, parking requirements and capacity augmentation requirements for approach roads to departure and arrival terminals to meet the demand of 35 MAP as envisaged in the expansion plan of Terminal 1.*
- *Augmentation of the Northern Access Road to 2 x 5 lane facility along with widening of the existing underpass to 2 x 6 lane facility.*
- *New 4-lane flyover at Aerocity Metro Station junction for T1 to T3 right turns traffic.*
- *Widening of the Central Spine Road (approx.1.5 km) to 2 x 6-lane facility and integrating the road with the new aerocity metro station junction flyover.*
- *Improvement of a section of the Radisson Road (approx. 1.1 km) in view of 2034 Masterplan and integrating with the provision of new Eastern Cross taxiway underpass structure*

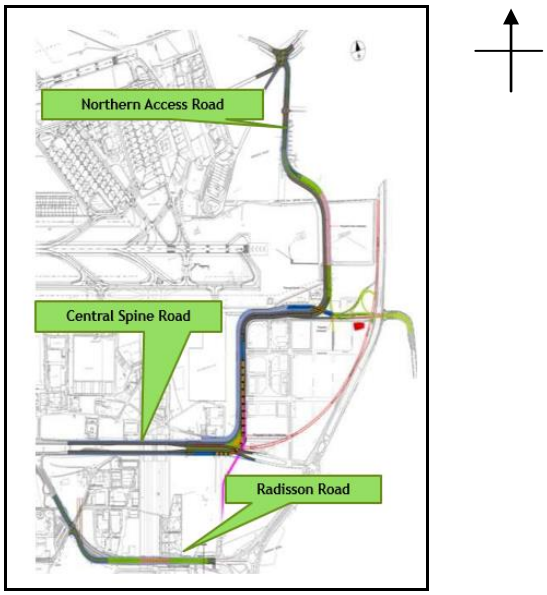


Figure 10: Land Side Roads

- *Northern Access Road widening*

The Northern Access road starts at the NSG signalized junction and terminates at Aerocity metro station junction. The road is approximately 2.9 km long and serves as the main link between the Terminal 1 and Terminal 3 of the IGI Airport. The existing 6 lane, 370 m long underpass runs beneath the approach of the runway 10-28.

- *Widening of Central Spine Road*

The Central Spine road starts from NH-8 at Mahipalpur junction and terminates at Terminal-3 of IGI Airport. The Northern Access road meets the Central Spine with a signalized T-junction near Aerocity Metro Station, located at about 500m from the Mahipalpur junction. This first 500m stretch of the Central Spine road has dual carriageway of 2 x 3-lane configuration; the carriageways being separated by a 25m wide median. From the T-junction with Northern Access road, the Central Spine Road is 2 x 4-lane with median varying between 9m and 48m.

- *Radisson Road*

The existing 2.0 km (approx.) long Radisson road starts from NH-8 in front of the Radisson Hotel and terminates on the Central Spine road. Currently the road is of 2x4-lane configuration with 2.6m wide median separating the both side

carriageways. A defunct toll plaza of NH-8 exists about 250m from the start of this road.

3.5.1 Landside Road Capacity Assessment

Table 12 - Landside Road Capacity Assessment

Traffic Survey Details							
Location Description	**Direction**	**Roadway Lanes**	**2015/16**	**2020/21**	**2025/26**	**2030/31**	**2033/34**
Northern Access Road	Delhi - T3	3	3020	4388	5196	6082	5986
	T3 - Delhi	3	2996	4354	6023	6773	6480
Central Spine Road	T3 - Aerocity	4	2693	3913	5619	6203	5820
	Aerocity - T3	4	1948	2830	4620	5289	4901
Radisson Road	Radisson - Airport	4	310	451	636	758	837
	Airport - Radisson	4	126	183	5	271	270

Determining when additional roadway capacity may be needed is accomplished through a level of service (LOS) analysis. LOS can be estimated based on the ratio of vehicle demand to capacity (i.e., V/C ratio).

3.5.2 Inference on Land Side Works (Package-3)

Table 93 - Inference on road widening

	Existing	***Proposed***	***Remarks By KITCO***
Northern Access Road	*2X3*	*2X5*	*As per the Master Plan, Northern Access road has already reached level of service F, which marks the forced flow or breakdown condition. Hence widening of the existing road to 2X5 configuration is acceptable.*

	-	*Proposed Super Elevation at CH 2+100 4%*	*As per IRC:86-1983 , minimum radius to limit the super elevation to 4% is 105m. Curves having radius less than 105m, it shall be limited to 7%. At Chainage 2+100 , super elevation has been limited to 4% .*
Central Spine Road	*2X4*	*2X6*	*As per the Master Plan, widening of the existing road to 2X5 configuration is necessary in 2020-2021under LOS F condition. However, considering the projected increase in the air traffic, augmentation of landside connectivity is unavoidable. Hence it is acceptable to go in line with expansion in the very near future.*
Radisson Road	*2X4*	*2X4*	*Traffic projection reveals that Radisson road have sufficient capacity to operate till design period. Level of service of Radisson road is LOS B. Hence it is not necessary to widen the road.*

- *Kerb widening of Terminal 1*

Table 104 - Inference on Kerb Widening

	Proposed-No. of Kerbs		***Remarks By KITCO***
	T1D	***T1C***	*As per average occupancy and hourly traffic volume estimated from passenger terminal survey output, assumed modal*
Cars	*38*	*42*	
Taxis	*61*	*72*	

Bus	*3*	*3*	*share and annual demand of 35 MAP, the proposed kerb lengths/no. of kerbs are justified. (Basis for some of the assumptions used in traffic volume estimation has not been provided in the report)*

4.6 Assessment of Terminal 3 capacity enhancement (Package 5)

T3 has an existing total built up area of 5, 54,000sqm. As per IMG norms, the terminal is sufficient to handle a Peak Hour Pax of 22,160, which will match with 56MAP. The building was designed for the higher capacity, but the current infrastructure at the contact points were done only for 30 MAP. Currently, the terminal is handling 34 MAP and DIAL wants to upgrade the infrastructure to 40 MAP for the Design year 2022. Therefore, the shortage in each process area was evaluated as per ADRM calculations based on survey inputs and Level of Service (LoS) C levels. Main shortage in infrastructure was found in the number of check-in counters, arrival hall baggage belts and kerb length requirements in Arrival & Departure concourse. Therefore, DIAL has proposed upgradation of the facilities that has been highlighted in the gap analysis and lump sum costing has been done for the components.

4.7 Cost Effective Options

KITCO analyzed various cost effective alternatives which are detailed below:

Figure 11: Option 1 – Alternative option instead of new Runway

4.7.1 Option1 – Alternative option instead of new runway

KITCO analyzed the option of enhancing the existing runway capacities by adding a northern parallel taxiway to Runway 10/28 and eastern cross taxiway from Runway 11/29. The ATM's that can be handled is enhanced only marginally.

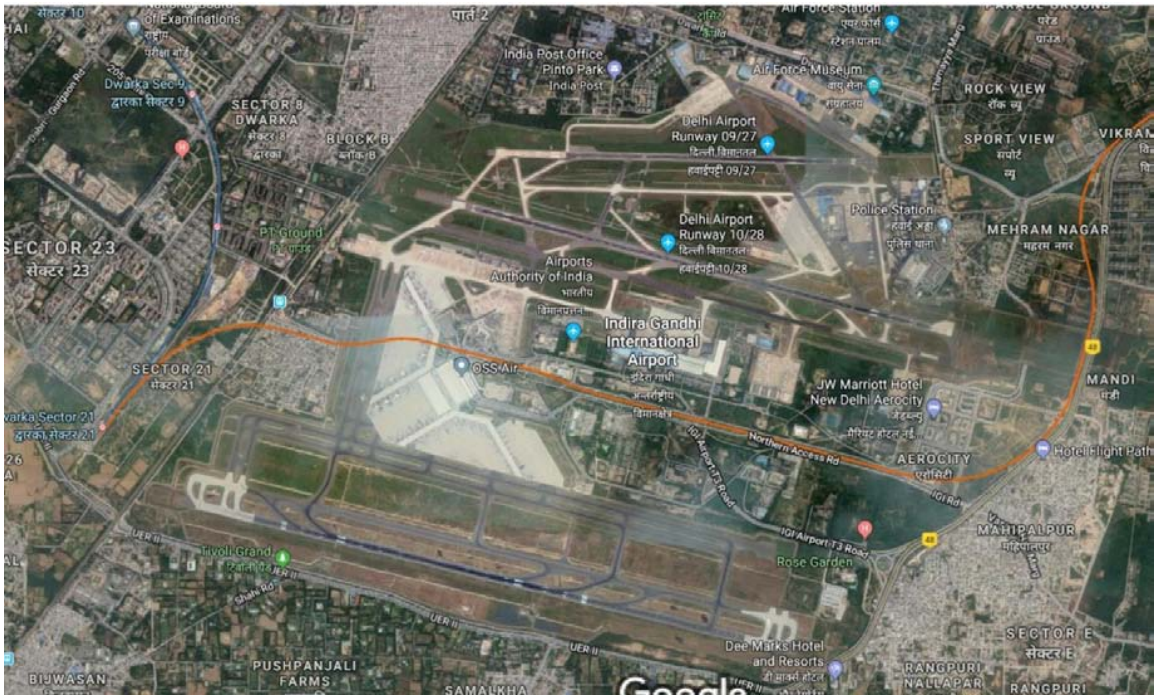


Figure 12: Option 2 – Alternative option instead of northside parallel taxiway for Runway 10/28

4.7.2 Option2- Alternate option instead of northside parallel taxiway

KITCO analyzed the option of providing new runway 11/29 and cross taxiway without providing northern parallel taxiway to runway 10/28. In this case, the aircraft movements to T1 affects the efficiency of runway 10/28 considerably and the ATM distribution is south centered and in favour of T3 only. In this option, refurbishment of runway 9/27 is inevitable.

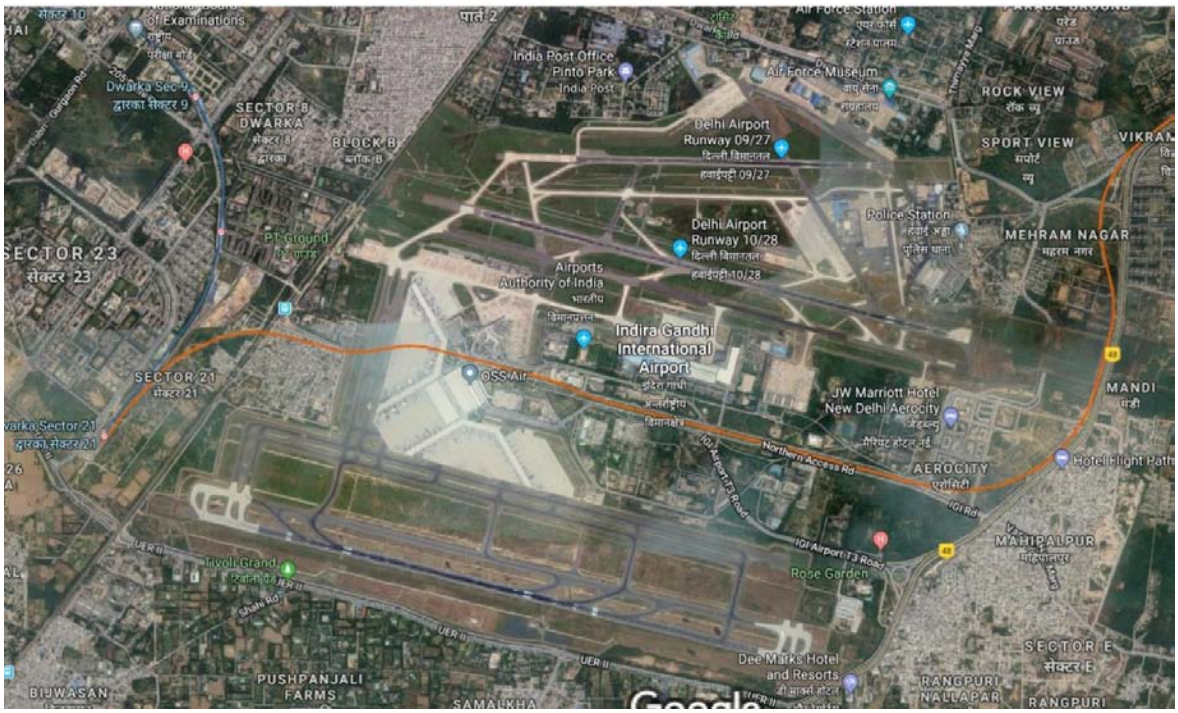


Figure 13: Option 3 – Alternate option instead of Eastern Cross taxiway

4.7.3 Option 3- Alternate option instead of Eastern cross taxiway

KITCO analyzed the option without eastern cross taxiway, which warrants the relocation of T1 to T2, the northern parallel taxiway is also not required in this option. But in this option the central spine road widening is beyond what is possible to cater the demand of passenger flow to T3 & T1. Therefore the option may be discarded.

Costs for each options were calculated and compared which is tabulated below in Table No-15.

Table 15- Summary of Cost for different options

SUMMARY OF COST FOR DIFFERENT OPTIONS

Sl No:	*Package*	*Description*	***DIAL Estimate***	***Option 1***	***Option 2***	***Option 3***
			Cost in Rs. Crore			
1	*1*	*Terminal and Apron*	*2512.00*	*2512.00*	*2512.00*	***2941.55***
2	*1,2 & 4*	*Airside works*	*4681.00*	***4371.56***	***4531.63***	***3413.63***
3	*3*	*Landside works*	*366.00*	*366.00*	*366.00*	***1148.60***
4	*5*	*Terminal 3*	*233.00*	*233.00*	*233.00*	*233.00*
5		*Others*	*911.00*	*875.00*	*894.00*	*905.00*
		Total cost	***8703.00***	***8357.56***	***8536.63***	***8641.78***
		Savings		***345.44***	***166.37***	***61.22***

Out of the 5 packages, Airside Works offers multiple combination options, which can minimize the total cost with enhance runway capacity. Main components for identified as New Runway, Northern Parallel Taxi Way and Eastern Cross Taxi Way. The Implication of total capacity, when one of the three main component is removed is analyzed and justification is provided.

The packages Terminal and Apron does not offer scope for alternate options except for reduction in Apron area. Terminal-3 package involves minimal modifications to accommodate transfers and enhance passenger capacity. Hence not much of a change is envisaged.

Even though option 1 seems to have a saving which is negligible compared to the total cost, the construction of new runway becomes inevitable in the year 2025-2026. Deferring the construction works of runway till that time is not a recommendable option due to the escalation in construction costs.

Hence the proposal by DIAL for construction of new runway, parallel taxiway, cross taxiway and associated connection taxiways are justified.

Chapter 5 – Cost Analysis

5.1 Cost Distribution

Cost Distribution of each package is given in table below and also represented in pie chart in Figure 14.

Table 16 - Cost distribution of each package

Package 1	*31%*
Package 2	*46%*
Package 3	*5%*
Package 4	*15%*
Package 5	*3%*

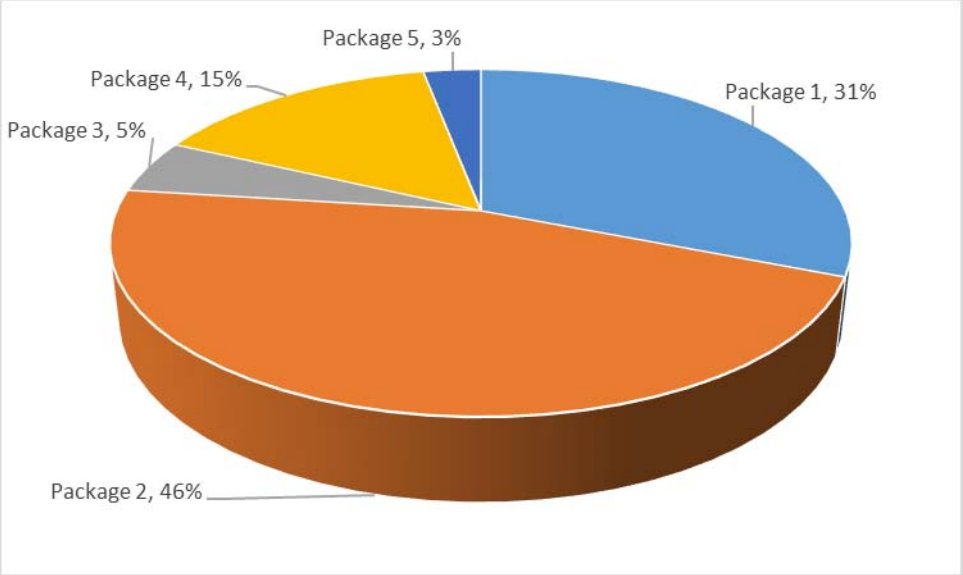


Figure 14: Cost Distribution

5.2 Capital Cost Proposal Methodology

DIAL has prepared the capital cost proposal by adopting the following methodology

- *Bills of Quantities for various items of work has been prepared.*
- *Equipment sizing / requirement has been evaluated & considered.*
- *Unit rates for various items of civil works has been taken from the Delhi schedule of rates (Apr2016).*
- *Appropriate price adjustment has been incorporated for the current base date of Sept 2017 in case of DSR rates. Adjustment as provided by CPWD- Building cost index @ 8.82% for Delhi has been considered. Additional 7.87% has been considered for Employer portion of PF, ESI and other labour compliances that is not included in DSR.*
- *Wherever rates are not available in Delhi Schedule of rates (mainly due to difference in specifications or specialized items), market rates have been considered. These include items related to airside pavements, Façade works, Roofing sheeting and structure, rock excavation by controlled blasting.*
- *For MEP, AGL, Specialized equipment/ System costs are based on quotations from suppliers / manufacturers.*
- *An factor of 17% (on an average) has been considered*

->to account for difficulties / constraints for working in an operating airport like restricted access, stoppages, VVIP movement, low productivity etc. This factor has not been considered for the supply portion in the case of specialized equipment.

->Estimated Cost Escalation / rupee devaluation during construction period from base date Sept 17 to Sept 2021.

- *Based on experience in similar projects costs towards following has been considered under " Others".*

->Preliminaries (Approx. 2%) (Items considered under preliminaries has been informed earlier)

- *Design development /supervision (4%)*
- *Contingencies (5%)*

The rate submitted by DIAL has been reviewed and following are the observations compared to the AERA CEILING RATES.

5.3 Passenger Terminal Building:

Construction of Terminal Building includes fully Air- conditioned and meeting the building code for fire protection system including fire and smoke detection & alarm system, sprinkler and hydrant system complying to the relevant statutory requirements, water supply and sanitary, Substance Equipment for Power supply including Standby generating units and related system, Passenger facilitation including flight information display and security surveillances, directional and information signage etc., Airlines related services of check-in, CUTE, CUSS, Baggage reconciliation system. Equipment namely in-line X-ray screening, standalone screening, required numbers of Baggage conveyors both for arrival and departure, escalators, Travellators and Elevators and passenger Boarding Bridges, other passenger services, Aircraft operational services as part of Terminal process facilities, the ceiling cost /sqm is Rs.65,000 as per AERA.

While reviewing the DIAL costing, KITCO considered the factors like operational difficulties, constrained material conveyance, anticipated dollar escalation, system modifications to adapt the revised requirements, and locational importance. KITCO also compared the rates of recently completed airports.

Accordingly, the rate/sqm recommended for Passenger Terminal Building is Rs.1,25,968/sqm against Rs.1,37,472/ sqm for 1,92985 sqm area. DIAL had re submitted the MDP of Terminal 1 & Apron Works (package 1) vide letter no. DIAL/2017-18/CEO-Office/1550 in which total area of Terminal indicated is 1,92,985 sqm area against 1,66,278 sqm area. An amount of Rs.2513 crores is proposed for Civil works, MEP & Airport systems which has been reworked to Rs.2431 crores as per the details of costing sheet attached as Annexure I.

5.4 Airfield works including Eastern Cross Taxiway

The cost distribution of airfield works is given in Table No-19 and also represented using pie chart in Figure No-15.

Table 117- Cost distribution of airfield works

Apron(Package 1)	*17.46%*
New Runway(Package 2)	*6%*
Taxiways(Package 2)	*24.01%*
Drainage(Package 2)	*13.50%*
AGL(Package 2)	*15.15%*
Eastern cross taxiway(Package 4)	*23.88%*

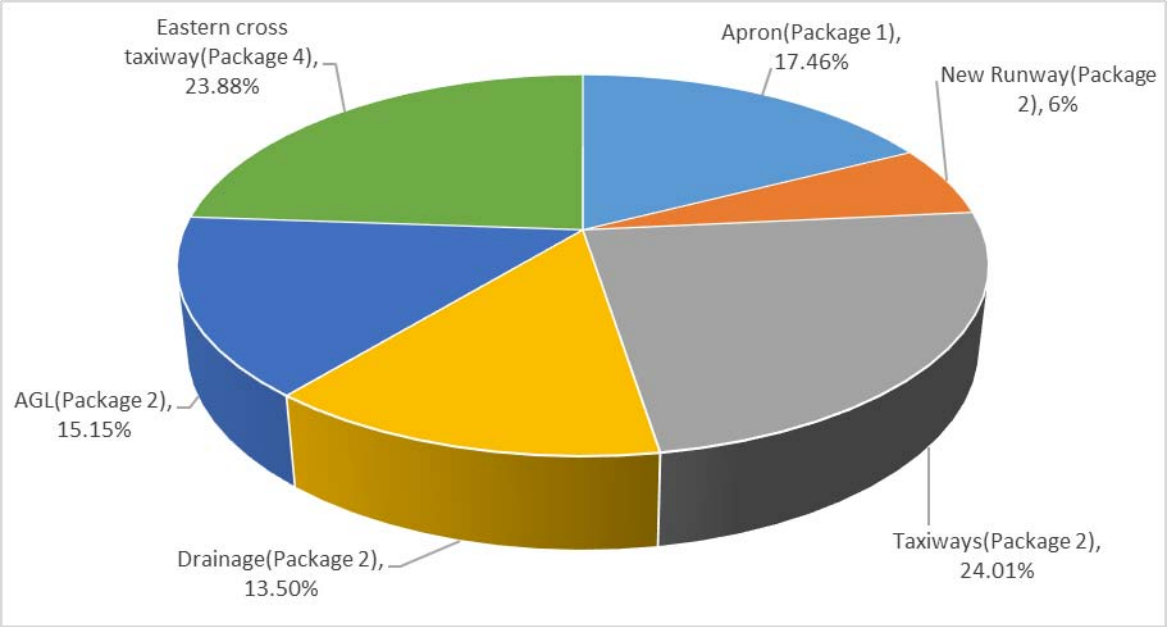


Figure 15: Cost Distribution of Air field works

For Construction of pavement (Apron, Taxiway, Runway), pavement for Code E aircraft, the ceiling cost is Rs.4700/Sqm as per AERA.

The costing proposed by DIAL is Rs.4681 crore KITCO considered the factors like operational difficulties, constrained material conveyance, Anticipated cost escalation, Design for heavier aircraft (code F) while evaluating the airfield costing. The revised cost works out to Rs. 4320 crores. Major reduction incurred is in the apron area which is detailed in Chapter 3.0.

***1)** The rate/sqm recommended for Apron is Rs.9778/sqm for 629685 sqm against Rs.11,127/sqm for an area of 7,16,255 sqm,*

2) *For taxiway - Rs.8306/sqm against Rs.8754.08/sqm for an area of 931461 sqm and*

3) *For runway - Rs.5978/sqm against Rs.6848.50/sqm for 505086 sqm.*

Details of costing attached as Annexure I.

In Package 5 for Terminal 3 works, DIAL resubmitted the revised costing as Rs.167 crore against Rs.233 crore, vide email dtd.10.3.18

5.5 Others

5.5.1 Preliminary works include demolition, relocation, enabling, diversions etc.

Cost of preliminary works @ 2% of the estimated cost of works is considered in the proposal. This is catered towards demolition, relocation & re-routing of utilities, traffic management systems, temporary signage, temporary roads & access gates etc. These are provisional sums and generally vary between 1% to 5% depending on the total estimated cost of works. Thus, the provision of 2% is considered reasonable.

5.5.2 Design development and supervision

Fee for design, development and supervision considered is @ 4% of the estimated cost of works. This is reasonable and justified.

5.5.3 Permits, Survey &insurance

A lumpsum amount of Rs. 30.00 crores is provisioned in the capital cost proposal towards insurance & permits which is reasonable.

5.5.4 Operational Capex

An amount of Rs. 30.00 crores is provisioned towards operational capex which is accounted for equipment like Runway sweeping machine, runway paint marking machines (big & small), runway rubber removal machines, passenger trolleys, motorized lifting platform, etc. Once the assets are created, operational expenditure shall be met from revenue budget. Hence the cost towards operational capex is not justified.

5.5.5 Contingencies

Cost for contingencies is provisioned in the capital cost proposal @ approx.5% of the estimated cost of works. Generally, contingencies for projects of this extent are catered at 3% of the estimated cost. Considering the magnitude of the project, the provision of 3% towards contingencies is considered adequate as presently followed by the government organizations such as AAI and CPWD.

In consideration of the above, the provision of 3% is considered reasonable for contingencies for this magnitude of work.

5.6 Construction Schedule

DIAL has submitted the construction programme and phasing plan with date of commencement as April 2018 and completion in October 2021. The total duration for the construction of Terminal and Apron parts of the phase 3A project is 42 months which is found to be reasonable and is justified. Detailed capital cost scheduling is attached as ***Annexure-II.***

5.7 Tendering Process

In order to ensure best quality and competitive cost from the vendors, transparent bidding process shall be followed.

5.8 Comparison of Basic Cost

Based on the available data, an attempt has been made to compare the cost incurred and specifications for the new international passenger terminal buildings at Cochin, expansion of terminal building at Hyderabad, terminal at Kolkata constructed by AAI, proposed terminal expansion at Delhi. A broad comparison of these are tabulated in Table Nos-21-23.(Annexure III).

5.9 Work to be executed through other (Joint ventures / concessionaires)

Costs mentioned in this head is not evaluated as details are not received from DIAL.

Chapter 6 - Conclusion

6.1 Summary of the exercise performed by KITCO

1. *The traffic projections has been verified by means of trend based projection using Data collected from Year 2006-2016.*
2. *Design year in which the 35MAP in T1 & 40 MAP in T3 are achieved is found from the traffic projections.*
3. *The correlation with the forecast projected by DIAL is verified and differences highlighted.*
4. *The peak hour capacity based on IMG norms is verified and validated. It is cross checked with the peak hour surveys conducted at IGIA and peak hour projections based on collected data and found to be matching with the IMG norms.*
5. *The total area required as per IMG norms per PHP is calculated and the terminal areas are justified.*
6. *Each process area is evaluated based on ADRM calculations with survey inputs and LOS C expectations and found matching with what is required for the projected PHP*
7. *Area allocations for other ancillary facilities are also cross checked and found well within the industry standards and best practices.*
8. *ATM forecast is also verified in line with the PHP forecast*
9. *Apron capacity is calculated based on ADRM calculations and design assumption to provide 30% spare active stands is as per L&B master plan 2016.*
10. *The night parking stand demand is verified as per L&B master plan and validated as per the Airline demand*
11. *The area shown for GA apron is deducted from the total Apron area and the cost variation due to area variation is highlighted*

12. *Taxiway proposals are assessed in detail and evaluated based on the need to enhance the efficiency of the airside.*
13. *The need for aircrafts in T1 Apron including GA aircrafts to use Runway 11/29 is verified and validated based on ATM data and runway curfews and the need to connect T1 to Runway 11/29 using eastern cross taxiway, which reduces the travel time to T1 apron substantially is justified.*
14. *The need for a northern parallel taxiway for Runway 10/28 is highlighted to avoid crossing of aircrafts to T1 and is justified, as DIAL has decided to retain the T1 location.*
15. *Rapid exit taxiways from Runway 10/28 and all linkages to apron and runways are cross checked and found justified.*
16. *The drawings are verified as per ICAO standards and the area requirements for taxiway are validated and cross checked with the quantities considered for estimate preparation.*
17. *Need for new runway 11/29 is assessed based on the combined runway capacity of existing 3 runways. AAI has calculated the combined capacity of the 3 runways, keeping in mind the restrictions in airspace, approach, obstacles, existing taxi network etc. as 67 ATM/ peak hour. L&B has reviewed the permutation/ combinations and has recalculated peak hour ATM of 84 based on simulations. IGIA has operated 84 ATMs per hour based on the standard of operations, prepared by L&B.*
18. *The ATM forecast is reviewed and found exceeding the combined capacity of 3 runways and therefore the need for fourth runway is justified.*
19. *The capacity assessment of land side roads has been done on the basis of existing and projected traffic volumes. Based on the capacity analysis, widening of roads is justified to maintain the desired level of service (LOS).*
20. *Capacity enhancement proposed by DIAL for the land side and airside works is for the design year 2035-36 whereas the T1 expansion is for the year 2025-26 and T3 enhancement is for year 2021-22. This is justified based on the fact that infrastructure developments can only be done on a long term basis, whereas buildings can be augmented with minimum interference with operational activities.*

6.2 The outcome of the exercise with reference to scope of work are summarized as below:

6.2.1 To examine the proposal of the airport and assess the need for the proposed project and its capacity/scope with reference to passenger growth/ Cargo volumes/ Air Traffic Movement and also to suggest cost effective alternatives

The proposal for expansion of the IGIA submitted by DIAL is justified in view of the traffic forecast and ATM projections for the design year and is detailed in Chapter 2.0

6.2.2 To examine the building standards and designs proposed by the airport operator in line with IMG norms/IATA/ICAO norms

The total area proposed for T1 building is satisfying the IMG Area norm for Domestic Terminals and is well within the limit and is discussed in detail in Chapter 2.0

6.2.3 To analyze the reasonableness of the proposed cost with reference to the tentative ceiling decided by Authority vide order no.7 dated 13/06/16 based on the details of the rates and quantity as per government /industry approved norms and advise the Authority on the justification of the costs

Detailed review of the cost estimate submitted by DIAL has been carried out by KITCO based on the information provided by DIAL and Government/industry approved norms. Details of analysis is briefed in Chapter 3.0.The revision to total capital cost is recommended as below in Table No-20.

Table 18 - Details of Capital Cost recommended

(Amount in Rs. Crore)

Packages	**Estimated cost by DIAL**	**Recommended cost By KITCO**
1 - Expansion of Terminal 1	2,513.00	2,431.00
2&4 - Airfield works including 4th Runway & Eastern Parallel Cross Taxiways	4,681.00	4,320.00
3 - Landside / Connectivity works	366.00	366.00
5 - Modifications to Terminal 3	167.00	167.00
TOTAL	7,727.00	7,284.00
Others	905.00	685.60
GRAND TOTAL	**8,632.00**	**7,969.60**

ANNEXURES

Annexure-I

Summary of Areas & Recommended Costs for Phase-3A Expansion Works – Civil Works

MDP PACKAGE	S.NO	DESCRIPTION	Area (Sqm)	Cost per area(Rs./Sqm)	Recommended cost (Rs. crore)
PACKAGE 1	I	**MAIN PACKAGES**	192985	125968	**2431**
		PASSENGER TERMINAL BUILDING			
	A	**Civil and Structural works including façade, roofing**			
	B	**Finishes & Interior works**			
	C	**MEP Systems**			
	D	**SPECIALISED SYSTEMS**			
	(I)	**Airport Systems**			
	(II)	**IT Systems**			
		AIRFIELD WORKS			
PACKAGE 1	A	Apron excepting associated AGL works	629685	9778	616.00
PACKAGE 2	B	Runway	505086	5978	301.90
	C	Taxiways	931461	8306	773.7
	(i)	North side			
		Other Works- Preparation of Basic Strip Area, Back Filling & Dismantling Works			117.38
	(ii)	South side			
		Other Works- Preparation of Basic Strip Area, Back Filling & Dismantling Works			103.79
	D	Drainage			
	(i)	North side			518.43
	(ii)	South side			74.00
	E	Airfield Ground Lightning for all airside works including Eastern Cross Taxiway			652.00
	F	Other Associated works like Electric Substation, SRFF, ARFF equipment etc			57.00

MDP PACKAGE	S.NO	DESCRIPTION	Area (Sqm)	Cost per area(Rs./Sqm)	Recommended cost (Rs. crore)
PACKAGE 4	**H**	**EASTERN CROSS TAXIWAY expecting associated AGL works**	691081	16003.9	1106.00
		SUB TOTAL - AIRSIDE			**4,320**
PACKAGE 3		**LANDSIDE WORKS**	**145370**	**25177.1**	**366.00**
		GRAND TOTAL			**7,117**
PACKAGE 5		**TERMINAL 3 (Transfer areas-I to I,and baggage handling equipment**			167.00
	I	**TOTAL VALUE OF MAIN PACKAGES**			**7,284**

Summary of Estimated Costs & Recommended Costs – Expansion of Delhi Airport Phase-3A

MDP PACKAGE	S.NO	DESCRIPTION	COST PROPOSED BY DIAL (Rs. Crore)	COST RECOMMENDED BY KITCO (Rs. Crore)	EXTENT OF ESTIMATE PRUNED BY KITCO (Rs. Crore)
	I	**MAIN PACKAGES**			
PACKAGE 1		**PASSENGER TERMINAL BUILDING**			
	A	**Civil and Structural works including façade, roofing**	906	879.03	26.97
	B	**Finishes & Interior works**	366	366.00	0
		SUB TOTAL- STRUCTURES AND FINISHES	**1,272**	**1245.03**	**26.97**
	C	**MEP Systems**			
	(i)	HVAC	185		
	(ii)	Electrical	315		
	(iii)	FF, Detection & suppression systems	20		
	(iv)	Fire alarm system	11		
	(v)	PHE	26		
		SUB TOTAL- MEP SYSTEMS	558	**533.00**	25
	D	**SPECIALISED SYSTEMS**			
	(I)	**Airport Systems**			
	(i)	PBB, GPU, PCA, VDGS			
		Passenger Boarding Bridges	150		
		Visual Docking Guidance System	98		
		GPU- pit connection for remote stands	32		
		PCA- pit connection for remote stands	34		

MDP PACKAGE	S.NO	DESCRIPTION	COST PROPOSED BY DIAL (Rs. Crore)	COST RECOMMENDED BY KITCO (Rs. Crore)	EXTENT OF ESTIMATE PRUNED BY KITCO (Rs. Crore)
	(ii)	Screening systems- Passenger Screening systems	34		
	(iii)	Baggage handling systems	111		
	(iv)	Screening systems- Hold Baggage Screening systems	82		
	(v)	Vertical and Horizontal Transportation systems	115		
	(vi)	Automatic tray retrieval	27		
	(II)	**IT Systems**	cost considered under (III)		
		Sub total- specialised systems	683	**653.00**	30
		SUB TOTAL -TERMINAL	**2,513**	**2,431**	**81.97**
		AIRFIELD WORKS			
PACKAGE 1	A	Apron excepting associated AGL works	817	616.00	201.0
PACKAGE 2	B	New Runway 11L/29R	281	260.41	20.59
	C	Taxiways			
	(i)	North side (North Parallel taxiway, connecting taxiways, RETs+ Runway 09-27, Echo-2 etc)	888	813.86	74.14
	(ii)	South side (RET S1 & S2, Y5, exit taxiway-1,2,3, S-3, Z2 taxiways etc	236	222.54	13.46
	D	Drainage			
	(i)	North side	558	518.43	39.6
	(ii)	South side	74	74.00	0
	E	Airfield Ground Lightning for all airside works including Eastern Cross Taxiway	652	652.00	0
	F	Other Associated works like Electric Substation, SRFF, ARFF equipment etc	57	57.00	0

MDP PACKAGE	S.NO	DESCRIPTION	COST PROPOSED BY DIAL (Rs. Crore)	COST RECOMMENDED BY KITCO (Rs. Crore)	EXTENT OF ESTIMATE PRUNED BY KITCO (Rs. Crore)
PACKAGE 4	**H**	**EASTERN CROSS TAXIWAY expecting associated AGL works**	1,118	1106	12.4
		SUB TOTAL - AIRSIDE	**4,681**	**4,320**	**361.2**
PACKAGE 3					
		Flyover at northern access road	64	64.00	
		Foot over bridge	1	1.00	
		Flyover at T1 D/T1C	55	55.00	
		Northern Access, Central Spine and other roads etc	133	133.00	
		Roads- T1C & T1D at grade	29	29.00	
		Multi level Car Park	cost considered under (III)		
		Other works like External /Utilities/ Canopy etc	84	84.00	
		LANDSIDE -SUB TOTAL	**366**	**366.00**	
		GRAND TOTAL	**7,560**	**7,117**	**443.12**
PACKAGE 5		**TERMINAL 3 (Transfer areas-I to I,and baggage handling equipment**	167	167.00	0
	I	**TOTAL VALUE OF MAIN PACKAGES**	**7,727**	**7,284**	**443.124**
	II	**OTHERS**			
	a	Preliminary works including demolition, relocation, enabling, diversions etc- 2%	150	145.7	
	b	Design Development & Supervision - 4%	309	291.4	
	c	Permits, Survey, Insurance	30	30.0	
	d	Operational capex	30	0.0	
	e	Contigencies- 3%	386	218.5	

MDP PACKAGE	S.NO	DESCRIPTION	COST PROPOSED BY DIAL (Rs. Crore)	COST RECOMMENDED BY KITCO (Rs. Crore)	EXTENT OF ESTIMATE PRUNED BY KITCO (Rs. Crore)
	II	**SUB TOTAL-OTHERS**	**905**	**685.6**	**219.4**
		TOTAL (I+II)- excluding financing and interest costs	**8,632**	**7969.6**	**662.4**
	Notes	These costs are based on preliminary estimates of works, services and other facilities/ support costs			
	III	**Phase 3A WORKS EXECUTED THROUGH OTHERS (JOINT VENTURES/ CONCESSIONAIRES**			
	a	Information Technology and Associated Systems	140	140	
	b	Ground Power and Pre-conditioned Air Units	137		
	c	Multi level car park (underground)	374		
		Total (III)	651		
	Notes	These costs are based on preliminary estimates of works, services and other facilities/ support costs			

Annexure-II

Key Construction Milestone – Expansion of Delhi Airport Phase-3A

Sl.No	DESCRIPTION	START DATE	END DATE	TOTAL COST RECOMMENDED BY KITCO (in Crore)	RECOMMENDATION FOR CAPITAL UTILIZATION IN YEAR 2018 (in Crore)	RECOMMENDATION FOR CAPITAL UTILIZATION IN YEAR 2019 (in Crore)	RECOMMENDATION FOR CAPITAL UTILIZATION IN YEAR 2020 (in Crore)	RECOMMENDATION FOR CAPITAL UTILIZATION IN YEAR 2021 (in Crore)	REMARKS
1	**Terminal 1**	**July (2018)**	**SEP (2021)**	**2431**					
a	Terminal 1- Arrival New Building (Phase I)	JULY (2018)	JUNE (2019)	**2431**	**607.75**	**729.3**	**607.75**	**486.2**	
b	Terminal 1 – Arrival Old Building (Demolition & Construction) (Phase II)	JULY (2019)	DEC (2020)						
c	Node Building (Phase 1 and II)	JULY (2018)	DEC (2019)						
d	Pier (Phase III)	OCT (2020)	SEP (2021)						
2	**Air Field Works & Terminal 1 Apron**	**JULY (2018)**	**MARCH (2021)**	**3214**					
a	Phase I	JULY (2018)	AUG (2019)	**3214**	**642.8**	**964.2**	**964.2**	**642.8**	
b	Phase II	JUNE (2019)	JUL (2020)						

Sl.No	DESCRIPTION	START DATE	END DATE	TOTAL COST RECOMMENDED BY KITCO (in Crore)	RECOMMENDATION FOR CAPITAL UTILIZATION IN YEAR 2018 (in Crore)	RECOMMENDATION FOR CAPITAL UTILIZATION IN YEAR 2019 (in Crore)	RECOMMENDATION FOR CAPITAL UTILIZATION IN YEAR 2020 (in Crore)	RECOMMENDATION FOR CAPITAL UTILIZATION IN YEAR 2021 (in Crore)	REMARKS
c	Phase III	AUG (2020)	MARCH (2021)						
3	**Eastern Cross Taxiway (ECT)**	**JULY (2018)**	**AUG (2020)**	**1106**					
a	Phase I	JULY(2018)	JUNE (2019)	**1106**	**221.2**	**553**	**331.8**	**0**	
b	Phase II	APRIL (2019)	NOV (2019)						
c	Phase III	DEC (2019)	AUG (2020)						
4	**Terminal 1 Landside**	**JULY(2018)**	**AUG (2021)**	**366**					
a	Phase I	JULY (2018)	JUNE (2019)	366	73.2	109.8	109.8	73.2	
b	Phase II	JUNE (2019)	MAY (2020)						
c	Phase III	JUNE (2020)	JULY (2021)						
5	**Terminal 3**	**JULY (2018)**	**JUNE (2020)**	**167**	33.4	83.5	50.1	0	
A	**Total cost (1+2+3+4+5)**			**7284**					

Sl.No	DESCRIPTION	START DATE	END DATE	TOTAL COST RECOMMENDED BY KITCO (in Crore)	RECOMMENDATION FOR CAPITAL UTILIZATION IN YEAR 2018 (in Crore)	RECOMMENDATION FOR CAPITAL UTILIZATION IN YEAR 2019 (in Crore)	RECOMMENDATION FOR CAPITAL UTILIZATION IN YEAR 2020 (in Crore)	RECOMMENDATION FOR CAPITAL UTILIZATION IN YEAR 2021 (in Crore)	REMARKS
8	**OTHERS**			**685.60**					
a	Preliminary works including demolition, relocation, enabling, diversions etc @2% of **A**			**145.7**	72.84	43.70	14.57	14.57	
b	Design Development & Supervision @4%			**291.4**	58.27	87.41	87.41	58.27	
c	Permits, Survey, Insurance			**30.00**	6.00	9.00	9.00	6.00	
d	Operational capex			**0**					
e	Contigencies @3%			**218.5**	32.78	54.63	65.56	65.56	
9	**Total Cost recommended by KITCO**			**7969.60**	**1748.24**	**2634.54**	**2240.18**	**1346.60**	

Annexure-III

Comparison of cost

	Cochin			Hyderabad			Kolkata			Delhi			Cost Difference from Cochin (Rs./Sqm)		
Sub	**Cost Rs. Cr**	**%**	**costper sqm**	**Cost Rs. Cr**	**%**	**costper sqm**	**Cost Rs. Cr**	**%**	**costper sqm**	**Cost Rs. Cr**	**%**	**costper sqm**	**Delhi**	**Hyderabad**	**Kolkata**
Civil Works	401.47	47%	26765	335.43	23%	32566	957.16	43%	48173	442.81	18.21%	22945			
Spl finishes	70.26	8%	4684	191.6	13%	18602	56	3%	2818	366.00	15.06%	18965			
External Façade	47.98	6%	3199	117.12	8%	11371	167.12	8%	8411	67.82	2.79%	3514			
Roofing System	Incl.		Incl.	104.54	7%	10150	161.76	7%	8141	368.4	15.15%	19090	29,866	38,041	32,896
HVAC	121.5	14.31%	8100	56.64	4%	5499	144.88	7%	7292	180	7.40%	9327			
Electrical system				74.38	5%	7221	193.54	9%	9741	310	12.75%	16063			
Plumbing & Drainage				17.18	1.2%	1668	71.74	3%	3611	21	0.86%	1088			
Fire fighting system				10.18	0.7%	988	27.8	1%	1399	7	0.29%	363			
Fire detection				5.83	0.40%	566		0%	0	15	0.62%	777	19,518	7,843	13,942
Vertical & Horizontal transport	207.95	25%	13863	536.92	37%	52128	424.72	19%	21376	653	26.86%	33837	19,974	38,265	7,512
PTB furniture															
Airport system															
Special works															
Total cost	849	100%		1450	100.0%		2,205	100%		2431.0	100.00%				
Area	150000			103000			198692			192985					
Cost Rs./sqm	56,611			140759			110962			125970			69,359	84,149	54,351

	Cochin	hyderabad	Delhi
Airside works			
Apron and taxiway for Code E + partly for Code F	Rs.4336per sqm		Rs.9042/sqm (for code F)
Runway		Rs.5705/sqm	Rs.5978/sqm

Comparison of Specifications of Terminal Buildings

Sl. No.	Criteria	Cochin	Other terminals	Delhi
1	Façade Glazing	Combination of Single & Double Glazed for 35 to 40% area	60-85% double Glazed paneling	Double Glazed paneling
2	Internal Wall finishes/cladding	Wooden panel with Laminates	ACP wall cladding with perforations.	Glass/gypsum board partitions
3	Roofing Sheeting system	3 layered system without Skylights (Kingspan)	5 layered system with Skylights for natural lighting.	9 layered system with Skylights for natural lighting.
4	False ceiling system	Hunter Douglas	Premium imported false ceiling	1. Aluminium Perforated Ceiling manufactured by M/s. Hunter Douglas India Pvt. Ltd. 2. calcium silicate false ceiling
5	Sanitary fixtures & fittings	Local Makes	Premium imported sanitary ware.	Premium imported sanitary ware.
6	Flooring in Passenger Movement areas	Vitrified Tiles	Granite Flooring	Granite ,vitrified tile flooring
7	Passenger Loading Bridges	Non-Glazed	Mostly Glazed	Fully glazed
8	Passenger Seating system	Wooden Sofas with cushion	Imported PU Based seating	

Sl. No.	Criteria	Cochin	Other terminals	Delhi
9	No. of floors levels of the terminal	Four levels	Six or more for other terminals	Four levels
10	Foundation of Terminal building	Pile foundations		Isolated footing
11	Tendering Process	Bid process adopted by CIAL appears to be better than other airport operators. Based on the details collected, it has been observed that there is very healthy competition and as such the bid received are lower than the estimated cost.	Due to invitation of bids from selective short-listed bidders, the competition gets restricted resulting in substantial higher bids than the estimate. The concessionaire should ensure adequate/healthy competition in order to get reasonable bids. It is also observed that Terminal cost (per sqm) executed by AAI like Chennai, Kolkata of similar magnitude is lower than Delhi, Mumbai, Hyderabad and Bangalore.	In order to ensure best quality and competitive cost from the vendors, transparent bidding process shall be followed.
12	Equipment	The cost of Airport system like PLB Escalators, Lifts, Travellators, VGDS, etc. is lesser	The cost of Airport systems is much higher.	The cost of Airport systems is much higher.
13	Terminal	Separate Domestic and international	Integrated Terminal	Separate Domestic and international
14	ASQ Rating	Lower	Higher	Higher

Annexure-IV

Governing Parameters (Reference: Highlights of IMG report)

Report of the Inter-Ministerial Group (IMG) on Norms & Standards for Capacity of Airport Terminals (2009)

IMG has deliberated in detail on various key issues and made following recommendations:

Growth Rate for Traffic Projections

Keeping in view the trend in air traffic in last few years, a span of five years be adopted for the projects planned during the current five-year plan period, i.e., up to 2011-12. Thereafter, as the growth rate stabilizes, the span for making projections should be increased to 7 years for a more realistic assessment.

Target year for Capacity Creation (Design Year)

Following norms could be adopted for capacity creation:

-Smaller air port s (< 5.0 MAP) - 10th year from Planning year.

-Bigger airports (> 5.0 MAP) - 7th year from Planning year.

Peak Hour Projections

Methodology given in ICAO Manual on Air Traffic Forecasting by finding ratios from historical data and recent studies be adopted. As per ICAO Manual, forecasts of peak period passengers are to be obtained from annual forecasts by applying ratios of busy period traffic; to annual traffic derived from actual data at various airports.

Actual data for the past five years should be analyzed to determine the Peak Hour Traffic and the trend growth thereof. Projections for the Design Year should be made based on the trend growth in the past. AAI should make arrangements for data collection of Peak Hour Traffic in respect of all non-metro Airports, so that same is available at the time of planning expansion of these Airports.

In absence of actual data, the Peak Hour Traffic may be estimated based on ratios given in Table-1 below.

Table 1- Ratio based Peak Hour Traffuc for estimation

SL. No	*Traffic (in MAP)*	*Ratio for International Terminal*	*Ration for Domestic Terminal*
		PH/PD	*PH/PD*
1	*1.0-5.0*	*0.30000*	*0.250000*
2	*0.5-1.0*	*0.3500*	*0.3500*
3	*Less than 0.5*	*0.4500*	*0.4500*

In the event that requisite data is not available for airports with traffic above 5 million passengers per annum, the above ratio-based norms may be considered in the interim.

Level of Services in Target Year

Level of Services 'C' as per IATA Airport Development Reference Manual (Jan 2004) denotes good service at a reasonable cost. Therefore, this level could be used for design for target demand in the design year. The unit area specified in paragraph E below represents Level of Service 'C'. Net impact of this norm would be that in the initial years, the passengers may experience LOS 'A' or 'B' and as the traffic increases LOS 'C' would be achieved.

Unit Area Norms

Overall space/area norm should be such as to provide a reasonable level of service for all components required in a Terminal Building. Commercial or Retail area providing amenities like food & beverages, book shops, counters for car rental, vending machines, public rest rooms etc., normally require 8-12 per cent of the overall area, and should be planned and provided accordingly. In bigger airports, i.e., with annual passenger traffic exceeding 10 million, commercial area could be up to 20per cent of overall area. Keeping in view the IATA norms and

discussion above, the norms as given in Table-2, are considered appropriate for Indian Airports.

Table 2 -Area Norms for type of Airports

SL.No	Nature of Terminal	Area Norm-sqm/php
1	Domestic Terminals	
	Traffic up to 100 php	12
	Traffic between 100-150 php	15
	Traffic between 150-1000 php	18
	Traffic above 1000 php	20
2	Integrated terminal for handling both domestic and international	25
3	International Terminals	27.5

Unit Cost of Construction

IMG recommended that the Appraisal Committee should specify the ceiling unit cost and the architect s/ engineers of AAI should plan and implement the project within the ceiling, subject to revision on account of increase in WPI.

Airports developed through Public Private Partnerships

In the case of airports developed through Public Private Partnerships, the project authorities may adopt a case by case approach with respect to norms relating to unit area and unit costs. Based on the judicious consideration of international best practices and financial viability, the norms may be specified in each case prior to inviting bids for private participation.

Highlights of AERA Order No. 07/2016-17

In the matter of Normative Approach to Building blocks in economic regulation of major airports - Capital Costs, AERA Vide Order No. 07/2016-17 issued orders as given below:

Pending finalization of a norm in this regard after going through a more rigorous process, the tentative ceiling cost of Rs.65,000/- per sqm of the terminal

building and Rs.4,700 per sqm for the Runway/taxiway/ Apron (excluding earthwork up to sub grade level) is approved as a reasonable benchmark for evaluating capital costs to be incurred by Airport Operators of major airports for the purpose of tariff determination on a tentative basis.

The airport operators are advised to relook at the costs proposed in their submissions and justify the increase, if any, over and above the ceiling rates as indicated above.

The Airport operators are expected to evaluate the costs in adoption of various alternatives finishes and the corresponding benefits that accrue to users in case of adoption of such alternative higher specifications.

In case the rates are higher than the ceiling rate approved by the Authority, the justifications, so submitted by the airport operators on actual incurrence of the cost shall be examined by a duly constituted Committee of experts to be constituted by Authority and based on their recommendations the final costs will be adopted.

These ceiling rates shall apply only in case of new projects where the works are yet to be awarded. In case of awarded projects, the capital costs will need to be examined by the committee approved for the purpose.

APPENDICES

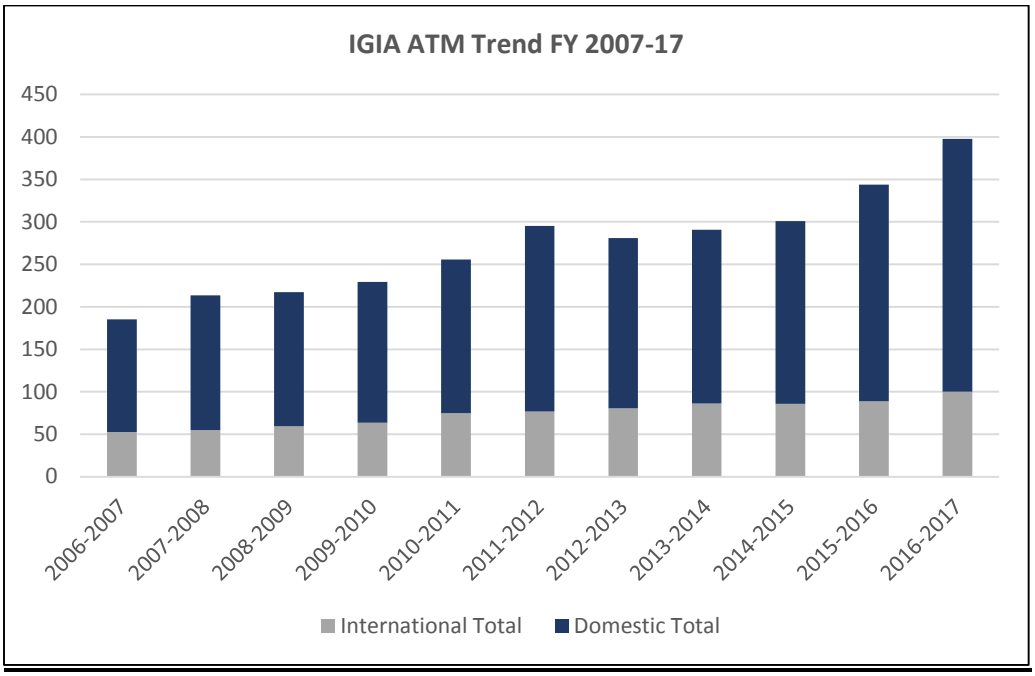
Queries and mails

Response to KITCO E-mail dated: 31st January, 2018.

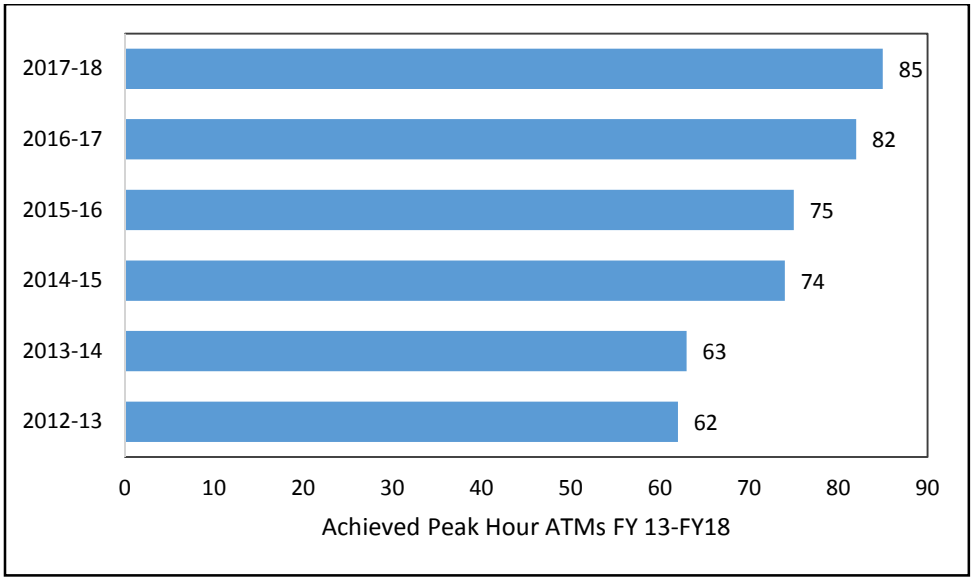
1. **Past trends in aircraft movements from the year 2006 /07 to 2016/17, total ATMs, peak hr ATM and bifurcation of domestic & International air traffic movements.**

Response:
Refer below table for Aircraft Movements year wise total ATMs alongwith bifurcation for Domestic & International.

	International			Domestic			
	Sch.	Non.Sch	Total	Sch.	Non.Sch	Total	G. Total
2006-2007	49.9	2.6	52.5	129.5	3.1	132.6	185.1
2007-2008	51.8	3.1	54.9	155.4	3.2	158.6	213.5
2008-2009	56.7	2.8	59.5	156.6	1.3	157.9	217.4
2009-2010	60.5	3	63.5	164.6	1.2	165.8	229.3
2010-2011	70.1	4.7	74.8	179.5	1.3	180.8	255.6
2011-2012	73.1	3.8	76.9	216.6	1.9	218.5	295.4
2012-2013	77	3.4	80.4	197.9	2.5	200.4	280.8
2013-2014	84.9	1.3	86.2	203.7	0.9	204.6	290.8
2014-2015	85	0.8	85.8	214.7	0.4	215.1	300.9
2015-2016	87.8	1.2	89	254.7	0.3	255	344
2016-2017	98.9	1.4	100.3	297.1	0.4	297.5	397.8



Peak Hour ATMs:
This is to be informed that, we have peak hour data from 2013 onwards.



2. **Also provide us the reference portions of ADRM 9 & 10 (reference pages only) which you have mentioned in the report for terminal facility requirements and areas, since we have only the 7th edition of ADRM.**

Response:
With reference to ADRM 9 & 10, ADRM 10 has been used for Design Development of Phase 3A. ADRM 10 is a licensed document & available only in soft form, which cannot be copied or printed. As discussed telephonically yesterday by Shri T J Reddy (CDO), you can see the relevant portion on the laptop that we going to carry to the meeting at your HQ on 6th Feb, 2018.

3. **Detailed project cost break-up along with quantities and unit rates for all packages.**

Response: In line with mail from our CDO, our costing team would be present on 7th Feb, 2018 to discuss the cost detail with KITCO (Refer below mail from CDO, dated: 2nd Feb, 2018).

Further, to my trailing mail, this is to inform you that our DIAL and AECOM teams dealing with the costing of the project would be available at your HQ on 7th Feb 2018. This is as per the discussions our CEO had with Mr Rakesh of KITCO on 1st Feb 2018.

Dated: 9th February, 2018

REPLY TO KITCO QUERIES RAISED DURING THE MEETING ON 6TH & 7TH FEB, 2018

AT HQ, COCHIN

S.No.	Query	Reply
1	Rock excavation photographs	Rock profile in T1 Area Attached as Annexure-1.
2	Glass Canopy Specifications	Please refer to façade specification covered in pages -97 to 130 of technical specification attached herewith. For glass canopy specifications refer item no. g, mentioned on page no. 99 of above specification. Also, refer attached drawing for glass canopy locations and typical section details as per drawing AECOM-DIAL-TB-AR-PD-DWG-GA-WP02A-0013 (R1) & AECOM_DIAL_TB_AR_PD_DWG_GA_WP03_4102-R1 Attached as an Annexure-2.
3	Roof Sheeting Specifications & Drawings	The roof sheeting designs being adopted for Terminal 1 is the same as that of roof sheeting of Terminal 3 at IGI Airport. Please refer attached specification & drawing indicating the typical roofing system detail for Terminal1. (AECOM_DIAL_TB_AR_PD_DWG_GA_WP02_5104-R1).

S.No.	Query	Reply
		We are also attaching Terminal 3 built-up reference & Terminal 3 roof drawing. Attached as Annexure-3.
4	Façade Glass – Item description & specification & Scope details in drawings	Please refer to the Façade specifications & drawing for façade scope plan & glazing details. (AECOM_DIAL_TB_AR_PD_DWG_GA_WP03_0011-R0 to dwg. 0015-R0 and AECOM_DIAL_TB_AR_PD_DWG_GA_WP03_5103 R1). For existing Terminal 1D Façade modifications, please refer the attached Sketch 0221. Attached as an Annexure-4.
5	Cradle System Specification	1. Please refer attached reference specifications for the glass cleaning system. 2. DIAL is adopting the same system for glass cleaning arrangement for the Terminal 1 also. 3. Please refer attached Sketch no. 0222, indicating the gantry system track location for the internal and external façade cleaning system for Terminal 1. 4. Also refer attached drawings and Specification related to Terminal 3, wherein similar façade cleaning system has been installed for external & internal façade cleaning. Attached as an Annexure-5.
6	Landscape basis	Attached as an Annexure-6.
7	ETFE Quote + Specification	ETFE performance Specification along with quotation are enclosed for your reference.

S.No.	Query	Reply
		Attached as an Annexure-7.
8	Roof Drain Gutter Specification	Roof sheeting performance specifications are enclosed for reference. Please refer attached drawing indicating the typical roof gutter & roof system detail for clarity. (AECOM_DIAL_TB_AR_PD_DWG_GA_WP02_5101-R1 to 5104-R1). Attached as an Annexure-8.
9	Interiors details- back up of Rs 366 cr –Area wise	Attached as an Annexure-9.
10	11/29 – Cross Section	Already shared by Mr. Rajiv Ojha on 7th Feb, 2018. (Re-sending the same). Attached as an Annexure-10.
11	Perimeter Road – location and cross sectional detail	**For Cross-section detail:** A typical cross section of Perimeter Road may be taken as (from top to bottom) 40 BC, 60 DBM, 250 WMM, 200 GSB and 500 subgrade. **Location Measurement Detail:** Total length of perimeter road construction is 1032.56 m break up is below: Sheet:1: 273.82 m. Sheet:2: 307.32 m. Sheet:3: 451.42 m. Attached as an Annexure-11.
12	Fresh summary sheet	Attached as an Annexure-12.
13	Operating equipment	Attached as an Annexure-13.
14	HVAC- Check low side cost – mainly	We are forwarding the quote received from one of the reputed HVAC

S.No.	Query	Reply
	pipes	vendor against each item of the complete HVAC works. Further following clarifications on the subject may please be noted: 1. Based on combined experience, an overall internal estimate was prepared for the works. 2. Attached quotation from vendor was similar at overall cost level. 3. The costs incurred in T3 were about Rs 400 cr for 20000 TR or Rs 2 lakhs / Tonne On comparison for 9000 TR at T1, the cost works out to about Rs.180 cr (*which is comparable with the Terminal 3 cost constructed nine years ago*). 4. As the Internal estimate was in line with the above, thus same was submitted as part of project cost. 5. Sample rate built up Calculation for one of piping item is attached Attached as an Annexure-14.
15	PBB, VHT cost check based on quotes	Attached as an Annexure-15.
16	PHE- Syphonic system- check	Cost of Syphonic Drainage System already included in PHE BoQ item no 7 as Annex A. Missed out Annex A is attached to main BoQ Attached as an Annexure-16.
17	DBR for Electrical revised	Attached as an Annexure-17.
18	Fire Fighting pipe rates	This point was discussed and all points were closed during the meeting on 7th Feb, 2018 at KITCO Office
19	Spares cost considered in AGL – Quantity Calculation Sheet	AGL BoQ, already shared on 6th Feb, 2018 via e-mail from Shri Sujit Nag, which consist of 10% extra spare cost. Wherever, it is required.

S.No.	Query	Reply
		Attached as an Annexure-19.
20	Rate analysis for PQC & PMB	Attached as an Annexure-20
21	Cost of Terminal 3 after revision of scope.	Revised scope consists of only I-I (International to International) transfer & modification/ upgradation of BHS. Revised cost works out to Rs.167 cr. T3 transfer peak hours assessment are being forwarded separately. Attached as an Annexure-21.
22	Aircraft departure details for pavement.	The aircraft numbers are given on page no-12 to 14 in section 3 of Airfield MDP (package-2). Which brings out the number and type of specific aircrafts used in design of runway and taxiway. The figures used for taxiway design have also been used in design of Apron. Attached as an Annexure-22.

Response to KITCO E-mail dated: 23rd January, 2018.

Point No 1: Design year fixed for the Terminal expansion T1 and T3.
Response: Design Year for T-1 Expansion = 2022-23
Design Year for T-3 Modifications = 2020-21

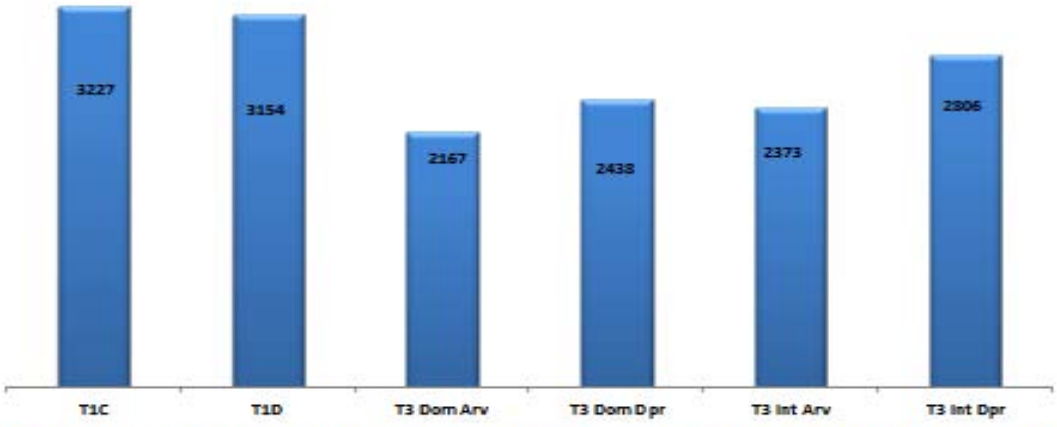
Point No 2: Existing actual area of Terminals T1 & T3.
Response: Existing Floor Areas of T1) =54000 Sq.m Approx.
Existing Floor Are of Terminal 3 = 553,887 Sq.M

Point No 3: Actual no. of passengers handled in T1 &T3 (arrival & Departure separate) for years from 2006-07 to 2016-17 & peak hour traffic.

Response:

trm wise yearly traffic

fy-c	T3 Int Dpr	T3 Int Arv	T3 Transit	T3 Int Total	T3 Dom Dpr	T3 Dom Arv	T3 Dom Total	T1 Dom Dpr	T1 Dom Arv	T1 Dom Total
2006-07	3304566	3098968	249832	6653366	3364311	3282556	6646867	3602702	3540509	7143211
2007-08	3651000	3443256	247819	7342075	5347198	5256972	10604170	3081067	2944350	6025417
2008-09	3855900	3738540	174873	7769313	4990653	4896864	9887517	2624209	2562376	5186585
2009-10	4058609	4022568	233034	8314211	5579584	5360826	10940410	3440689	3429385	6870074
2010-11	4567252	4420952	287570	9275774	6128539	5824779	11953318	4394086	4319709	8713795
2011-12	5240486	5191874	317649	10750009	7008236	6560184	13568420	5712885	5850651	11563536
2012-13	5652456	5542095	371551	11566102	5089023	4828279	9917302	6331462	6553545	12885007
2013-14	6269487	6128248	283574	12681309	5267520	5003488	10271008	6885781	7038888	13924669
2014-15	6760876	6560266	213282	13534424	5943140	5649805	11592945	7853680	8004506	15858186
2015-16	7171253	6810089	170830	14152172	7823557	7605686	15429243	9524703	9318047	18842750
2016-17	7836434	7542486	118464	15497384	9220310	8978363	18198673	12112741	11894298	24007039



The international departure terminal has a peak hour pax of 2806 and the arrival terminal has a peak hour pax 2373. T3 domestic has a peak hour pax of 2438 in departure and 2167 in arrival terminals. Terminal 1 has a departure peak of 3154 pax and arrival peak of 3227 pax.

Point No 4: Existing Air Traffic Movements (ATM s) with segregation with peak hour details

Response:

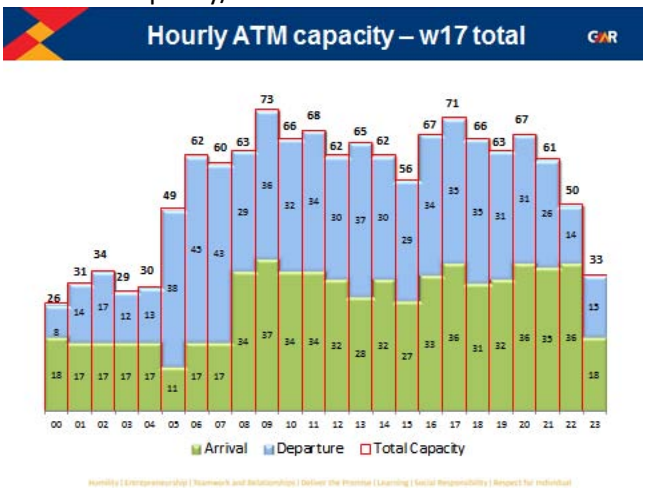
JAN 2018 YTD	371467

Runway utilization:

	ARR&DEP	ARR	DEP
09	5.2%	-	10.3%
27	13.5%	26.76%	0.2%
10	11.4%	18.1%	4.64%
28	23.3%	7.62%	39.1%
11	15.3%	13.8%	16.9%
29	31.2%	33.64%	28.8%

Point No: 5 Existing capacity of each runway and combined capacity also.
Response:
Combined Scheduled Peak hour capacity: 73 ATMs
Combined Achieved peak hour: 85 ATMs

MAX DEP capacity/HR: 36 ATMs
MAX ARR capacity/HR: 37 ATMs



Point No: 6 Critical aircraft for which each existing run way caters.
Response:
09/27 – Code E
10/28 – Code F
11/29 – Code F

ESTIMATE OF OPERATIONAL EQUIPMENT

S.No	Item	Qty	Rate	Amount	
1	Runway sweeping machine	2	6,50,00,000	13,00,00,000	
2	Runway paint marking machines- big	1	1,25,00,000	1,25,00,000	
3	Runway paint marking machines- small	2	35,00,000	70,00,000	
4	runway rubber removal machines	1	6,50,00,000	6,50,00,000	
5	Passenger trolleys	2500	26,000	6,50,00,000	
6	Motorised lifting platform	3	75,00,000	2,25,00,000	
			Total	30,20,00,000	
			say	30 cr	

Function	Area/m^2	Remarks	
Terminal entry check and space for farewellers	281	2314	Forecourt Area
Check-in Hall	8,437		
Departures security	6,528		
Transfers security	2,127		
Contact gates (22 No.)	6,135		
Bus gates (13 No,)	4,733		
Departures baggage make-up area	9,043		
Baggage reclaim and arrivals hall (excluding commercial)	9,300		
Arrivals meeter/greeter area	3,313		
Toilets	5,464		
Airport offices	5,798		
Airline offices	5,141		
Ramp accommodation	7,535		
Circulation/structure/MEP	95,298		
Commercial areas	22,503		
Back of house areas	1,349		
Grand Total	1,92,985		

TAX INVOICE
(See Rule Sec-23)

Original for Receipient
Duplicate for Supplier/Transporter
Triplicate for Supplier

OOMS POLYMER MODIFIED BITUMEN PRIVATE LIMITED

Head Office Address: R.O. UNIT NO.807, 8TH FLOOR BLOCK-B, UNITECH BUSINESS ZONE GOLF COURSE, EXTN. ROAD, SECTOR-50 Gurgaon, Haryana -122002 (India). Tel: 0124-4093600 Email :

OOMS POLYMER MODIFIED BITUMEN PRIVATE LIMITED Khasra No419/1 On NH-2 Vill -Dautana, Tehsil- Chatta, Distt - Mathura - 281401 (U.P)

GSTIN/Unique ID : 09AAACO4150E1ZR
Invoice No. : OPMB/KK/0106
Invoice Date : 26.09.2017
State : UP State Code : 09

Purchase Order No : Date :

Transport Name	:	SUNNY TRANSPORT	G.R.No. : 1168
Vehicle Number	:	UP85AT7348	Transportation Mode : By Road
Date of Supply	:	26.09.2017	
Place of Supply	:	HARYANA	

Details of Receiver | Billed to:

Name : C. P. ARORA ENGINEERS CONTRACTOR
Address : VILLAGE- SOLDHA, TEHSIL- BAHADURGARH DISTT- JHAJJAR, HARYANA
State : HARYANA State Code 06
GSTIN/Unique ID : 06AACCC4651Q1ZC

Details of Consignee | Shipped to:

Name : C. P. ARORA ENGINEERS CONTRACTOR
Address : VILLAGE- SOLDHA, TEHSIL- BAHADURGARH DISTT- JHAJJAR, HARYANA
State : HARYANA State Code : 06
GST IN/Unique ID: 06AACCC4651Q1ZC

Sr. No.	Name of Product / Service	HSN	Unit	Qty (MT)	Rate	Amount	Less: Discount	Taxable Value	CGST Rate %	CGST Amount	SGST Rate %	SGST Amount	IGST Rate %	IGST Amount	Total
1	PMB (ELASTOMERIC) SBS BASED	2715	MT	19.990	49,000.00	979,510.00		979,510.00	9		9		18	176,311.80	1,155,822
	Freight Insurance Packing & Forwarding					19,990.00		19,990.00	9		9		18	3,598.20	23,588
			Total :	19.990		999,500	-	999,500	-		-			179,910.00	1,179,410

Terms: *Goods once sold will not be taken back or exchanged.
*All Disputes are subject to Delhi Court Jurisdiction.

Total Amount Before Tax	999,500
Add : CGST	-
Add : SGST 9%	-
Add : IGST 18%	179,910.00
Tax Amount : GST	-
Total Invoice Amount	1,179,410
GST Payable on Reverse Charge :	

Total Invoice Value (Inwords) : ELEVEN LAC SEVENTY NINE THOUSAND FOUR HUNDRED TEN ONLY

Declaration :
We Declare that this invoice Shows the actual Price of the goods described and that all particulars are true and correct.

Electronic reference Number

Certified that the particulars given above are true and correct.
For OOMS Polymer Modified Bitumen Pvt. Ltd.

Ooms Polymer Modified Bitumen (P) Ltd. KOSI

Authorised Signatory

[E&OE]

Gmail **sindhu anna <sindhuanna999@gmail.com>**

Chilled water pipe rates from DSR / chiller rates

5 messages

Diksha Singh <Diksha.Singh@gmrgroup.in> Tue, Apr 3, 2018 at 3:49 PM
To: sindhu anna george <sindhuannageorge@kitco.in>, sindhu anna <sindhuanna999@gmail.com>, "amitrajkhera@kitco.in" <amitrajkhera@kitco.in>
Cc: T J Reddy <tj.reddy@gmrgroup.in>, Sridhar CR <CR.Sridhar@gmrgroup.in>

Dear Madam,

Please refer below working further to our discussion on

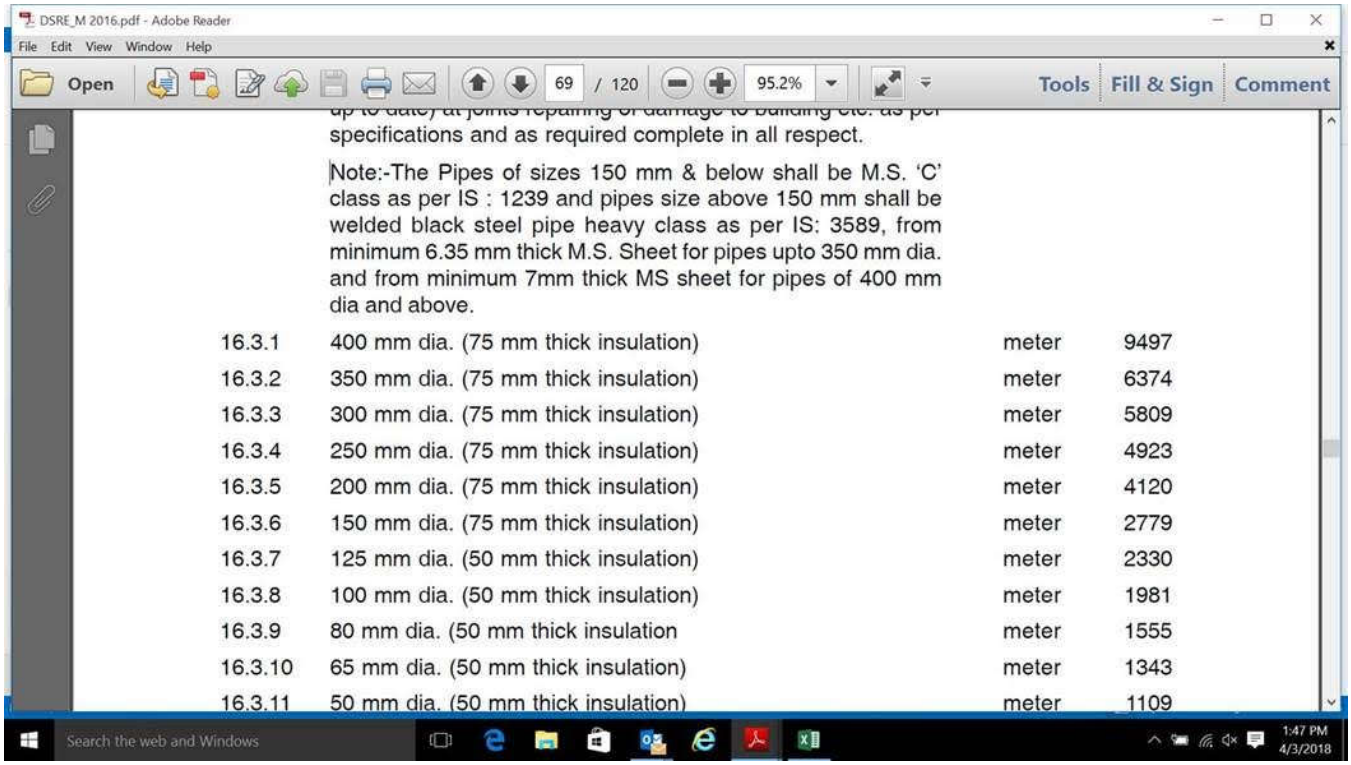
Piping calculation:

DSR rate for 200 mm pipe – Rs 4120 / lm (S.no 16.3.5)

Escalation to 2017 , + labour component (7.8%) + 17% for escalation + working in operational area – Rs 5650 /lm

Chillers :

	INR Lakhs
Chiller Price (US)- York	259.7
VFD Price(add 10%)	25.97
Total Price	285.67
Dollar variation @ 10%	314.237
Contractor's O&P @15%	361.3726



Regards,

Diksha Singh

2 attachments

DSRE_M 2016.pdf
1707K

Price Break up sheet_IGI.PDF
255K

Diksha Singh <Diksha.Singh@gmrgroup.in> Tue, Apr 3, 2018 at 3:54 PM
To: sindhu anna george <sindhuannageorge@kitco.in>, sindhu anna <sindhuanna999@gmail.com>, "amitrajkhera@kitco.in" <amitrajkhera@kitco.in>
Cc: T J Reddy <tj.reddy@gmrgroup.in>, Sridhar CR <CR.Sridhar@gmrgroup.in>

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2 attachments

DSRE_M 2016.pdf
1707K

Price Break up sheet_IGI.PDF
255K

Diksha Singh <Diksha.Singh@gmrgroup.in> Tue, Apr 3, 2018 at 4:00 PM
To: sindhu anna george <sindhuannageorge@kitco.in>, sindhu anna <sindhuanna999@gmail.com>, "amitrajkhera@kitco.in" <amitrajkhera@kitco.in>
Cc: T J Reddy <tj.reddy@gmrgroup.in>, Sridhar CR <CR.Sridhar@gmrgroup.in>

[Quoted text hidden]

2 attachments

DSRE_M 2016.pdf
1707K

Price Break up sheet_IGI.PDF
255K

Diksha Singh <Diksha.Singh@gmrgroup.in> Tue, Apr 3, 2018 at 5:30 PM
To: sindhu anna george <sindhuannageorge@kitco.in>, sindhu anna <sindhuanna999@gmail.com>, "amitrajkhera@kitco.in" <amitrajkhera@kitco.in>
Cc: T J Reddy <tj.reddy@gmrgroup.in>, Sridhar CR <CR.Sridhar@gmrgroup.in>

[Quoted text hidden]

2 attachments

DSRE_M 2016.pdf
1707K

Price Break up sheet_IGI.PDF
255K

---

sindhu anna <sindhuanna999@gmail.com> Tue, Apr 3, 2018 at 6:26 PM
To: Ajish unnithan <ajishunnithankitco@gmail.com>

Regards,

Sindhu Anna George
Consultant
Kitco Ltd.
Kochi.

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2 attachments

DSRE_M 2016.pdf
1707K

Price Break up sheet_IGI.PDF
255K

Gmail **sindhu anna <sindhuanna999@gmail.com>**

Basis of selection of specialised Equipment at the IGI Airport, New Delhi.

2 messages

Sridhar CR <CR.Sridhar@gmrgroup.in> Wed, Apr 4, 2018 at 12:56 PM
To: sindhu anna george <sindhuannageorge@kitco.in>, sindhu anna <sindhuanna999@gmail.com>, "amitrajkhera@kitco.in" <amitrajkhera@kitco.in>
Cc: Diksha Singh <Diksha.Singh@gmrgroup.in>, T J Reddy <tj.reddy@gmrgroup.in>, Indana Prabhakara Rao <IndanaPrabhakara.Rao@gmrgroup.in>

Dear Madam,

Further to the discussions yesterday on the above subject, please find below the explanation for use of same “makes” wrt to specialized equipment like PBB, GPU, CPA, VDGS, Screening systems, BHS, VHT , automatic tray retrieval systems etc.

-

IGI Airport being in public domain selection of specialized equipment as above should be made keeping in mind the following important aspects.

1. Leading manufacturer in the field who has vide experience of design, sourcing of material, manufacturing & provide long term support with spare parts.

2. Capability of providing adequate support for supervision during erecting, testing & commissioning.

3. Has proven field records of achieving very high serviceability during the operation & maintenance.

4. Has proven record of being significantly energy efficient.

5. Overall life cycle cost to the purchaser should be low so that, OPEX & CAPEX to be incurred during the lifetime for the purpose of running maintaining and rehabilitating the same is advantageous & cheaper.

While, any airport undergoes an expansion, it is always advisable that the systems which has proven its worth with respect to overall energy efficiency, life cycle costing & serviceability & the point mentioned above, preference should be given to such system manufacturers and installer. Further, OMDA requires under Schedule 3 (Objective Service Quality Requirements) that DIAL achieve and maintain targets which are linked to the performance of specialized systems. Therefore, it is prudent to adopt / implement systems that are already tried and tested.

Major expansion planning such as Phase 3A Works of IGI Airport, New Delhi needs also to take care the aspect of spare parts planning, annual maintenance cost (AMC) logistical support from the manufacturer, system expandability and accordingly, it was envisaged that similar proven systems as adopted for Terminal 3 should be considered.

Rgds

Sridhar CR

---

sindhu anna <sindhuanna999@gmail.com> Wed, Apr 4, 2018 at 12:58 PM
To: Ajish unnithan <ajishunnithankitco@gmail.com>

Regards,

Sindhu Anna George
Consultant
Kitco Ltd.
Kochi.

[Quoted text hidden]

Annexure-2

SUMMARY OF ESTIMATED COSTS FOR PHASE 3A EXPANSION WORKS SUBMITTED BY DIAL			
MDP PACKAGE	**Sr.NO**	**DESCRIPTION**	**ESTIMATED COST IN CRORES**
	I	**MAIN PACKAGES**	
PACKAGE 1		**PASSENGER TERMINAL BUILDING**	
	A	**Civil and Structural works including façade, roofing**	906
	B	**Finishes & Interior Works**	366
		SUB TOTAL - STRUCTURE AND FINISHES	**1,273**
	C	**MEP Systems**	
	(i)	HVAC	187
	(ii	Electrical	314
	(iii)	FF, Detection & suppression systems	21
	(iv)	Fire alarm system	10
	(v)	PHE	27
		SUB TOTAL- MEP SYSTEMS	**558**
	D	**SPECIALISED SYSTEMS**	
	(I)	**Airport Systems**	
	(i)	PBB, GPU, PCA, VDGS	
		Passenger Boarding Bridges	155
		Visual Docking Guidance Systems	76
		GPU- pit connection for remote stands	24
		PCA- pit connection for remote stands	47
	(ii)	Screening systems- Passenger Screening systems	32
	(iii)	Baggage handling systems	115
	(iv)	Screening systems- Hold Baggage Screening systems	84
	(v)	Vertical and Horizontal Transportation systems	123
	(vi)	Automatic tray retrieval	28
	(II)	**IT Systems**	cost considered under (III)
		SUB TOTAL- SPECIALISED SYSTEMS	**683**
		SUB TOTAL- TERMINAL	**2,514**

SUMMARY OF ESTIMATED COSTS FOR PHASE 3A EXPANSION WORKS SUBMITTED BY DIAL			
MDP PACKAGE	**Sr.NO**	**DESCRIPTION**	**ESTIMATED COST IN CRORES**
		AIRFIELD WORKS	
PACKAGE 1	A	Apron excepting associated AGL works	797
PACKAGE 2	B	New Runway 11L/29R	276
	C	Taxiways	
	(i)	North side (North Parallel taxiway, connecting taxiways, RETs + Runway 09-27, Echo-2 etc)	872
	(ii)	South side (RET S1& S2, Y5, exit taxiway-1,2,3, S-3, Z2 taxiways etc)	235
	D	Drainage	
	(i)	North side	580
	(ii)	South side	79
	E	Airfield Ground Lighting for all airside works including Eastern Cross Taxiway	622
	F	Other Associated works like Electric Substation, SRFF, ARFF equipment etc	100
PACKAGE 4	**H**	**EASTERN CROSS TAXIWAY excepting associated AGL works**	**1,118**
		SUB TOTAL- AIRSIDE	**4,679**
PACKAGE 3		**LAND SIDE**	
	A	Flyover at northern access road	61
	B	Foot over bridge	1
	C	Flyover at T1 D/T1C	51
	D	Northern Access, Central Spine and other roads etc	127
	E	Roads- T1C & T1D at grade	31
	F	Multi level Car Park	cost considered under (III)
	G	Other works like External Utilities/ Canopy etc	96
		SUB TOTAL- LANDSIDE	**366**
PACKAGE 5		**TERMINAL 3 (Transfer areas- I to I , and baggage handling equipment)**	**167**
	I	**TOTAL VALUE OF MAIN PACKAGES**	**7,726**

SUMMARY OF ESTIMATED COSTS FOR PHASE 3A EXPANSION WORKS SUBMITTED BY DIAL			
MDP PACKAGE	**Sr.NO**	**DESCRIPTION**	**ESTIMATED COST IN CRORES**
	II	**OTHERS**	
	a	Preliminary works including demolition, relocation, enabling, diversions etc	150
	b	Design Development & supervision	309
	c	Permits, Survey , Insurance	30
	d	Operational capex	30
	e	Contingencies	386
	II	**SUB TOTAL-OTHERS**	905
		TOTAL(I + II)- excluding financing and interest costs	**8,632**
	Notes	These costs are based on preliminary estimates of works, services and other facilties / support costs	

	III	**Phase 3A WORKS EXECUTED THROUGH OTHERS (JOINT VENTURES / CONCESSIONAIRES)**	
	a	Information Technology and Associated Systems	140
	b	Ground Power and Pre-conditioned Air Units	137
	c	Multi level car park (underground)	374
		Total (III)	651
	Notes	These costs are based on preliminary estimates of works, services and other facilties / support costs	

Quotations

INR PRICE BREAK UP SHEET

Dated - 28/11/2017

IGI- Terminal 1

S.No	CHILLER CONFIGURATION	WATER COOLED CENTRIFUGAL CHILLER	WATER COOLED CENTRIFUGAL CHILLER	WATER COOLED CENTRIFUGAL CHILLER	WATER COOLED CENTRIFUGAL CHILLER
	Capacity	1000 TR	1000 TR	1090 TR	1090 TR
	Plant	**China**	**US**	**China**	**US**
	Model Number	YK CHILLER	YK CHILLER	YK CHILLER	YK CHILLER
1	CIF Nhava Sheva Price in USD	$200,000	$270,000.0	$225,000	$298,000
3	Exchange Rate 1 USD = Rs.65/-	INR 13,000,000	$17,550,000.0	INR 14,625,000	INR 19,370,000
4	basic Custom Duty @ 7.5%	INR 975,000	$1,316,250.0	INR 1,096,875	INR 1,452,750
5	cess @3% on above	INR 29,250	$39,487.5	INR 32,906	INR 43,583
6	Total Price on above(In Lacs.)	INR 14,004,250.0	$18,905,737.5	INR 15,754,781.3	INR 20,866,332.5
7	GST @ 28% on above	INR 3,921,190.0	$5,293,606.5	INR 4,411,338.8	INR 5,842,573.1
8	Port Clearance, local transportation, loading,unloading, marine cum Erection Insurance, commissioning, Supply of refrigerant and adaptor box	INR 1,400,000.0	INR 1,500,000.0	INR 1,400,000.0	INR 1,500,000.0
9	GST @18% on above	INR 252,000.0	INR 270,000.0	INR 252,000.0	INR 270,000.0
10	**Total Price on above(In Lacs.)**	**INR 195.8**	**INR 259.7**	**INR 218.2**	**INR 284.8**
11	**No. of Chillers**	**9**	**9**	**9**	**9**
12	**Grand Total (In Lacs.)**	**INR 1,762.0**	**INR 2,337.2**	**INR 1,963.6**	**INR 2,563.1**

Note:

a) 1 US$ = INR 65. Any change in the same will affect the landed price of chiller.

b) INR price includes all taxes at present rate

c) Any Changes in Statutory taxes/duties or imposition of new levies will be to your account

d) Port Clearance,Local transportation, Transit Insurance, Erection Insurance & Commissioning shown in break up above

e) Warranty of Chillers will be 12 months from date of commissioning or 18 months from the date of dispatch whichever ends earlier.

GST No. : 08ABFFM6647P1ZH PAN : ABFFM6647P

MODI INFRA SOLUTION

MODI GROUPS

QUOTATION

Date:	10/01/2018			
Party	C.P.Arora Engg.cont.pvt.ltd. Village: Soldha Bahadurgarh	ORDER TO BE RAISED ON :	**Modi Infra Solution** 9,Leela Mansion, Rajbhawan Road, Civil Lines, Jaipur-302006 GSTIN :-08ABFFM6647P1ZH	**A/C No:** 2312079941 Bank: Kotak Mahindra Bank IFCS: KKBK0000271

KIND ATTN: Mr. S.B.Tripathi

Dear Sir,
As per earlier discussed with you here is our quote for supplying aggregates to your site.

PRODUCT	3 STAGE	2 STAGE
10 MM/ 20 MM/ DUST	1400 RS. + 5% GST	1150 RS. + 5% GST

TERMS & CONDITIONS:

1. Validity of offer: 10 Days from the date of this quotation.
2. Above Rate Including Royalty Fee
3. Payment Terms:- on advance payment only.

Thank you for giving us the opportunity to bid for your business .We look forward for your valuable order.

Sincerely Yours,

Signing Authority
M/s Modi Infra Solution

Muskaan Engitech Pvt.Ltd.
AN ISO 9001 : 2008 COMPANY
ENGINEERING CONTRACTORS

Reference No. mepl/17/aecom/400322 **Dt.24/08/2017**

Sub: **Expression of Interest**

For the Execution of Aecom Airport Parking, Delhi, (Excavation).

To,

The Project Incharge
M/s AECOM
9th floor, Infinity Tower 5c
DLF Cyber City, DLF Phase II, Gurugram (INDIA)

Site:-
Excavation Work
Airport Parking
New Delhi, INDIA

Kind Attend:- Mr. Suresh Kumar

Dear Sir,

With references to your above site Project, we would like to express our interest for the same as we are in this field from past few years & willing to forward our best rates for the persuasion at your end.

Hope you will consider the same & assist us to start the further process at our end at the earliest.

Awaiting for the positive response.

Enclosed: -

1. **Annexure-A**

Thank you,

For Muskaan Engitech Pvt. Ltd.

(Director signatory)

MUSKAAN ENGITECH PVT LTD

Muskaan Engitech Pvt. Ltd.

Respected Sir,

Annexure -A

The Following excavation work item wise rate for you kind persual.

DETAILED B.O.Q FOR Excavation of tranch in all kinds of soil, Soft Rock and Hard Rock			
PROJECT	Delhi Airport Parking		
LOCATION	AECOM, Delhi Airport Parking		
S. No.	Item Description	Unit	Amount
A	EXCAVATION, BACKFILLING & TRANSPORTATION		
1	**Earth work**		
1.1	Excavation for rock **(where Control blasting is required)** including trimming of excavation bottom, disposal & stacking of excavated materials all complete as per specifications and drawings and instructions of Engineer.	cum	2,033.90
2	**Carriage of Disposal**		
	Extra over item No. 1 above carriage of all types of excavated materials beyond the initial lead of 0.5 km. included in item no. 1 above upto anywhere within site area as per instructions of engineer.		
2.1	per cum per km	Cum/per km	15.00
		Total Amount	

Terms and Condition:

Technical conditions

1. If the work is held up due to any hindrance or any other way, an idle charge for the machinery + Staff will also have to be paid by AECOM
2. AECOM has to consider for an extra item if any, the rates for the same shall be settled through negotiation.
3. Measurements + survey of the area will have to be taken jointly.
4. Diesel will be provided The AECOM at site for the this project. The diesel will be deduct as per RA bill.
5. The dewatering in scope of AECOM if required.

Muskaan Engitech Pvt. Ltd.

Others.

1 GST extra **@ 18%**

2 Mobilization charges @ 15% of the total amount of the work order shall have to be paid by AECOM on arrival of machineries and materials at site.

3 If there is any adhoc increase in Diesel and Material rates from the current rates shall have to be paid by AECOM separately.

4 Monthly payments during the month's work shall have to be paid by AECOM

For Muskaan Engitech Pvt. Ltd.

(Director signatory)

DIAL CALCULATION

Earth work /cum = 2033.90/-

Disposal /cum to Govt Approved dumping yard @30KM = 450/- (=15×30)

SUB TOTAL = 2483.90/-

Add for Escalation during construction as well as working in operating Environment 397.42/-

Total = 2881.32/-

Internally evaluation rate is Rs 2837.38/- has been considered

ANNEXURE-4

GEOTECH INVESTIGATION REPORT

ASL NO. 363

PROJECT:
EXPANSION OF AIRPORT TERMINAL – 1, DELHI

2016-2017

Prepared By -

T-2398

ISO/IEC: 17025-2005 accredited lab

ASL Estd. 1990

www.arunsoillab.com

ARUN SOIL LAB PVT. LTD.

Geotech & Material Consultants for Civil Engineering Projects
E-11, First Floor, Lekhraj Market-I, Indira Nagar, Lucknow- 226016
Phone: 2341943; Telefax: 4001043; Mobile: 9415025566, 9415501637, 38
arunsoillab.asl@gmail.com; info@arunsoillab.com

"QUALITY CONSCIOUSNESS IS OUR CORE CONCEPT"

ACKNOWLEDGEMENT

WE ARE GRATEFUL TO AECOM INDIA PRIVATE LIMITED FOR PROVIDING US THE OPPORTUNITY TO CARRY OUT THESE INVESTIGATIONS.

THE CO-OPERATION EXTENDED BY THEIR ENGINEERS DURING FIELD INVESTIGATIONS IS THANKFULLY ACKNOWLEDGED.

INDEX

SUB-SOIL INVESTIGATION REPORT FOR PROPOSED EXPANSION OF AIRPORT TERMINAL – 1, DELHI

INTRODUCTION

The work of sub-soil exploration was awarded to us by AECOM India Private Limited vide their Order No. …….. dated …….. The object of the investigation was to study the geo-technical properties of soil both in field and laboratory and determine safe allowable pressure for the foundation soil.

The fieldwork consisted of fourteen bore holes of 10.00 metre depth each and seven bore holes of 15.00 metre depth each. The fieldwork was conducted from 08/11/2016 to 30/11/2016. The location of the bore holes is shown in the Site Plan.

REFERENCES

1. **IS: 1892-1974** for field work including existent ground water table.
2. **IS: 2132-1986** for sampling in Undisturbed and Disturbed form.
3. **IS: 2131-1981** for Standard Penetration Test.
4. **IS: 2720** for all laboratory tests on soil samples collected.
5. **IS: 6403-1981** for determination of Bearing Capacity.
6. **IS: 8009(Part I)-1976** for calculation of settlement of foundations.
7. **IS: 1904-1986** for permissible maximum settlement, differential settlement and angular distortion.

INTERPRETATION OF THE LAB TEST RESULTS

GENERAL NATURE OF SOIL STRATA

The results of lab tests and bore hole log charts of bore holes 1A, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 13, 14, 15, 16, 17, 18, 19, 20, 21 and 22 indicate that the strata at the site is found to comprise of both cohesive as well as non-cohesive soil except filled up soil being present from top up to 0.50 metre depth below ground level at the borehole location 1A and borehole 20.

The cohesive type soil comprises of either silty clay soil of low plasticity and compressibility or clayey gravel or clayey silt soil of low plasticity and compressibility belonging to 'CL', 'GC' and 'CL-ML', 'ML' group of IS classification and having 62 to 92 percent material finer than 75 micron.

However, the non-cohesive type soil is found to comprise of either sandy silt 'ML' type soil or silty sand 'SM' type soil having 28 to 83 percent fines.

The results of classification tests indicate that the natural soil stratum present at the Site is found to comprise of both fine-grained soils (clayey soil) and coarse-grained soils (sandy soil).

S.P.T. VALUES

The S.P.T. values obtained in the respective clayey layer region present as per bore-log charts enclosed are found to range from 5 to 54 indicating 'Medium' to 'Hard' consistency.

However, the S.P.T. values obtained in the respective sandy layer region present as per bore-log charts enclosed are found to range from 7 to 85 indicating 'Loose' to 'Very Dense' relative density.

The results of S.P.T. values indicate that the stratum at the Site is 'Loose' to 'Very Well' compacted.

WATER TABLE

Water Table at the Site was not observed up to 15.00 metre depth explored below ground level on the day of soil investigation during the second to fifth week of November 2016. However, the existing water table may rise by some amount in the post-monsoon period. Therefore, a water table at a depth of (Df+B) metre below ground level and beyond has been adopted for calculation purposes.

BEARING CAPACITY CALCULATIONS

The Safe Bearing Capacity of the proposed STRUCTURE without any distress is determined from the considerations of the following criteria.

[A] SHEAR CRITERIA

The soil beneath the foundation shall be safe from risk of shear failure.

[B] SETTLEMENT CRITERIA

The foundation should not settle or deflect to an extent causing damage to the Structure or impair its usefulness.

The Bearing Capacity Calculations for the Foundation shall be governed as per IS: 6403-1981, IS: 8009(Part-I)-1976 and IS: 1904-1986 on the basis of available information regarding the proposed design.

BEARING CAPACITY ON SHEAR CONSIDERATIONS

ULTIMATE NET BEARING CAPACITY

As per IS: 6403-1981, the Ultimate Net Bearing Capacity 'qd' on shear consideration for a Structure is given by the formula: -

FOR GENERAL SHEAR FAILURE

qd = c.Nc.Sc.dc.ic+q(Nq-1).sq.dq.iq + 1/2 B.r.Nr.Sr.dr.ir.W'.

FOR LOCAL SHEAR FAILURE

q'd = 2/3 c.N'c.Sc.dc.ic+q(N'q-1).Sq.dq.iq + 1/2 B.r.N'r.Sr.dr.ir.W'.

FOR ISOLATED RCC RECTANGULAR COLUMN FOOTING [ON BOREHOLE 1A]

Isolated RCC Rectangular Column Footing with the size of the base of the footing as 3.00 metre x 2.00 metre at a foundation depth of 1.80 metre below ground level.

BEARING CAPACITY ON SHEAR CONSIDERATIONS

Governing shear parameters are from Bore Hole No. 1A

Failure Mode - General Shear

Foundation Type - ISOLATED RECTANGULAR

SIZE : 3.00m x 2.00m

Depth of Foundation : 1.80m

Existing Ground level : 0.00m

Ground Water Table level: -15.00m

Void Ratio: 0.598

Bulk density (W)of soil above Foundation base : 17.16kN/m^3.

Geotech & Material Consultants for Civil Engineering Projects
E-11, First Floor, Lekhraj Market-I, Indira Nagar, Lucknow- 226016
Phone: 2341943; Telefax: 4001043; Mobile: 9415025566, 9415501637, 38
arunsoillab.asl@gmail.com; info@arunsoillab.com

Bulk density (W)of soil below Foundation base : 18.83kN/m^3.

Cohesion C : 14.71kN/m^2

Factor of Safety : 3.00

Shape factor	Depth Factor	Inclination Factor
Sc = 1.133	Dc = 1.267	Ic = 1.000
Sq = 1.133	Dq = 1.133	Iq = 1.000
Sg = 0.733	Dg = 1.133	Ig = 1.000

Water Table Correction Factor W' = 1.000

Effective surcharge at base level q = 30.89kN/m^2.

****For General Shear Failure****

Ultimate Net B.C. = Qult_n = C*Nc*Sc*Dc*Ic + q*(Nq-1)*Sq*Dq*Iq + 0.5*B*W*Ng*Sg*Dg*Ig*W'

Angle of Internal Friction(phai) : 22.00

Bearing Capacity Factors

Nc = 16.89

Nq = 7.83

Ng = 7.13

Thus Qult_n = 739.26kN/m^2.

Net Safe Bearing Capacity (Qns) = 246.42kN/m^2.

Failure mode - Local shear

Foundation type - ISOLATED RECTANGULAR

SIZE : 3.00m x 2.00m

Depth of foundation : 1.80m

Existing ground level : 0.00m

Ground water table level: -15.00m

Void ratio: 0.598

Bulk density (W) of soil above Foundation base : 17.16kN/m^3.

Bulk density (W)of soil below Foundation base : 18.83kN/m^3.

Cohesion C' : 9.81kN/m^2

Factor of safety : 3.00

Shape factor	Depth factor	Inclination factor
Sc = 1.133	Dc = 1.235	Ic = 1.000
Sq = 1.133	Dq = 1.117	Iq = 1.000

Sg = 0.733 Dg = 1.117 Ig = 1.000

Water table correction factor W' = 1.000

Effective surcharge at base level q = 30.89kN/m^2.

****For local shear Failure****

Ultimate Net B.C. = Qult_n = C'*N'c*Sc*Dc*Ic + q*(N'q-1)*Sq*Dq*Iq + 0.5*B*W*N'g*Sg*Dg*Ig*W'

Effective angle of internal friction(phai') : 15.07

Bearing capacity factors

N'c = 11.03

N'q = 3.97

N'g = 2.68

Thus Qult_n = 308.92kN/m^2.

Net Safe bearing capacity (Qns) = 102.97kN/m^2.

Failure Mode - Intermediate Between General & Local Shear

Under Local Shear Failure Mode Net Ultimate Bearing Capacity= 308.92kN/m^2.

Under General Shear Failure Mode Net Ultimate Bearing Capacity= 739.26kN/m^2.

Void Ratio: 0.598

Thus Ultimate net Bearing Capacity (Qult_n) = 635.98kN/m^2.

Net Safe Bearing Capacity (Qns) = 211.99kN/m^2.

BEARING CAPACITY ON SETTLEMENT CONSIDERATIONS

Governing settlement parameters are from Bore Hole No. 1A

Foundation shape:RECTANGLE

Foundation size:

Length = 3.000 mBreadth = 2.000 mDepth of foundation = 1.800 m

Existing ground level = 0.000m

Ground water table level = -15.000m

Applied pressure at foundation base = 211.990kN/m^2

****Parameters for layer no. 1****

Stress increment method - 2:1 Slope Theory

Layer thickness = 1.800m

Saturated bulk density = 17.163kN/m^3

****Parameters for layer no. 2****

Consolidation settlement with Cc

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E-11, First Floor, Lekhraj Market-I, Indira Nagar, Lucknow- 226016
Phone: 2341943; Telefax: 4001043; Mobile: 9415025566, 9415501637, 38
arunsoillab.asl@gmail.com; info@arunsoillab.com

Stress increment method - 2:1 Slope Theory

Layer thickness = 0.700m

Saturated bulk density = 18.830kN/m^3

Compression index = 0.10700

Initial void ratio = 0.598

****Parameters for layer no. 3****

Consolidation settlement with Cc

Stress increment method - 2:1 Slope Theory

Layer thickness = 1.500m

Saturated bulk density = 18.928kN/m^3

Compression index = 0.10000

Initial void ratio = 0.600

****Parameters for layer no. 4****

Consolidation settlement with Cc

Stress increment method - 2:1 Slope Theory

Layer thickness = 0.800m

Saturated bulk density = 18.830kN/m^3

Compression index = 0.11300

Initial void ratio = 0.581

****End of input parameters ****

****Increment of stresses for all layers****

Increment in stress at middle of layer 1= 0.000kN/m^2

Increment in stress(2V:1H Slope) at centre of layer 2= 161.567kN/m^2

Increment in stress(2V:1H Slope) at centre of layer 3= 82.849kN/m^2

Increment in stress(2V:1H Slope) at centre of layer 4= 49.377kN/m^2

****Effective stresses for all layers****

Effective Stress at centre of layer 1= 15.447kN/m^2

Effective Stress at centre of layer 2= 37.484kN/m^2

Effective Stress at centre of layer 3= 58.270kN/m^2

Effective Stress at centre of layer 4= 79.998kN/m^2

****Layer 2 settlement****

Normally consolidated as per configuration

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Consolidation settlement of this layer 2 = H*Cc*Log{(P+DelP)/P}/(1+Eo)= 33.987mm.

****Layer 3 settlement****

Normally consolidated as per configuration

Consolidation settlement of this layer 3 = H*Cc*Log{(P+DelP)/P}/(1+Eo)= 36.013mm.

****Layer 4 settlement****

Normally consolidated as per configuration

Consolidation settlement of this layer 4 = H*Cc*Log{(P+DelP)/P}/(1+Eo)= 11.937mm.

Total settlement of all layers below foundation base = 81.9mm.

Depth Correction factor= 1.000

Rigidity correction factor= 0.800

Total settlement of all layers below foundation base with depth correction factor= 81.9mm.

Total settlement of all layers below foundation base with rigidity factor= 65.5mm.

FINAL TRIAL

Foundation shape:RECTANGLE

Foundation size:

Length = 3.000 mBreadth = 2.000 mDepth of foundation = 1.800 m

Existing ground level = 0.000m

Ground water table level = -15.000m

Applied pressure at foundation base = 184.000kN/m^2

****Parameters for layer no. 1****

Stress increment method - 2:1 Slope Theory

Layer thickness = 1.800m

Saturated bulk density = 17.163kN/m^3

****Parameters for layer no. 2****

Consolidation settlement with Cc

Stress increment method - 2:1 Slope Theory

Layer thickness = 0.700m

Saturated bulk density = 18.830kN/m^3

Compression index = 0.10700

Initial void ratio = 0.598

****Parameters for layer no. 3****

Consolidation settlement with Cc

Stress increment method - 2:1 Slope Theory

Layer thickness = 1.500m

Saturated bulk density = 18.928kN/m^3

Compression index = 0.10000

Initial void ratio = 0.600

****Parameters for layer no. 4****

Consolidation settlement with Cc

Stress increment method - 2:1 Slope Theory

Layer thickness = 0.800m

Saturated bulk density = 18.830kN/m^3

Compression index = 0.11300

Initial void ratio = 0.581

****End of input parameters ****

****Increment of stresses for all layers****

Increment in stress at middle of layer 1= 0.000kN/m^2

Increment in stress(2V:1H Slope) at centre of layer 2= 140.235kN/m^2

Increment in stress(2V:1H Slope) at centre of layer 3= 71.910kN/m^2

Increment in stress(2V:1H Slope) at centre of layer 4= 42.857kN/m^2

****Effective stresses for all layers****

Effective Stress at centre of layer 1= 15.447kN/m^2

Effective Stress at centre of layer 2= 37.484kN/m^2

Effective Stress at centre of layer 3= 58.270kN/m^2

Effective Stress at centre of layer 4= 79.998kN/m^2

****Layer 2 settlement****

Normally consolidated as per configuration

Consolidation settlement of this layer 2 = H*Cc*Log{(P+DelP)/P}/(1+Eo)= 31.680mm.

****Layer 3 settlement****

Normally consolidated as per configuration

Consolidation settlement of this layer 3 = H*Cc*Log{(P+DelP)/P}/(1+Eo)= 32.728mm.

****Layer 4 settlement****

Normally consolidated as per configuration

Consolidation settlement of this layer 4 = H*Cc*Log{(P+DelP)/P}/(1+Eo)= 10.653mm.

Total settlement of all layers below foundation base = 75.1mm.

Depth Correction factor= 1.000

Rigidity correction factor= 0.800

Total settlement of all layers below foundation base with depth correction factor= 75.1mm.

Total settlement of all layers below foundation base with rigidity factor= 60.0mm.

BEARING CAPACITY CALCULATIONS TABLE

Sl. No.	Description	On BH 1
1.	Depth of foundation below ground level (m)	1.80
2.	Length of footing (m)	3.00
3.	Width of footing (m)	2.00
4.	Water Table below ground level assumed (m)	-15.00
5.	Cohesion (Kg/sqcm.)	0.15
6.	Angle of Internal Friction (Ø)	22
7.	Density above foundation level (gms/cc)	1.75
8.	Density below foundation level (gms/cc)	1.92
9.	Overburden (tonne/sqm.)	3.15
10.	Void Ratio (e_0)	0.598
11.	Net Safe Bearing Capacity (tonne/sqm.)	21.62
12.	Settlement produced (mm)	65.50
13.	Safe Allowable Pressure (tonne/sqm.)	**18.76**
14.	Settlement produced for safe allowable pressure as in Sl. No. 13 and within safe permissible limit as per IS: 1904-1986 (mm)	**60.00**

HARMFUL SALTS

Soil samples obtained from 0.00-0.50 metre, 1.50-1.85 metre and 1.85-2.30 metre depth below ground level from all the 20 bore holes were tested for the presence of harmful salts like Carbonates, Bicarbonates, Chlorides and Sulphates. The results given in Table below indicate that the harmful salts are present above safe permissible limits.

TABLE

BOREHOLE NO	DEPTH IN METRES	CARBONATES %	BICARBONATES %	CHLORIDES %	SULPHATES %	P^H VALUE
	0.00-0.50	0.021	0.201	0.033	0.010	7.0
01	1.50-1.85	NIL	0.168	0.040	NIL	7.5
	1.85-2.30	0.021	0.134	0.033	NIL	7.0
	0.00-0.50	NIL	0.134	0.026	0.050	7.0
02	1.50-1.85	0.021	0.101	0.020	0.010	7.0
	1.85-2.30	NIL	0.101	0.013	NIL	7.5
	0.00-0.50	0.021	0.168	0.040	NIL	7.0
03	1.50-1.85	NIL	0.201	0.046	NIL	6.5
	1.85-2.30	NIL	0.134	0.040	NIL	7.0
	0.00-0.50	NIL	0.0672	0.026	0.010	6.5
04	1.50-1.85	NIL	0.201	0.033	NIL	7.0
	1.85-2.30	0.021	0.168	0.026	NIL	7.5
	0.00-0.50	0.021	0.201	0.013	NIL	7.0
05	1.50-1.85	NIL	0.201	0.013	NIL	7.5
	1.85-2.30	NIL	0.168	0.020	0.050	7.5
	0.00-0.50	NIL	0.134	0.026	NIL	7.0
06	1.50-1.85	0.021	0.101	0.020	NIL	6.5
	1.85-2.30	0.021	0.134	0.013	NIL	7.0
	0.00-0.50	0.021	0.134	0.026	NIL	7.0
07	1.00-1.35	NIL	0.101	0.020	NIL	7.5
	1.35-1.80	NIL	0.134	0.033	NIL	7.5
	0.00-0.50	NIL	0.134	0.020	0.010	7.0
08	1.00-1.35	NIL	0.168	0.013	NIL	7.5
	1.35-1.80	0.021	0.101	0.013	NIL	7.0

BOREHOLE NO	DEPTH IN METRES	CARBONATES %	BICARBONATES %	CHLORIDES %	SULPHATES %	P^H VALUE
	0.00-0.50	NIL	0.201	0.026	0.050	6.5
09	1.00-1.35	0.021	0.201	0.033	NIL	7.0
	1.35-1.80	NIL	0.168	0.040	0.010	7.0
	0.00-0.50	0.021	0.134	0.020	NIL	7.5
10	1.00-1.35	0.021	0.101	0.020	NIL	7.5
	1.35-1.80	NIL	0.101	0.026	0.010	7.0
	0.00-0.50	0.021	0.201	0.013	NIL	6.5
13	1.00-1.35	NIL	0.168	0.020	NIL	7.0
	1.35-1.80	0.021	0.134	0.013	NIL	6.5
	0.00-0.50	NIL	0.134	0.033	NIL	7.5
14	1.00-1.35	NIL	0.101	0.026	0.010	7.0
	1.35-1.80	0.021	0.168	0.020	NIL	7.0
	0.00-0.50	NIL	0.168	0.046	0.010	7.5
15	1.00-1.35	NIL	0.201	0.040	NIL	7.0
	1.35-1.80	NIL	0.168	0.033	NIL	7.0
	0.00-0.50	0.021	0.134	0.040	0.050	7.0
16	1.00-1.35	NIL	0.101	0.033	NIL	7.5
	1.35-1.80	NIL	0.168	0.040	NIL	7.0
	0.00-0.50	0.021	0.134	0.026	NIL	7.0
17	1.00-1.35	0.021	0.168	0.020	NIL	7.0
	1.35-1.80	NIL	0.168	0.026	0.050	7.5
	0.00-0.50	NIL	0.201	0.040	NIL	7.0
18	1.00-1.35	0.021	0.168	0.033	NIL	7.0
	1.35-1.80	NIL	0.134	0.020	NIL	7.0
	0.00-0.50	NIL	0.134	0.026	0.010	6.5
19	1.00-1.35	NIL	0.101	0.020	NIL	7.0
	1.35-1.80	NIL	0.134	0.026	NIL	6.5
	0.00-0.50	0.021	0.168	0.033	NIL	7.0
20	1.00-1.35	NIL	0.101	0.026	NIL	7.0
	1.35-1.80	NIL	0.134	0.020	NIL	7.0

BOREHOLE NO	DEPTH IN METRES	CARBONATES %	BICARBONATES %	CHLORIDES %	SULPHATES %	P^H VALUE
	0.00-0.50	NIL	0.201	0.020	NIL	7.0
21	1.00-1.35	0.021	0.168	0.020	0.010	7.0
	1.35-1.80	NIL	0.134	0.026	NIL	7.5
	0.00-0.50	0.021	0.101	0.033	NIL	7.0
22	1.00-1.35	0.021	0.134	0.026	NIL	7.0
	1.35-1.80	NIL	0.101	0.020	NIL	7.0

RECOMMENDATIONS:

Results indicate that the Harmful Salts are present above Safe Permissible Limit value of 0.250 %. Therefore, necessary remedial measures need be taken to check the rise of salts through the foundation up to the Super-Structure as per laid down Specifications and requirements at the Site.

RECOMMENDATIONS FOR PROPOSED EXPANSION OF AIRPORT TERMINAL – 1, DELHI

SAFE ALLOWABLE PRESSURE

FOR ISOLATED RCC RECTANGULAR COLUMN FOOTING [ON BOREHOLE 1A]

A Safe Allowable Pressure of 184.00 kN/sqm that is 18.76 tonne per square metre is recommended to be adopted for Isolated RCC Rectangular Column Footing with the size of the base of the footing as 3.00 metre x 2.00 metre at a foundation depth of 1.80 metre below ground level. Therefore, a total load of 112.56 tonnes shall be borne by each such Column.

NOTE: -

The above recommendations are based on the field investigation data results and the laboratory tests results of the samples collected from the test locations and our experience in this regards. If the actual sub-soil conditions during excavation for the foundations differ from that has been reported, a reference should be made to us for suggestions.

Further, the recommendations are based on the assumptions as mentioned in the Report and the designer of the Structure should take into consideration all the factors required as per codes. The recommendations should be taken as guidelines for the designer.

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A structural Assessment report has been submitted by M/s AECOM for Terminal 1 building at IGI airport, New Delhi. The assessment report is based on the investigations conducted by M/s Cortex to analyse the present concrete strength based on concrete core tests and various non-destructive tests.
The findings and conclusions from the reports are enumerated below:

- The grade of concrete in different type of structural members like beam, column and slabs vary, with f_{ck} in the range of 11MPa to 15.The same variation has been reported within individual type of member also. For structural assessment of the strength of structure it is recommended to consider an average f_{ck} for concrete be taken as 13MPa.
- Due to non-availability of structural reinforcement drawings, the structural strength of members cannot be ascertained.
- The site survey and findings are for the areas which were approachable and visible.
- Based on the outcome of the report, M/s AECOM undertook a structural analysis of the existing T1C building to assess its structural integrity in the event of earthquake forces of Zone IV intensity and the analysis concluded that the present building structure does not confirm to ductility provision for earthquake as per IS 13920. Thus major retrofitting in the form of carbon fibre wrap or jacketing is envisaged.

Recommendations

- The existing T1C building structure at IGI Airport, New Delhi is structurally deficient and the structure does not meet the current provisions of relevant Indian Design Standards for buildings with regard to concrete strength and earthquake resistance.
- In order to make it compliant to current design standards, the building should be strengthened. The strengthening measures provided by M/s AECOM are found to be in order.
- According to The Guideline of the National Disaster Management Authority on Seismic Retrofitting of Deficient Building and Structures, June 2014, if the cost of strengthening of the structure exceeds 70% of the reconstruction cost (demolition and rebuild) the building should be demolished and rebuilt and on the basis of the report issued by M/s AECOM the cost of retrofitting is more than 100% of the cost for demolishing and rebuilding, thus it is recommended to demolish the existing structure and rebuild.

B.Bhattacharjee

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Structural Assessment Report on Existing T1C Terminal Building

CONTENTS

1. INTRODUCTION

1.1 BACKGROUND

Terminal 1 of IGI Airport handles the Low Cost Carrier (LCC) domestic traffic of the airport. Terminal 1 comprises of T1C as arrival hall and T1D as departure hall, and other ancillary components, e.g Main Service Block (MSB), Sub Service Block (SSB). T1C was constructed at beginning of the 1970s and followed with a series of extension works from 1974 to 2008.

AECOM has been appointed to as consultant to carry out concept and preliminary design for the new extension of the Terminal 1. The extensions consist of expansion to the existing T1C building or provision of new arrival hall and new pier to easy the access of the arriving passengers.

DIAL requested AECOM to carry out an structural assessment of the T1C building if it is suitable to extend its design life another 50 years and to resist the earthquake load in according with requirements of India Seismic Code 1893 (2002) Zone IV.

1.2 OBJECTIVE OF THIS REPORT

This report outlines the findings on the review of the existing conditions of T1C arrival hall including site visit and structural check with computer model. The available existing information on the T1C arrival hall is recorded in this Working Paper. It covers primarily:

- Extension in 1974
- Extension in 1980
- Extension in 2008
- Soil Investigation report

The original structural drawings of T1C are not available.

2. EXISTING DRAWINGS & DOCUMENTATIONS

2.1 DRWINGS AND INFORMAITON FROM DIAL

- Extension in 1974
- Extension in 1980
- Extension in 2008
- Soil Investigation report

The original structural drawings of T1C are not available.

3. EIXSITNG STRUCUTRAL CONDITIONS

3.1 GENERAL

Site visits within and around the terminal building T1C and T1D of the IGI Airport were conducted in the mornings of 5 and 6 October 2016 respectively.

The objective of the visit was to enable the Project Team to have a better appreciation and understanding of the airport layouts, existing facilities and conditions, airport operations and the passengers' experience when using the terminal.

As-built drawings were received on 13 October 2016 but they are only structural as-built drawings for the extension works and the original structural as-built drawings are not available.

A review of the existing airport as-built documentation was carried out in the afternoon of 14 October 2016.

Following sections summarize the key observations and findings on the structural aspects of the works, made during the two visits and review of the existing structural information.

3.2 SITE VISITS

The two visits, led by members from DIAL, comprised a general walk through of the arrival and departure halls, the holding gates, public areas and common facilities within the airport only. These are fairly similar to what the passengers will experience when arriving and departing the terminal.

Some of the team members had also visited the major plant and equipment rooms to look at the existing services and MEP provisions.

The Project Team was given to understand that the main terminal T1C building was completed approximately 45 years ago. There were some extension works of the building structure undertaken subsequently, as part of the airport overall upgrading programme.

It was observed during the visits that the majority of the building structure is concealed by floor finishes and some areas are covered with ceilings. Columns are concealed with claddings. It was therefore not possible to identify the structural size of the T1C building was originally constructed with.

The flat slab with slab stiffeners and columns form the moment frame to resist the lateral load. As informed by DIAL that this building was renovated only one and half years ago, there is no sign of deterioration can be observed from at ground level. However, there are two obvious pop-up of the roof slab at the column locations. It is suspect that there is excessive deformation of the slab or due to other causes.

Main Service Block and Sub Service Block have been also visited. These two structures are observed a beam-slab floor system is typically adopted at these areas supported on columns in conventional reinforced concrete construction. No visible sign of structural deterioration was observed at these areas.

During the visits, it was also observed that there are potentially separation joints before the original T1C building and its expansion. The extent and exact routing of the joints could not be established through visual inspection some areas are not reachable on the day of site visit.

Some relevant photographs taken during the site walk were incorporated under **Appendix A.** Due to security reason, no photo is allowed to be taken on the roof.

3.3 REVIEW OF EXISTING DOCUMENTATION

The review on the existing geotechnical documentation is summarized as below:

- A set of soil investigation report including sinking 100 boreholes with in-situ testing results was provided, some of them are with lab test.
- It was noted that the report was submit in August 2006 and field work was carried out during a period of May to July 2006.
- The soil investigation works were carried out as part of the airport overall masterplan study. It was noted that the boreholes were distributed across the masterplan study area.
- There were 4 boreholes located relatively nearer to the T1 terminal building. However, for a better appreciation of the subsurface condition directly below the proposed site, the existing borehole information is considered insufficient.
- There are some existing footing layout plans and details which suggest that the terminal buildings appear to be supported on pad footings.
- In view of the above and to provide the Contractors with more accurate geotechnical information below the site during the tender process, we recommend the carrying out of additional soil investigation around the terminal building. We envisage a total of 10 boreholes shall be sufficient for this purpose. The locations of the boreholes should tie in with the proposed concept of the transformation works and existing site conditions.

The review on the existing as-built structural documentation is summarized as below:

- The review of existing as-built structural information was carried out in AECOM office.
- Based on the documentation provided by DIAL, there is no information of as-built structural information of the existing airport terminal T1C except the extensions works.
- There are basically no original general arrangement plans and reinforcement details, which are critical and essential if one is undertaking any structural modification to the base building.
- What is available are some very scattered information of T1C extension works

containing details of beam reinforcement, column schedules, steel roof structure, footings, staircases, walls and expansion joints. Some are stamped with ‘For Construction’ while others are just labeled as ‘Detailed Design’. It cannot be ascertained whether these are true as-built or otherwise.

4. GENERIC STRUCTURAL CHECK ACCORDING TO SEISMIC ZONE IV

4.1 ASSUMPATIONS FOR STRUCTURAL CHECK

As the original as-built drawing of T1C building are not available, only a few references can be made to the drawings for afterwards extension works. Below assumptions are made to enable the structural check:

- ✈ It is assumed that column sizes in the extension drawings are correct.
- ✈ There is no information of foundations and ground slab and roof slab. Considering the loading on structural span, a 300mm thick RC slab is assumed for both ground and roof slabs.
- ✈ Concrete grade is assumed to be M25 for all structural elements.

4.2 COMPUTER MODEL ANALYSIS AND RESULTS

The existing T1C structure was modelled by using software Etabs 2015 in accordance with the India Standard Codes for seismic design for Zone IV and loading combinations.

Approximate and quick checks were carried out according to IS 15988 (2013), clause 6.5. The strength and stiffness of the existing structure were compute and compare.

- ✈ Shear Stress in Reinforced Concrete Frame Columns

This equation assumes that all of the columns in the frame have similar stiffness. The term $\left(\frac{n_c}{n_c - n_f}\right)$ is based on the assumption that shear force caused by columns at the end of RC frame are typically half of those carried by interior columns. If a concrete column has a capacity in shear that is less than the shear associated with the flexural capacity of the column, brittle column shear failure may occur and result in collapse. The columns in these buildings often have ties at standard spacing equal to the depth of the column, whereas the current code requires the maximum spacing for shear reinforcing as d/2.

The average shear stress in concrete columns, τ_{col}, computed in accordance with the following equation shall be lesser of 0.4 MPa and 0.1√fck

$$\tau_{col} = \left(\frac{n_c}{n_c - n_f}\right)\left(\frac{V_j}{A_c}\right)$$

Case 1 Lower Part	Case 2 Upper Part
τ_{col} = [5380x10^3/(42-9)]/(0.25π x 610^2) τ_{col} = 0.558 N/mm^2 > 0.4 > 0.1√fck = 0.5 (Inadequate, exceeded by 40%)	τ_{col} = [3800x10^3/(36-9)]/(0.25π x 610^2) τ_{col} = 0.482 N/mm^2 > 0.4 > 0.1√fck = 0.5 (Inadequate, exceeded by 20%)

✈ Axial Stress In Moment Frames

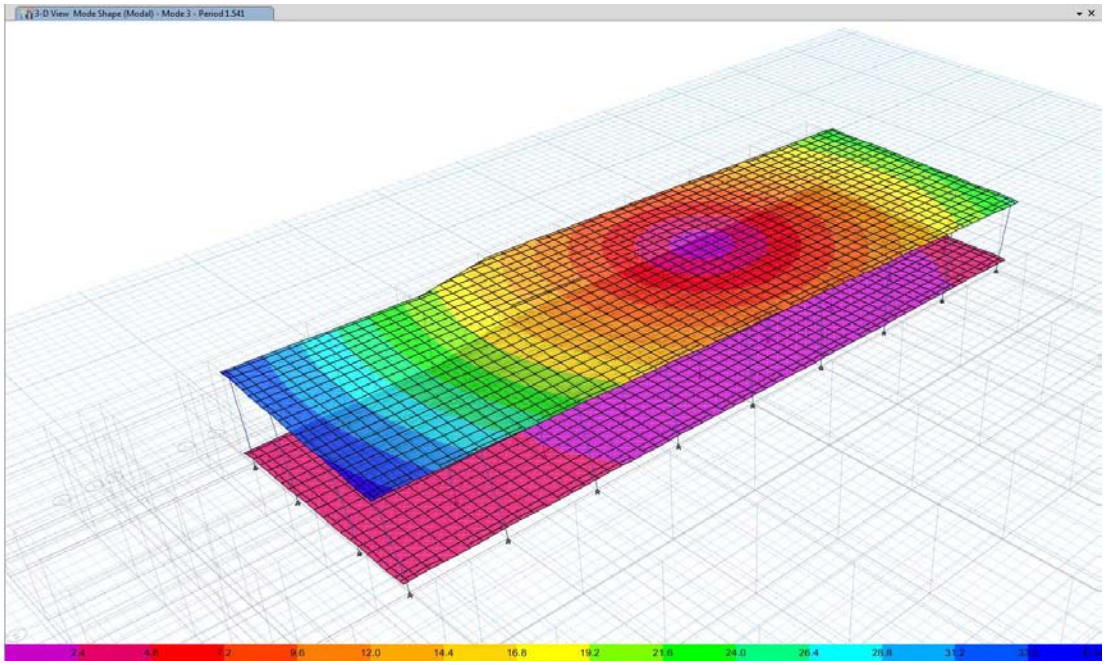
Response to earthquake ground motion results in a tendency for structures and individual vertical elements of structures to overturn about their bases. Although actual overturning failure is very rare, overturning effects can result in significant axial stresses. Columns that carry a substantial amount of gravity load may have limited additional capacity to resist seismic forces. When axial forces due to seismic overturning moments are added, the columns may buckle in a non-ductile manner due to excessive axial compression. The factor 2/3 in the equation is based on the assumption that floor forces due to earthquake are distributed in the inverted triangular pattern over the building height.

The overturning forces alone (F_o) as calculated using the following equation shall be less than 0.25fck.

$$F_0 = \frac{2}{3}\left(\frac{V_B}{n_f}\right)\left(\frac{H}{L}\right)$$

Case 1 Lower Part	Case 2 Upper Part
F_o = 2/3 (5380x10^3/9) (7300/76500) = 38 kN Compression stress =38x10^3/A_{col} = 0.13 MPa. < 0.25fck = 6.25 (Adequate)	F_o = 2/3 (3800x10^3/9) (7300/76500) = 27 kN Compression stress =27x10^3/A_{col} = 0.10 MPa. < 0.25fck = 6.25 (Adequate)

Case 2: Mode 3 (Rotation, T = 1.541s)



Letter from Bureau of Civil Aviation Security

File No: CAS-5(4)/2008/DIV.I/T-III Vetting (E-88185)

भारतसरकार / GOVERNMENT OF INDIA

नागरविमाननमंत्रालय / MINISTRY OF CIVIL AVIATION

नागरविमाननसुरक्षाब्यूरो / BUREAU OF CIVIL AVIATION SECURITY

'अ' खंड, I-III तल, जनपथभवन, जनपथ / 'A' WING I-III FLOOR, JANPATH BHAWAN, JANPATH

नईदिल्ली-110001 / NEW DELHI - 110001

Dated: 10/02/2017

To

The Regional Director,
BCAS Delhi Region,
New Delhi.

Subject:- **Security vetting of development of Eastern Cross Taxiway (ECT) at IGI Airport, New Delhi - reg.**

Sir,

Kindly refer to DIAL letter no. DIAL/CEO-Office/2013-14/2617 dated 19/07/2013 regarding above cited subject.

2. On the basis of the recommendation of the standing Committee for inspection held on 30/05/2014, and the decision taken on 20/07/2016, and in terms of Rule 5 (3), read with Rule 9 of the Aircraft (Security) Rule 2011, I am directed to convey the 'In Principle Approval' by the Appropriate Authority to the design, subject to conditions recommended by standing committee and implementation of extant rules and regulations issued by BCAS from time to time, and the observations of Central Security Agency as follows :-

"All the entities operating from the buildings in the vicinity of the area, should submit their security programmes/ plans as per BCAS security requirements, as the same may pose a threat as the taxiway would be clearly visible from certain floors and rooftops of the buildings located nearby. Apart from strict access control to these buildings, complete sealing of the rooftops and floors overlooking the taxiway should be ensured and only authorized person should have access to the roof tops. Moreover, there is no control over any unauthorized movement in the forest area near the Sky Chef Flight Kitchen and MRSS. Hence, proper sanitization/access control also needs to be considered. Besides the above, a security Naka and rumble stripes/speed-breakers before approaching the underpass are also suggested."

13/2/17

3. You are, therefore, requested to conduct final survey on completions of facility with checklist as per OM dated 29.01.2014 for final Security clearance.

This has the approval of DG, BCAS.

Yours faithfully

(Mathai P.U.)
Dy. Director (Policy)
Tele. No. 011-23731721

Cc:-i) Director (Security), AAI, Rajiv Gandhi Bhawan, New Delhi.
ii) Executive Director, DIAL, IGI Airport, New Delhi.