# Analyzing the structural cost, performance, and flexibility in the terminal design of Mumbai Airport

تحليل التكلفة الهيكلية والأداء والمرونة في التصميم النهائي لمطار مومباي.

**by**

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# ABSTRACT

The recent growth in the aviation industry has led to the highest necessity for the dev___ designing the airports. Statistics are available for a few airports, but there is no comprehensive base of information on how airport terminal buildings operate or the conditions their user experience.

The major aim of this research is to design a framework for analyzing the performance, cost and flexibility in terminal design of airports; to do so the main studies has been done exploring factors affecting the management and functionality of airport terminals considering the different parameters and the effectiveness of the terminal and the key challenges in designing functional aspects of an efficient airport terminal.

The contribution of this research work will help approach to develop an efficient framework to overcome the problems occurring in airport terminals. The research paradigm will be positivism, carried out scientifically in order to analyze the performance and flexibility of the airport terminal.

SPSS software has been used for the descriptive and regression data analysis for interpretation; the analysis presents an elaborate picture of the findings; other statistic tools are also used. The conclusions are based on the analysis of data presented, suggestions are made for, and that can be analyzed, in coherence with the research objectives further if any. Hence, posit certain areas of research that can be further extended and broadened by other researchers in near future.

# ملخص موجز

وقد أدى النمو الأخير في صناعة الطيران إلى أعلى الضرورة لتطوير تصميم المطارات. تتوفر الإحصاءات لعدد قليل من المطارات ، ولكن لا توجد قاعدة شاملة للمعلومات حول كيفية عمل مباني صالات المطارات أو ظروف تجربة المستخدم.

الهدف الرئيسي من هذا البحث هو تصميم إطار عمل لتحليل الأداء والتكلفة والمرونة في تصميم المطارات النهائي. للقيام بذلك تم إجراء الدراسات الرئيسية لاستكشاف العوامل التي تؤثر على إدارة ووظائف محطات المطار مع مراعاة مختلف المعايير وفعالية المحطة والتحديات الرئيسية في تصميم الجوانب الوظيفية لمحطة مطار فعالة.

ستساعد مساهمة هذا العمل البحثي في تطوير إطار عمل فعال للتغلب على المشكلات التي تحدث في مطاريف المطارات. سيكون نموذج البحث ايجابيًا ، ويتم تنفيذه علميًا لتحليل أداء ومرونة مبنى المطار.

تم استخدام برنامج SPSS لتحليل البيانات الوصفية والإنحدار للتأويل ؛ يقدم التحليل صورة مفصلة للنتائج ؛ تستخدم أيضا أدوات الإحصائية الأخرى. تستند الاستنتاجات إلى تحليل البيانات المقدمة ، والمقترحات المقدمة ، والتي يمكن تحليلها ، بالاتساق مع أهداف البحث أكثر إن وجدت. ومن هنا ، افترض بعض مجالات البحث التي يمكن توسيعها وتوسيعها من قبل باحثين آخرين في المستقبل القريب.

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# DEDICATION

I dedicate this dissertation to my family, friends, especially first to my father Syed Shafiuddin second my cousin Syed Saleh Imaduddin and third my uncle Late Syed Ahmed Mohiuddin, Grandfather Late Syed Fasiuddin (Bashu Miyan) & Grandmother Late Syeda Meherunissa Begum; who never stopped supporting, encouraging & whose life history inspired me to finish my studies abroad and this research. I also dedicated to myself for being able to complete the dissertation. Last but not the least I dedicate this to my sunshine Afrah Arsheen Shaikh.

# Contents

# CHAPTER 1
# INTRODUCTION

## 1.1 Research Background

The airline sector has witnessed major changes from the date of commencement of many commercial air travels. Airports are complex location consisted of interrelating structures of people, luggage, freight and airplane flows. The impacts of deregulation, the introduction of low cost carters and the effects of international economic, ecological and dogmatic impacts have all contributed to determining the landscape of contemporary air-travel. The growth in passenger travel has contributed to an expansion in the proportions of the terminal buildings necessitated to deal with the yearly passenger loads. The true size of these services depends on the forecasts of the number of travelers travelling nevertheless the given airfield every year. The measure of suggested construction size is established partly in the Level of Service (LOS) measured metrics (Harrison, 2015).

Passed on the predictable passenger intensification for the near future, the sector has acknowledged that existing methods to terminate plans are not sustainable. The size of terminal buildings could not endure to grow constantly. In number of metropolitan areas, the need of accessing land for terminal extension is an off-putting factor. Besides the ever-increasing cost pressures in the industry, there are some other causes of transformation in the airline industry, which have the potential to considerably have an effect on the structure of terminal buildings in the near future. One of the challenges is the convergence of industry principles, facilitating technologies and a public which is set to welcome these new technologies and services.

Airports are the significant place for regional, national and international transportation system. Important airport operations offers permission to air transport both for travelers and freight services. Fast growth of aviation in the last two decades has set off a major expansion in the quantity of airports. Airports could be inspected in two regions: airside and landside. The land side region comprises main-terminal buildings, freight terminals and as well vehicle parking. In this region, the major user is the passenger and every activity is carried out to address the demands of the travelers. The airside area includes every facilities and constructions relating to the aircraft (Akyüz, et al 2017).

Over the last few years, India has been changed as one of the most active and energetic nations across the world. As India's trade and inventive capital Mumbai have been at the advanced and progressive of this change. The new terminal at CSIA proves all these things are true and the new terminal building of CSIA is beyond one's imagination and vision. CSIA is acknowledged as one of most challenging and busiest airports in the country and the world as well. Regardless of the challenges, it is one of the most important airfields in South Asia and operates around 18.6% of India traffic as a whole. CSIA was recognized as the 30th busiest airport across the world during 2010with regards to cargo with 671,238 tons operated. At the end of 2011, Airports Council International ranked this airport in the 3$^{rd}$ best in the world with the 25 to 40 million traveler category (GVK, 2014).

CSIA, which was previously recognized as SAHAR International airport, has been given the esteemed 'Golden Peacock National Quality Award' during 2014. The aviation industry contributes to facilitate global business and tourism. It is of great assistance in connecting population across the continents. The CSIA ranks top with regards to the total number of passengers and size of cargo movement. It is certainly the second busiest airport followed by

Delhi in concern with the passenger flow and the first with regards to cargo movement. The airport has noticed a surge in traffic number as a result of the progression of a new top-notch integrated terminal building (T-2) which comprises around 439,000 sq. m. CSIA will extend a Sky City in next to no time in the environs of the airport for users and this will further multiply the size of traffic at the CSIA (NCAIR, 2014).

The newly launched Terminal 2 building at the CSIA has been built by Indian based conglomerate GVK Power & Infrastructure Ltd. gives a remarkable, technologically complex and attractively spectacle offered ceiling in the interior of the terminal, with incorporated columns, with a striking retail passageway featuring ceiling petals and skylights, made by Formglas. The structure of ceiling materials integrates around 4000 coffers each one almost 100 square feet in size, and columns above 100 feet high. Form glass holded classy 3D and CAM technology to fabricate molds along with glass fiber reinforced gypsum (GFRG) objects was used to construct the modular ceiling and pillar components fixed on site (KBYTES, 2014).

The new terminal building at CSIA is the ideal representation of Mumbai's accomplishments, its determination, dream and its imagination. Inspiring structural design, careful planning, high-techno modern technology and outstanding service standards all are being a sign of the city's aspiration, imagination and potential and are essential to the new terminal. It exhibits the delight and promise of travel, the expectation of new breakthroughs and the happiness to be established in the travel itself. The sophisticated and international quality of the new terminal is an invocation of Mumbai, the city of innovations and imaginations. Professionals have built a place that attaches with passengers at a sensitive and emotional level whilst resourcefully and efficiently giving a seamless and pleasant journey (GVK, nod).

Airports are amongst the most important public construction types of the contemporary age. Gateways to countries and metropolitans, airports contribute to shaping the international view of their contiguous environment. Besides, they are major financial hubs and creators of wealth. As facilitators of industries and tourism, airfields are source to financial growth and to connecting people. The industry's sophistication in construction technology functions and responsibility to design quality has led to a portfolio that highlights various essential architectural activities of contemporary times (SOM, 2013).

This research will be studying and analyzing the cost, flexibility and factors which will affect the design of airport. To do so the study will set objectives and lay down research questions based on the objectives present.

In the literature review; all studies related to the airport will be done following that in the research methodology, plan will be made and further it will be followed thereafter on the set rules. Survey will be done to record correspondent answer based on which data analysis will be done relating to the objectives and research question. Last, results and conclusion will be discussed.

**1.2. Objectives**

i. To determine the various types of air services taking place at the airport which will affect the cost, flexibility and design of the airport infrastructure.

ii. To determine the facilities at the airport and whether they are interconnected with each other which will affect the cost, flexibility and design of the airport

iii. To determine whether the airport infrastructure and its facilities requires renovation and upgradation

iv. To ascertain the financial viability of the airport.

**1.3 Research Questions**

1. What are the various types of air services taking place at the airport?
2. Facilities of the airport infrastructure according to their present condition?
3. Airport infrastructures and its facilities according to the need of renovation and upgradation.
4. Co-relation between facilities of the airport and airport infrastructures and facilities according to the need of renovation and upgradation.
5. Is the airport financially viable?

**1.4 Significance of the Study**

The current study increases the hypothetical information regarding passengers and their experiences and satisfaction in an airport terminal construction. With a systematic approach, this study intended to dispense with the challenges in airport terminal design by investigating the

diverse troubles and challenges exist in designing terminal buildings. The proposed study method focused the addition of theoretical knowledge regarding terminal design, building and passenger experience and perceptions obtained from investigations with professionals. It is suggested that the determinations of this survey could be directly carried out towards the procession of a tool to help out airport architects, technologists and designers optimize the allowance of terminal marks from an insight of passenger experience. The current field will be an asset to scholars and experts in terms of understanding about flexibility in airport design.

## 1.5 Cauterization Plan

- Chapter 1 is the introduction chapter of the proposed work that provides the detailed structure about this research concept "structural cost, performance and flexibility in terminal design of airports" including the research background, aims and objectives of the subject area, research queries, and significance of the work..

- Chapter 2 is the review of literature chapter that explores several works related to the concept of designing a framework for studying the structural cost, performance and flexibility in terminal design of airports. In improver to these, this study examines in particular near the importance of flexibility in airport terminal buildings.

- Chapter 3 is the research methodology chapter that supplies an overview about research design, research strategy, sampling design, sampling design, and population of the study, data types, and data collection methods, design of questionnaire, data analysis and rendering techniques that employed in this research. In improver to these, this chapter discusses in particular about the limitations of the current work.

- Chapter 4 is the data analysis where it breaks down and discusses structural cost, performance and flexibility in terminal design of airports.

- Chapter 5 is a discussion and findings, where the work investigates with the help of statistical tools.

- Chapter 6 is the last chapter that draws about the summary of findings obtained through the discussion section and also provides a conclusion to the research topic "structural cost, performance and flexibility in terminal design of airports and various challenges faced by terminal building" followed by testimonials and recommendation based on the outcomes of the inquiry.

# Chapter 2

# Literature Review

## 2.1 Introduction

The literature normally deals with gathering data or source of information upon chosen topic by various authors and researchers through studies, journals, articles, bogs and so on. In this section the topics under discussion would brief about the factors influencing the design of airport terminal such as: Infrastructure and design - performance standards; planning and designing; challenges in planning and designing; space requirements; LCA (Low Cost Airport) terminals and facilities offered by airports in general; Mumbai International Airport; Performance framework for terminal design; Flexibility in airport terminal design and Research Gap.

## 2.2 Infrastructure and Design of Airport Terminal

The infrastructure basically describes the "organized physical structure" along with the facilities (for instance the roads, buildings, enterprises, etc) offered. The use of "infrastructure" was originally found in the late 1880s in English and French. However the word itself is a combination of two different words "Infra" from Latin meaning 'below' with "Structure", which eventually forms as basic structure (Prud'homme, 2004). This section of research would explore in-depth about the infrastructure and the designing phases along with other factors as mentioned above in airport terminals.

### 2.2.1 Performance standards

Basically the performance standards in constructions are the criteria that are to be followed under planning and designing phase. Thus the parameters in constructions and the designing and planning phase is normally stated as standards or measures; in aviation or in construction of airport terminals the performance standards would revolve around operational costs, flexibility, space requirements and other criteria that are to be strictly followed by the terminal plan. In general airport terminal planning and designing the parameters are strictly followed and adhered so that the project doesn't gets rejected; if the designing gets rejected due to improper standards and regulations, it has to be redesigned based upon the regulations.

The regulations should also adhere to the economic aspects like traffic: transportation congestion; demand; etc. Ashford (1988) had studied about the European view on service design concept's level for airport passenger-terminals. In his study he found that transport congestion has been rapidly increasing since the number of passenger cars in roadways and ships carrying goods and services via waterways; to reduce this congestion in the transportation airways initiated more terminals and passenger aircrafts which would eventually reduce the transportation issues, partially if not fully. The author also analyzed that highway planning and airport terminal designing in civil engineering should collide as one when constructing an airport terminal since it would deal with pedestrian space, aircraft launch space and other factors like transporting passengers from airport to aircraft, etc. Hence concentrating on standards like time (queuing, delivery, baggage, etc), cost (baggage, operational, etc), space (waiting area, transportation, parking facility, etc), etc would increase the performance and in-turn the performance standards would heightened, in individual airport terminals.

In another study Humphrey et al, (2002) studied about the performance management in the airport terminals and found out that the: the modern airport performance measures are rapidly evolving along with the demand and market requirement. The evolving performance measures would adhere to dynamic regulatory, environment aspects, technical innovation, growth, demand, ownership and other variable that influence the airport terminal frameworks. According o the authors, contingency airport terminals would be effective under any circumstances rather than innovative and traditional airports which would focus on creativity and load delivery, respectively.

Wirasinghe and Correia (2005) studied about the LOS (Level of Services) in passenger airport terminal and they found that the critical need in aviation is to analyze the LOS characteristics prior designing or planning a terminal; based on LOS the operational cost and space requirement as factors would either increase or decrease and this in-turn would affect the entire plan. As Vreedenburgh (1999) mentioned in his article that, in-order to run a smooth operation airports must follow certain regulations and standards; the necessity of regulations would: I) ensure operational efficiency as per State's standards, ii) impact the financial and safety performance, iii) eradicate conflicts between stake holders, IV) ensure documentation and agreements via written statements, certifications etc. Thus the regulations moderate the performance standards and in turn the efficacy.

Poh (2007) in his report stated that general performance standards could be classified as a) processing speed (check-in process, custom/ immigration clearance, baggage security and delivery, screening, etc); b) functionality standards (minimum connecting-time); c) availability (core Operating system such as: escalators, trolleys, monitors, etc). In his report he also stated that the airports vary from each other in offering services and quality however the norms and

regulations carried under each individual airport terminal should cross over the basic necessities and should facilitate the passengers demand. Thus the performance standards such as cost, time, space, facilities, etc along with regulatory acts have been carefully monitored and designed by civil engineers prior planning the construction of airport terminals internationally and globally.

**2.2.2 Planning and Designing**

The planning and designing of the airport terminal could also be mentioned simply as airport construction. Similar to other buildings the airport terminals also has basic necessities as top priorities such as: working area, waiting area, restrooms, cafeteria, pedestrian blocks etc.

According to ASM (2005), the planning and designing of airport terminal should focus on aspects like: ticketing, queuing, kiosks, hold room area, food and beverage and retail locations apart from cost and performance since it is the main scope of the passenger airport terminal planning. Basically the airport designing consists of several areas, such as aircraft area, pedestrian area, waiting area, working area, etc. However every area is designed and planned as per the norms and regulations according to the adhered regulations.

Wahab and Dulaimi (2011) studied about the impact and relationship of stakeholder management with airport construction. In their study the authors have analyzed the significance of the airport terminal construction through design and planning. According to the authors, the designing phase should be the most important factor in planning the airport terminal construction since it projects the diagrammatic representation (blue-print or layout) of the original building. Assumptions and anticipations towards the cost, transportation traffic, passenger facilities, service qualities and time delays could be planned once the design has been completed. In the planning and designing phase identifying the critical areas where necessary alterations could be made and back-up plans

could be drafted. Hence, the study argues that civil engineers while planning the construction should carefully measure the parameters and consider the factors that could affect the construction.

According to the CAAC (2014) report, an airport terminal construction plan and design should be approved and verified as per the technical standards and regulations and it also comply with the State laws. If the design and plan doesn't comply with the general standards it might be rejected, hence focusing on aviation parameters is necessary for the civil engineers while drafting the layout for airport terminals. The report also insists that safety regulations, licensing, fuel supplies, operations and other factors that impact the airport terminal setup should be considered while designing the plan, so that the project could be estimated with low-budget rather than high budget. The low-cost terminals could be constructed with better plans and management which could guide the civil engineers to invest in the facilities and innovations that could compete with other airports internationally and also globally. Thus the report mainly focused on factors that assist the designing and planning phase of the airport terminals and upon expansion of the existing airports rather than projecting plans and designs for hybrid airport terminals.

Fife and McNerney (n.d.) studied about planning, construction and design of airport by studying the factors that affects the construction itself. In his study the author identified that modern aviation insists on designing the airport terminals with innovation and trends rather than focusing on services and facilities like traditional airport terminals. The author also found that factors like: delay and capacity; new aircrafts; environmental concerns and technology have been impacting the planning and designing phase of the airports in the current era. However the author just attempted to analyze the factors that affect the designing and planning instead of providing clear solutions for the issues that exist in developing a plan or deign in airport terminal.

Harrison (2015) studied about the principles in designing the airport terminals and she found out that passenger feedback or passenger input is very essential in developing a plan or design for airport terminals. According to the author, when demand meets supply, performance and profit would increase and the passengers would be comfortable and satisfied. She analyzed the significance of planning and designing the airport terminals and argued in her study that, terminal designs projects no sustainability and hence researching about the land-space and environmental aspects prior planning and matching up with demands with designs could decrease the operational cost which offers low-budget or low-cost projects. According to her findings, large infrastructure based designs and plans would incur high cost but would fail to generate high revenue. As per her study, the key issue behind failure of generating revenue in large airport terminals in aviation industry would be due to high investment and hence designing as per demand or passengers capacity would be the efficient cost management.

In ACRP (2010) guidebook, the authors Brown et al has stated that the design and planning of airport terminal might seem like a crucial part of the construction however it is the most essential and necessary phase where the clear picture of what and how is projected, overall to make the LOS and security and safety measures into a efficient possibility via better foundations. As per the report, the design process should consider: project type, services types, approach, objectives and goal of the project, demand forecasts, conceptual planning, facilities programming, designing, value engineering, construction process and certification and final approval (Neufville, 1994). Though the term 'design' or 'plan' seems simpler it is quite complex in deciding upon the foundations by overcoming all the factors and planning should be carried on; planning process, on contrary should focus on factors like:

1) Master plan (forecasts of airport demand, airfield configuration, consideration of use of lands, etc);

2) Land use compatibility (regional, community and other land use);

3) Ground access of transportation plans (regional airport system, regional transportation, ground access system of airport, intermodal connections);

4) Planning the terminal site (considerations of: airfield, landside, utilities);

5) Airport security;

6) ITC (Information Technology and Communications);

7) Environmental protections (NEP Act; NEPA: Passenger terminal planning and Environmental considerations; apart from NEPA: Terminal planning and environmental regulatory considerations, Relationship of NEPA and environmental sustainability);

8) Sustainability (LEED certifications, designing and planning process sustainability, terminal designing and planning's major sustainability elements); and

9) Business planning (business considerations, concession planning and funding options).

Thus the planning and designing process focuses on many attributes and factors rather than the structure alone. In another study by Horonjeff (2010), the design and planning of airport terminals should consider proper geometrical measurements for constructions and adhere to the regulations. According to the authors, air-transportation has reduced congestion in roadways and waterways hence increasing the passenger airport terminals or expanding the existing terminals as per the demand would effectively impact the transportation and services. Hence the authors

insisted that planning and designing the structures as per the land use will either result in higher cost or would end-up in limited space which wouldn't meet up with the demand and hence the decrease in revenue or congestion in transportation.

**2.2.3 Challenges faced by airport terminals while designing and planning**

Choudhuri, Dixit and Tiwari (2015) emphasize and discuss the major topics and challenges confronted by the Indian air power. The Indian air travel industry is one among the top ten world aviation industry. Indian airline industry manages 121 million domestic and 41 million international passengers. Additionally, India en route with more than 85 International airlines and unites over 40 countries through 5 domestic Indian carriers. The domination of public sector vanished with the entry of private investment in the airline industry. However, the industry growth limited through lacking infrastructure, excise and duty structure, unions formed by public oil companies, poor guideline, management problems and lack of idea by the government. The major confronts encountered by the Indian Aviation Industry are huge burden of debt, high charges at airport, higher maintenance cost, policy paralysis, Less customer base, poor regulation, stumpy airport status, Rupee depreciation and so on. Similarly the airport passenger terminals observes the existence of many challenges like gates and check-in facilities, terminal design, baggage handling, long passenger walking, limited federal funds, narrow passage paths.

Shareef (2016) addresses the common issues and problems faced at the operations of airport passenger terminal. The passenger check-in issues incorporate the ease of use check-in counters and congestion over there result in self-check by the passengers. Lack of regularity, late arrival and space are the source of baggage handling confronts. The other constraints are issues with gate allocation, use of remote stands for aircraft parking, diverse size of aircrafts, last in first out

situation, and finally the security threats such as hijacking, criminal and terrorist attacks and bomb threats are the other issues that affect the air passengers. The brunt of these challenges impinges on the passenger flight operations by means of convenience, security and travel time. Many suggestions and recommendations have been addressed to provide a remedy for these confronts. To get an efficient solution, further research needs to be scrutinized with dire enhancement measures.

Alodhaibia et al (2017) elucidate the challenges met by the passengers within the airport terminal and the actions that take place amid boarding and curb side. The passenger flow and the related actions are raised with the simulation framework developed using Discrete Event Simulation (DES). The DES is put up with the help of Extends V9.2 simulator software which takes the input as flight schedule. This model evaluates the efficiency of operational process which incorporates immigration and custom boarding, security and check-ins. To recognize and investigate the passenger flow, the proposed model is used considering the departure of the flight. Thus the efficiency of the airport operation is predicted and assessed. It is made evident from the study that flight schedule influence the effect of passenger flow mainly. The proposed simulation model framework predicts the different flight schedule ahead of time and affords feedback to enhance the model before implementation.

Enciso, Vargas and Martinez (2016) analyze the passenger flow at national airport and present a pedestrian model to control the passenger traffic. Modeling and simulation are the research method used for the development of the project. The proposed method is generalized and developed in such way that it can open up the possibility of engaging this technique for pedestrian traffic with other buildings. It works efficiently on existing ventures and further proposes amendment for proficient storage and betterment of passenger flow. Further due to the

rise in demand increases the time for boarding and landing. It is noted that the satisfaction of the passenger with respect to operational and cost efficacy is hard to manage with the emergent demand. The implementation of the simulation model improves the performance of air flow passengers' path thus avoid congestion.

Wing, Cloutier and Felder (2015) focus on some of the restrictions related with the application of modeling loom to the vibrant system within the slope area of the metropolitan airport. Ramp is the energetic area which slows down the operations of aviation which further cause delay and cancellation of flights with the notice of operating condition and weather variation. A set of confronts with any variation are encountered while modeling the ramp. The model is designed and developed in such way that it should be easily accessible tool for planners and operators of the aviation industries. The ideology mainly focuses on the adaptability and use of ramp without the help system thinker. Thus Airlines would be able to administer healthier floor cost with the utilized optimization of crew and equipments which would beneficial for the complete aviation industry.

Roosens focus on confronts of congestion related delays at airport and pays attention to optimize the short run operational methods. The congestion delays can be enhanced by increasing the capacity of long run infrastructure and optimizing the short run to use the existing airport capacity. The runway capacity can be increased with minimizing the runway occupancy capacity (ROT) focusing the traffic. The adverse weather conditions can be evaluated and managed using landing system and micro bust detection equipments. Further the developed system of satellite navigation will allow airplanes to fly through more straight and resourceful routes. Milbredt et al (2017) proposed interior design concept through the new terminal for the passengers with the help of passenger centric airport management. The model implements the design ideas of

artificial terminal build up in an international airport. It uses the microscopic simulation to display the information which is easier for the travellers to make it out the direction.

Alnasseri, Osborne and Steel (2013) sheds light on confronts and intricacies in making and observing construction project in related to the airport area. To achieve the organizational success different strategies are involved which influence the project management and human related competencies. A theoretical framework for airport operational process is developed and implemented to cope with the building context and improves the financial operations by controlling & managing the construction projects.

Leva, Sordo and Mattei (2014) present a revolutionized initiative run from the small regional airport to manage the challenges in the current competitive environment of air travel. The initiative moves ahead to provide a taxonomic framework for managing performance with a particular focus on day-to-day operations. Finally a tool was directed to support the integrated SMS establishment within the regional airports and manages the changes for safer operations of airlines. Singh (2016) show the current scenario in Indian aviation sector with relation to the growth and customer satisfaction. The paper further discusses the comprehensive transformations that drastically change the face of aviation industry. It also probes the construction of Indian aviation industry and the entrepreneurial challenges. Eventually the new regulatory problems are detailed with liberalization and the steps necessitated by the entrepreneurs to overcome them.

## 2.2.4 Space requirements

The space requirement in airport terminal differs as per the airport terminal's land use along with the plan and design of the airport terminal structure. Space requirements could be of various areas as mentioned earlier, for instance the required space for waiting area should be designed as per the demand or the capacity of the passengers. Likewise the space requirements for areas such as airside, landside and ground access in airport vary too. Hsu and Chao, (2005) studied on spatial requirements and analyzed that deciding the space as per the capacity and land use is a priority before allocating the spaces for respective areas. For instance the assumption of allocating space relies upon the mathematical calculations (formulas) of square meters with required essential facilities nearby. Similarly for instance in their study they have stated that to calculate the departure area based space requirement and finding the passengers that will be utilizing the airport terminal and facilities we can consider the average walking distance of departing passengers along with the baggage claims and customs and security area. According to the authors the construction focuses on pricing, performance and productivity in public facilities however the LOS, space allocation and concession revenue in commercial activities have not been explored in depth, hence they attempted to explore the factors and revealed that space requirements in airport terminals is quite essential than other factors that impact the service quality and performance.

According to Pavlyuk (2012), the competition between the existing passenger airport terminals are based upon the spatial requirements since the passengers' expectations rely upon the facilities rather than the airlines or the operational activities. Hence concentrating on developing or

expanding terminals with large space has become a necessity in airport terminal designing. As per the author in the past three decades the growth of an airport terminal towards passenger demands and developing or expanding the existing space with more facilities have been witnessed at large. However the space allocation could be classified as rental and non-rental areas where the majority of 55% would be for non-rental and the rest 45% for rental area. The author also studied about the user impact on space requirement and stated that passenger terminal hugely gets impacted by LOS as per the demand of user, community and promoter (The SCI, 2009; Losekoot, 2015). Hence as per the study, by forecasting the users, community and promoters input, the space should be allocated. Thus each area is allocated as per the requirements and would vary from each airport terminal to another.

**2.2.5 Low cost airport terminals**

The low cost carrier terminals (LCCT) have been rapidly growing in the last two decades. Hanaoka et al., (2009) in their study have argued that passenger satisfaction will be attained only when their demands and needs are met. The study also analyzed about the LCCT and its impact upon the customers/ passengers. As per the findings, the LCCT has been impacting the aviation industry in the past years however the effect of LCCT is still unclear. The key concept of LCCT is low budgeted airport terminal that offers passengers with limited services and facilities. However the services rendered and pricing in LCCT significantly impacts the customers directly. The authors unveiled through their findings that, limited facilities in Kuala Lumpur airport such as: children play-area, shopping choices, pricing in retail-outlets, rest areas, terminal comfort, cleanliness, ambience, etc. have hugely impacted the passengers in negative aspect. However the key factors queuing time, baggage delivery, security and safety measures, ticketing time delay

have been stated as satisfactory. Hence it can be presumed that, LCCT offers limited facilities and tries to render better services at the same time.

However researchers like Humphreys et al (2006) and Mandic et al., (2017) studied about the low cost airlines and their impact on performance and found that LCC have increased in number and due to this criteria, the necessity of more LCT have been initiated hence designing an efficient and effective LCT airports globally was made as a priority in the aviation industry. The studies also portrayed that from early 2000s till 2015 the increase in LCT have been estimated as 32% and this have hugely impacted the air transportation. Thus the necessity of more LCT have positively impacted the aviation proving that LCC have rendered quality based LOS and satisfied the passengers (transit and tourists).

**2.3 Mumbai International Airport**

Initially the Mumbai International airport (Chhatrapati Shivaji Maharaj International Airport (IATA: BOM, ICAO: VABB) was known as Sahara International Airport. This is the second busiest terminal in India (after Delhi) and Asia's 14th busiest airport globally would be the Mumbai international airport (MIA). The travelers traffic has crossed 45 million in the last (2016-17) year. Initially the airport was constructed and opened in 1942 and recently the GVK Industries remodeled the Mumbai airport Terminal 2 and opened it for access in 2014 (Mishra, 2014). 8years of mega construction has led the builders to offer the innovative and interactive airport terminal for the passengers which offer many facilities and services that made the international airports to turn their heads towards Mumbai international airport at its first operations.

Mumbai airport has the 2nd largest ATC (Air Traffic Control) tower which stands at 279ft (85m) long after Delhi (101.9m). The Mumbai International Airport Limited (MIAL) operates the Mumbai airport which is originally a joint venture of GVK Industries and AAI (Airports Authority of India). The infrastructure of the MIA has been recognized globally for its structure and artifacts. The MIA has 2 passenger terminals and intersecting runways respectively. The terminal and runways has been recently upgraded and the traffic has been reduced and monitored regularly by the ATC tower.

However the overall cost was estimate around 1.5billion US$ (98billion INR) and the ATC was alone 2.80billion (Wikipedia, 2018). Thus the larger the scale of construction is, the huger the expenditure would be. The terminal 2 in MIA is designed as "X" shaped of 450sq meters and includes taxiways, aprons, etc. and monitors both domestic and international passenger aircrafts.

## 2.4 Performance Framework for Terminal Design

Focus upon the passengers, airport operators, airlines and other factors that assist in increasing the performance in airports discussed by various researchers would be focused here.

George (2013) in his study focused upon performance analysis on Cochin International Airport Ltd and found out that the performance of the airport terminal has increased due to few factors such as check-in facility, amenities, airport's accessibility and terminal facilities. Through his data analysis and findings the author has also established a firm belief that the passengers in airport terminals tend to pull towards the facilities and services rather than the airlines itself. For instance the study revealed that the travelers are quite satisfied and comfortable; the facilities being provided and services and hence only 1% were recommending for betterment. Through the analysis the author also stated that for better performance an airport terminal should primarily focus on amenities and facilities in the designing and planning phase rather than investing huge amount in interior decorations to attract people.

Lee et al., (2000) in their study has found that the revenue via air transportation has increased from 1990s when compared with 1980s. The key reason as per findings would be the determination of cost, reducing time delays, safety regulations and maximizing the facilities and services offered towards the passengers. The authors finally studied about the impact of factors that could assist the performance in airport terminals and concluded that meeting the passengers' demands, offering better services and facilities, airlines, airport operators, compensation and concession and timely delivery of services were the most witnessed factors. Hence when planning or designing the airport terminal structure, the civil engineers should focus on both internal and external factors and design the structure as per the need by satisfying the regulations and norms.

## 2.5 Flexibility in Airport Terminal Design

Current necessity in the airport terminal towards flexible design such as hybrid airport terminal joints along with increased facilities and services which have been recently gaining attraction and recognition would be discussed here.

According to Shuchi (2016), the new designs and the plans in airport terminal have been attracting passenger's attention in the past years via trendy facilities and quick or fast services. Traditional airport terminals were designed to allocate people and render operational services alone. Extension or expanding the traditional airport terminals would incur huge cost. Hence designing a new and innovative designs and plans for modern airport terminals seems like a comfortable and cost effective measure. In her study the author studied about the concept of flexible design which can be both modular design and low cost.

Neufville (2007) studied about the low-cost airlines and its flexible design towards risk management. As per his views and findings, the flexibility in deign effectively reduces the cost/ investment: operational cost and in-turn would offer financial support in future for betterment of airport terminals and also during uncertainties or calamities. The airport terminals constructed under flexibility-based designs would support in many ways: technical support, financial support, services and facilities, etc; hence while designing the terminals by properly and accurately measuring the areas (transportation, hold room, beverages and foods, baggage, pedestrians, parking, etc) as per norms and allocating for extension would also support the airport terminals in many ways for many years. For instance, with flexible design, dividing the passenger's waiting area with glass partition would effectively reduce the cost, time, space and delay in facilities or services rendered.

**2.6 Research Gap**

The existing journals and articles upon the airport terminal infrastructure along with designing and planning had been done by researchers and analyzers in the past years. However the existing link and relationship between the factors influencing the design of airport terminal has been studied by limited researchers and that too as an individual factor, such as, studies on performance, measures challenges in designing and planning, space requirements, etc. Hence to bridge the missing links between existing researches, the current research would focus and analyze all the factors such as financial viability, infrastructure renovation and upgradation, air services relationship with the airport infrastructure and how it will affect and its role in airport infrastructure flexibility, cost and its design that influence the airport designing and planning in depth, especially the Mumbai airport terminal's planning and designing.

However the challenges and issues that hidden within has been partially ignored by the researchers in order to focus upon specific factors. Mostly the factors like: space requirements and airport terminal planning and designing has been studied at large. Hence the current research would analyze the ignored factors mention above which will also unveil the significance of designing airports under proper and legal measures against the improper designing and planning which results in effective performance and how the infrastructure of airport terminals impact passengers.

Among all the discussed factors, the cost in developing airport terminals has been considered as a challenge in the developing countries; contrarily, the developed countries has overcome such challenges and developed airport terminals with better performance and facilities than the airports in under-developed or developing countries. The new hybrid designs (including both

modern and traditional) in the current era have been effective when compared to either traditional or modern airport terminals. The economic and social aspects have also been impacted by the airport terminal designs and planning measures; thus each individual factors such as financial viability, infrastructure renovation and upgradation, air services relationship with the airport infrastructure and how it will affect and its role in airport infrastructure flexibility, cost and its design have been analyzed and studied in this research. But all together the factors mention haven't been researched and analyzed, hence the chosen topic, especially the Mumbai international airport and its infrastructure, would solve the issue and bridge the existing research gap.

# Chapter-3

# Research Methodology

In this research various methods, assumptions methodologies which are added in set of pre-determined beliefs to analyze the various facts in order to collect and analyze the various data and facts which is relayed to the structural cost, performance, and flexibility in the terminal design of airports.

In the subsequent chapter various research methods were used. For effective conduction of the research study research design, research approach, sampling design, sampling plans, techniques were used so that evaluation of the result could be done effectively.

| | |
|---|---|
| Research Paradigm | • Positivism |
| Research methodology | • Qualitative |
| Research approach | • Deductive |
| Research Design | • Descriptive |
| Sampling design | • Simple random sampling |
| Sampling Plan | • **Sampling Unit**: 150 airport staffs and workers of different airport terminal<br>• **Target Population**: Employees of aircraft service sector<br>• **Sample Size: 150**. |
| Data Collection | • **Data**: Surveys (Closed ended Questionnairees) |
| Data Analysis | • Statistical analysis (Chi- Square and Simple Percentage, SPSS) |
| Validation | • Reliabilty and Validity. |
| Theamitic Analysis | • Thematic analysis of answered statement |
| Ethical Consideration | • Discretion, cover-up and anonymity of the respondents |

**Figure 3.1: Methodology adopted**

**3.1 Research Paradigm**

**3.1.1. Positivism and Interpretivism research paradigm**

Research paradigm is referred to as the set of beliefs and assumption of the researcher which is used by the researcher to take decisions regarding the conduct of the research process. The use of research paradigm helps in carrying out the research study by adopting a well-defined strategy which could channelize the various aspects of research approaches in a proper manner.

There are two types of research paradigms positivism and interpretivism.

The positivism paradigm involves the application of prevailing theory to develop hypotheses that are required to be tested at the time of conduction of the research process. Positivism paradigm is independent in nature is ideal for carrying out research studies that are quantitative in nature. The qualitative research paradigm of data collection is found to be objective and deductive in process. The process applied to collect data is through by conducting investigations, experiments, surveys, observations, testing, observation, and structured content analysis.

Interpretivism is referred to as the integration of human interests into the research study. It is the interpretation of reality which is based on the philosophical position of idealism and social constructions. It is based on the naturalistic approach of data collection which could be done by conducting interviews and observations and content analysis.

### 3.1.2. Selected research paradigm

In the current study, the researcher had used positivism research paradigm. The research will be carried out scientifically in order to analyze the cost, performance, and flexibility of the airport terminal.

The positivist approach is best suited for the current study as it is qualitative in nature so that by using this approach the research mainly focuses o infrastructure, construction and super structure, material used, runway capacity and all the numerical facts which are relayed to the structure engineering of the Mumbai International Airport. The use of positivism approach will help to explore the arithmetical and numerical aspects of the data in a refined manner. The ontology of the positivistic paradigm is real, external and independent in nature which is based upon the existence of a lone truth or reality.

The epistemological assumption of positivistic approach is based on the fact that reality could be measured and the emphasis is laid on a collection of data using reliable and valid tools like statistics and other numerical formulae. The methodological assumption is related to the use of experimental research and survey research methods which could be effectively used to collect the facts and figures related to the cost, performance, and flexibility of the airport terminal.
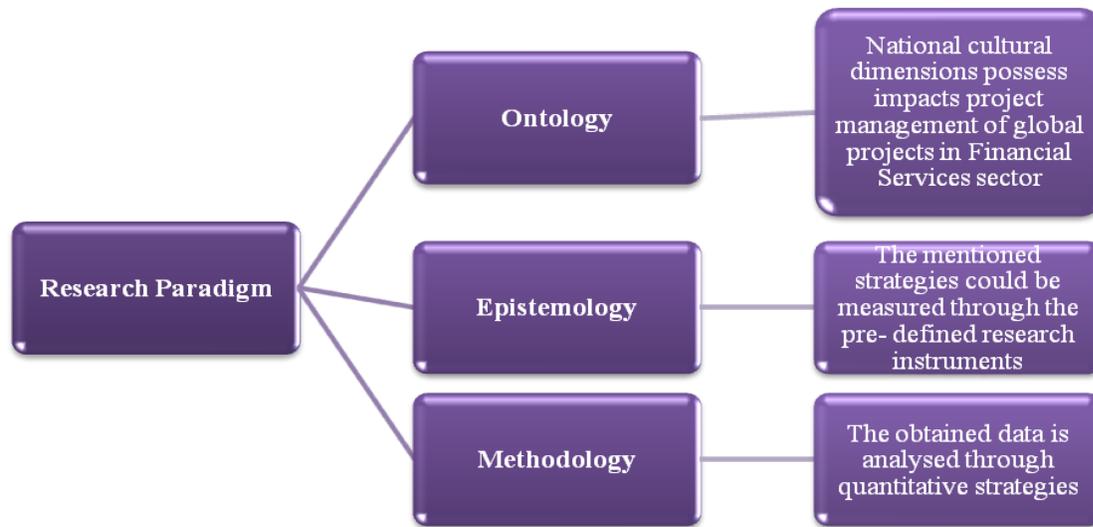
**3.2 Selected research paradigm**

## 3.2 RESEARCH APPROACH

### 3.2.1. Inductive and deductive research approach

The research approach is referred to as the style or technique that is used by the researcher to carry out the research study in a proper manner.

Research approaches can be broadly classified into two research approaches quantitative and qualitative. Deductive and inductive are two research approaches that widely used by researchers to carry out the research process in an effective manner.

Deductive method is used to test the authenticity of the assumptions or hypotheses used in the study. This method is used to estimate the propositions or examine the hypotheses that are based upon the prevailing theory. It is found to be quantitative in nature.

The inductive research approach is referred to as the creation of new theories and generalizations. This method is used to explore the differential themes and patterns that are present in the study and create a conceptual framework for an effective research study. It is found to be qualitative in nature.

### 3.2.2. Selected research approach

In the current research study related to the analyzing the structural cost, performance, and flexibility in the terminal design of airports the researcher had been using a qualitative research approach. This helped to identify the need and prospects of different airport terminal design in an effective manner. The deductive approach enabled the researcher to carry out the research in a qualitative way by carrying out arithmetical calculations and presenting the data in a numerical form.

This involves the determination of pre-defined theories that are used for the formulation of hypothesis and collecting evidence and proofs. It also enables to carry out the accurate examination of the proposed hypothesis in a proper manner such that the rejection or acceptance of the hypothesis could be done in a logical manner. It will enable the researcher to accept and reject the hypotheses and establish conclusions and outcomes from the study in a proper manner.

## 3.3 RESEARCH DESIGN

### 3.3.1. Descriptive, explanatory and exploratory research design

The research design is regarded as the blueprint of the research by which the researcher selects and chooses the various research tools and techniques to effectively collect the data and validate it to the findings in a controlled manner. The research design provides a detailed description of the collected data in such a way that it is easily traceable and readable by the reader. It assembles and allocates the different data in a rational manner so that the conduction of the research could be done in a well –defined way. It helps in the provision of outcome in the most accurate and précised manner. It acts as an outline or framework that is used for collecting, evaluating and analyzing the facts and figures. The researcher can use different kinds of research designs to carry out the research study. They are Exploratory Research design, Descriptive Research design, explanatory research design, and Evaluation Research design.

The qualitative research design is also used by the researchers to find out about the understanding and implication of the research studies that are complex in nature. It is evaluated on the basis of the knowledge of the people, their nature and case studies. It is present in the descriptive and exploratory form. It lays stress on recognition and gathering of facts and figures and lays less impact on predicting the concluding outcomes. The information is collected using this method by making illustrations, and related approaches.

A quantitative research design is used to analyze and establish a correlation between the various variables that could be presented in a numerical manner with the aid of statistics. It is further categorized into four research designs that are Descriptive design research, correlation design research, experimental design research, and quasi-experimental design research.

The descriptive research design is referred to the research process through which data is collected and presented in a more restrained way. In this research design, the researcher has no control over the variables. The descriptive design does not include any involvement of hypotheses and examines the established data in a restrained way.

### 3.3.2. Selected research design

In the current research study related to the analyzing the structural cost, performance, and flexibility in the terminal design of airport, this research has been done using descriptive research design. The usage of descriptive research helped in forming a detailed plan which is related to airport infrastructure of Mumbai that helped to analyze the background of the airport by including characteristics, challenges in the airport terminals. It also enabled to portray the different features related to the cost, performance, and flexibility in a confined manner. The practices that were conducted to carry the research examinations were depicted effectively by the use of descriptive research design. It is best suited for the current study process as it does not include the examination of the hypotheses and reaches to the conclusion by establishing relations with the predefined theoretical concepts.

By descriptive research designs it helps to frame the hypotheses which show the effective relationship between cost performance and flexibility in the design in terminal in airports. It also helped to explore the various factor that influencing the structure and design of the airport terminals.

## 3.4 DATA COLLECTION

### 3.4.1. Data collection

Data collection is referred to as the establishment of an organized framework by the use of which the researcher could collect data from a variety of sources in an effectual manner. By the application of proper data collection method all the relevant data could be collected in a precised form such that all the inquiries related to the research could be solved in the best manner. It aids in making effective evaluations of the results and endures capabilities which could lead to the achievement of future probabilities and patterns.

In this research it has been used different means to collect the data in a concise manner like surveys and interviews.

The survey is regarded as the most popular technique that is used for the collection of information from relevant sources. The use of personal interviews and close-ended survey which has a predestined answer set has provided the valid facts related to this study. Qualitative data collection of data is the data which indicates about the physical nature of the study like its quality, volume etc. It does not involve any numerical presentation of information.

### 3.4.2. Selected data collection method

In this research the data collected is accurate information related to the study from different sources in a proper manner. This research has prepared a questionnaire which is close-ended and qualitative in nature. The questionnaires were distributed among participants so that their responses could be recorded properly. The questionnaire was distributed among 150 respondents (airport staffs and workers) of the different airport terminal to collect the evidence. Close-ended questionnaires were used which will enable the participants to express their views precisely in a single attempt.

**3.5 SAMPLE AND POPULATION**

**3.5.1. Sampling methods**

Sampling is a method in which a single unit is determined from the given population randomly. In other words, this is used in statistical analysis in which a pre-determined number of observations are taken from a larger population. Three types of sampling designs have been identified which are used by researchers to carry out the research study in an effective manner which is samplings designs are simple random sampling, stratified sampling, and cluster sampling.

The sampling technique is further categorized into two parts. They are probability designs and non-probability designs consequently. In the probable sampling method, each and every individual that has been selected from the population is regarded to be in the form of non – zero form. It can be further classified into three sampling sub-heads that are random sampling, systematic sampling, and stratified sampling. The examination of error could be done adequately with the help of probability sampling method.

**3.5.2. Selected sampling method**

In the current study related to the analyzing the cost, performance, and flexibility in the terminal design of airport, in the research it has been used simple random sampling method. The simple random method is one of the probability sampling techniques that are used to collect data. It is regarded as the procedure which is utilized for choosing the respondents from the naturally occurring group of people where each and every respondent gets an equal opportunity to get selected for the study process.

### 3.5.3. Sampling unit and population

The survey will be conducted with among 150 respondents (airport staffs and workers) to collect the evidence.

**Gender**

From the table we conclude that out of 150 respondent, 79.3% are male and 20.7% are female. It is also represent in pie chart.

**Gender**

|  |  | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Male | 119 | 79.3 | 79.3 | 79.3 |
|  | Female | 31 | 20.7 | 20.7 | 100.0 |

Table 1:- represent the frequency table for Gender.

**Education Qualification**

From the table we conclude that out of 150 respondents, 17.3% have diploma, 72.0% have bachelors, 10.7% have master degree as education qualification. It is also represent in pie chart.

|  |  | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Diploma | 26 | 17.3 | 17.3 | 17.3 |
|  | Bachelors | 108 | 72.0 | 72.0 | 89.3 |
|  | Masters | 16 | 10.7 | 10.7 | 100.0 |

Table 2:- represent the frequency table for education qualification.

**Designation**

From the table we conclude that out of 150 respondents, 62.7% are Avionics technicians, 19.3% are flight dispatcher. It is also represent in pie chart.

**Designation**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Pilot | 21 | 14.0 | 14.0 | 14.0 |
| | Avionics Technicians | 94 | 62.7 | 62.7 | 76.7 |
| | Flight Dispatcher | 29 | 19.3 | 19.3 | 96.0 |
| | Airline Station Manager | 2 | 1.3 | 1.3 | 97.3 |
| | Operation Manager | 4 | 2.7 | 2.7 | 100.0 |
| | Total | 150 | 100.0 | 100.0 | |

Table 3:- represent the frequency table for designation

**3.6 DATA ANALYSIS**

Statistical analysis is very much essential for the test of hypothesis too in an empirical deductive research approach. In order to carry out the research process in an adequate manner, the examination of the various facts is necessary to be done. For this, the data analysis procedure is carried which will allow the qualitative analysis of the collected data in a uniform manner.

To conduct the qualitative analysis of data this research uses various kinds of tools and techniques. It is found that different kinds of evaluation process and procedures are followed to carry out the assessment and information analysis procedures.

For carrying out qualitative researches, this research effectively used the process of interviews and focus different designated respondents as mention in the last section of previous chapter. It is conducted by involving the analysis of the common patterns of the responses that are given by the respondents. It helps in examining all the facts that are stated in accordance with aims and objectives set for the research study process.

**3.6.1. Statistical tools used /chosen parameters**

In the current study airport infrastructure, its construction, background of airport and its design characteristics, various present challenges of an effective airport terminal are measured with the help of statistical tools. The statistical tools play an important role. It enabled this research to evaluate and investigate the various facts in an adequate manner.

Statistical tools are regarded as those tools that are used for collecting, examining and showcasing a large volume of data in a correct and consistent manner. The utilization of statistical tools helped to identify the different patterns and trends that exist in the collected data.

There are different kinds of tools that are utilized to examine the facts and information to acquire more relevant details regarding the present study. This study engrosses the following statistical tools.

i.   Simple percentage analysis:

Percentages can be used to compare similar terms in the data collected.

Percentage =      No of responses        X 100

           A total number of responses

ii.   Chi-square

In this research utilizes a chi-square test for the analysis of assumed data in the proposal.

iii.   SPSS:

SPSS stands for Statistical Package for Social Science. SPSS Software was designed in this study in minding that the quantifiable data has to be analyzed in a quantifiable manner

iv Pearson correlation

        Measures a linear dependence between two variables

v  Spearman correlation

        Measures correlation between two variables is equal to the Pearson correlation between the rank values of those two variables

The parameters in this research are as follows:

1. Various types of air services taking place at the airport

   (Commercial aircrafts, private aircrafts, Cargo, Military operation and others)

2. Facilities of the airport according to their present condition. (Airport terminal, Parking, Periphery roads, Airport lighting, Aircraft hangers, Airport people movers, Airport apron, Airport movement safety area, security area, Airport surveillance, Runways, Air-traffic control and aircrafts ground handling, landing area and departure area)

3. Airport infrastructures and facilities according to the need of renovation and upgradation.

4. Airport financially viable

**Thematic analysis of statements**

Thematic analysis is a widely-accepted qualitative data analysis method. It is applied within different frameworks, to answer different types of the research question. It answers queries related to people's experiences, or people's views and perceptions.

| Themes | Sub-Themes |
|---|---|
| Average per day passenger and aero plane traffic | • Per day passenger traffic at the airport<br>• Per day aero plane traffic at the airport |
| Number of functional runways and terminals | • No. of functional runways<br>• No. of terminals |
| Operations and facilities of the airport | • Requirement of maximum budget allocation<br>• Factors affecting smooth and efficient operation of the airport<br>• Structural changes done to facilitate better functioning |
| Comparison of airports | • Comparison to other international airports within the country<br>• Comparison to other international airports of other developed countries |
| Suggestions for improvement | • Suggestions for improvement of structural design and performance |

Table: 4 Major themes and sub-themes

## 3.7 ETHICAL CONSIDERATIONS

The ethical considerations are the valid consents and permissions that are taken by the researcher to carry out the research process in an adequate manner. For the researcher takes valid consent from the participating respondents in a written format. Prior to this researcher had informed all the respondents about the aims and objective of the current research study so that they could participate in the research process in an appropriate way. Additionally, the researcher also took all the valid consents and permission from the governing bodies. The researcher has taken valid permission from the aircraft authorities so that no constraint or issues occur while carrying out the research study process (Bauer, 2014). It is also assured to the respondents that they will not be physical, emotionally or mentally harmed during the conduction of the research. The researcher has also committed to the respondents that their responses will be kept confidential and will be used only for the research study process.

# Chapter 4
# Data Analysis Report

## 4.1 Descriptive Statistics

1. **What are the various types of air services taking place at the airport? Please choose as many as applicable.**

   Following are the frequency of various types of air services taking place at the airport.

|  |  | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Commercial | 10 | 6.7 | 6.7 | 6.7 |
|  | Charted Commercial | 16 | 10.7 | 10.7 | 17.3 |
|  | Scheduled Commercial | 16 | 10.7 | 10.7 | 28.0 |
|  | Fueling | 9 | 6.0 | 6.0 | 34.0 |
|  | Stay of private aircrafts within the airports | 9 | 6.0 | 6.0 | 40.0 |
|  | Cargo Freighting | 11 | 7.3 | 7.3 | 47.3 |
|  | Commute of privates aircrafts | 5 | 3.3 | 3.3 | 50.7 |
|  | Fire fighting | 8 | 5.3 | 5.3 | 56.0 |
|  | Search and Rescue | 7 | 4.7 | 4.7 | 60.7 |
|  | Reconnaissance | 7 | 4.7 | 4.7 | 65.3 |
|  | Law Enforcement | 13 | 8.7 | 8.7 | 74.0 |
|  | Aerial Resource Managements | 13 | 8.7 | 8.7 | 82.7 |
|  | Military Operations | 6 | 4.0 | 4.0 | 86.7 |
|  | Emergency Managements | 10 | 6.7 | 6.7 | 93.3 |
|  | Others | 10 | 6.7 | 6.7 | 100.0 |
|  | Total | 150 | 100.0 | 100.0 |  |

Sign-t results

| Median 6.7 | Probability Distribution |
|---|---|
| (significance level = 0.05) | $P(s) = C(n, s)(0.5)^n$ |
| | S: number of success in 12 trials with binomial distribution |
| | P(S): Probability for S with p = 0.5 for one trial |
| | CPF: Cumulative probability forward |
| | CPB: Cumulative probability backward |
| | P(<=5 or >=7) = 0.774414 |
| | Fail to reject the Ho at the significance level = 0.05 |
| NORMAL APPROXIMATION | NORMAL APPROXIMATION |
| Z = (s - n/2) / Sqrt((n)(0.5)(0.5)) | (continuity correction) |
| = (7 - 12/2) / Sqrt(12/4) | Z = (s - 1/2 - n/2) / Sqrt((n)(0.5)(0.5)) |
| = 0.5774 | = (7 - 1/2 - 12/2) / Sqrt(12/4) |
| P(>\|Z\|) = 0.563703 | = 0.2887 |
| | P(>\|Z\|) = 0.77283 |
| | Fail to reject the Ho at the significance level = 0.05 |

**2. Please rate the following facilities of the airport according to their present condition as per your judgement.**

The value for Cronbach alpha which in this case is .857

**Reliability Statistics**

| Cronbach's Alpha | Cronbach's Alpha Based on Standardized Items | N of Items |
|---|---|---|
| .857 | .852 | 150 |

**Item Statistics**

| Facilities | Mean | Std. Deviation | N |
|---|---|---|---|
| Airport Terminal | 4.05 | 1.244 | 150 |
| Runways | 3.67 | .993 | 150 |
| Parking | 4.15 | .839 | 150 |
| Periphery roads | 4.25 | .899 | 150 |
| Airport lightings | 4.15 | .900 | 150 |
| Non Directional Beacon Systems | 3.99 | .905 | 150 |
| Area Navigation Systems | 4.02 | .930 | 150 |
| Lateral Navigation Systems | 3.97 | 1.147 | 150 |
| Human Weathers Observation Systems | 4.06 | 1.012 | 150 |
| Automated Weathers Observation Systems | 4.07 | .864 | 150 |
| Airport Lounges | 4.05 | .988 | 150 |
| Air Traffics Controls | 3.94 | 1.031 | 150 |
| Aircrafts ground handling | 3.87 | 1.085 | 150 |
| Aircrafts Hangers | 4.25 | .868 | 150 |
| Airport people mover systems | 4.12 | .819 | 150 |
| Airport Apron | 4.12 | .882 | 150 |
| Airport movement area safety system | 4.07 | .967 | 150 |
| Airport security System | 4.07 | 1.014 | 150 |
| Airport surveillance Systems | 4.04 | .975 | 150 |
| Aviation light Signals | 4.04 | .897 | 150 |
| Flight information display systems | 3.98 | .979 | 150 |
| Landing area | 4.07 | .991 | 150 |
| Departure control area | 4.09 | .922 | 150 |
| Duty free shops | 4.04 | .911 | 150 |
| Automatics Terminal Information Service | 4.11 | .916 | 150 |

**3. Rate the below mentioned airport infrastructures and facilities according to the need of renovation and upgradation.**

The value for Cronbach alpha which in this case is .918

**Reliability Statistics**

| Cronbach's Alpha | Cronbach's Alpha Based on Standardized Items | N of Items |
|---|---|---|
| .918 | .915 | 150 |

**Item Statistics**

| | Mean | Std. Deviation | N |
|---|---|---|---|
| Airport Terminal | 2.75 | 1.118 | 150 |
| Runways | 2.86 | 1.187 | 150 |
| Parking | 3.05 | 1.180 | 150 |
| Periphery roads | 2.99 | 1.020 | 150 |
| Airport lightings | 3.15 | 1.019 | 150 |
| Non Directional Beacon Systems | 3.05 | 1.064 | 150 |
| Area Navigation Systems | 3.13 | 1.057 | 150 |
| Lateral Navigation Systems | 3.07 | 1.069 | 150 |
| Human Weathers Observation Systems | 3.09 | 1.010 | 150 |
| Automated Weathers Observation Systems | 3.07 | .991 | 150 |
| Airport Lounges | 3.04 | 1.092 | 150 |
| Air Traffics Controls | 2.85 | 1.180 | 150 |
| Aircrafts ground handling | 2.89 | 1.148 | 150 |
| Aircrafts Hangers | 3.25 | .921 | 150 |
| Airport people mover systems | 3.22 | 1.009 | 150 |
| Airport Apron | 3.01 | 1.071 | 150 |
| Airport movement area safety system | 2.99 | 1.081 | 150 |
| Airport security System | 3.03 | 1.068 | 150 |
| Airport surveillance Systems | 3.03 | 1.068 | 150 |
| Aviation light Signals | 3.09 | 1.003 | 150 |
| Flight information display systems | 3.11 | 1.037 | 150 |
| Landing area | 2.98 | 1.033 | 150 |
| Departure control area | 2.89 | 1.121 | 150 |
| Duty free shops | 3.10 | 1.073 | 150 |
| Automatics Terminal Information Service | 3.00 | 1.030 | 150 |
| Others | 3.16 | .997 | 150 |

**4 Co-relation between facilities of the airport and airport infrastructures and facilities according to the need of renovation and upgradation.**

**A) PEARSON CORRELATION**

| No | X | Y | X-E(X) | Y-E(Y) | [X-E(X)][Y-E(Y)] | [X-E(X)]^2 | [Y-E(Y)]^2 |
|----|------|------|---------|---------|------------------|------------|------------|
| 1 | 4.05 | 2.75 | 0.0004 | -0.2776 | -0.0001 | 0 | 0.0771 |
| 2 | 3.67 | 2.86 | -0.3796 | -0.1676 | 0.0636 | 0.1441 | 0.0281 |
| 3 | 4.15 | 3.05 | 0.1004 | 0.0224 | 0.0022 | 0.0101 | 0.0005 |
| 4 | 4.25 | 2.99 | 0.2004 | -0.0376 | -0.0075 | 0.0402 | 0.0014 |
| 5 | 4.15 | 3.15 | 0.1004 | 0.1224 | 0.0123 | 0.0101 | 0.015 |
| 6 | 3.99 | 3.05 | -0.0596 | 0.0224 | -0.0013 | 0.0036 | 0.0005 |
| 7 | 4.02 | 3.13 | -0.0296 | 0.1024 | -0.003 | 0.0009 | 0.0105 |
| 8 | 3.97 | 3.07 | -0.0796 | 0.0424 | -0.0034 | 0.0063 | 0.0018 |
| 9 | 4.06 | 3.09 | 0.0104 | 0.0624 | 0.0006 | 0.0001 | 0.0039 |
| 10 | 4.07 | 3.07 | 0.0204 | 0.0424 | 0.0009 | 0.0004 | 0.0018 |
| 11 | 4.05 | 3.04 | 0.0004 | 0.0124 | 0 | 0 | 0.0002 |
| 12 | 3.94 | 2.85 | -0.1096 | -0.1776 | 0.0195 | 0.012 | 0.0315 |
| 13 | 3.87 | 2.89 | -0.1796 | -0.1376 | 0.0247 | 0.0323 | 0.0189 |
| 14 | 4.25 | 3.25 | 0.2004 | 0.2224 | 0.0446 | 0.0402 | 0.0495 |
| 15 | 4.12 | 3.22 | 0.0704 | 0.1924 | 0.0135 | 0.005 | 0.037 |
| 16 | 4.12 | 3.01 | 0.0704 | -0.0176 | -0.0012 | 0.005 | 0.0003 |
| 17 | 4.07 | 2.99 | 0.0204 | -0.0376 | -0.0008 | 0.0004 | 0.0014 |
| 18 | 4.07 | 3.03 | 0.0204 | 0.0024 | 0 | 0.0004 | 0 |
| 19 | 4.04 | 3.03 | -0.0096 | 0.0024 | 0 | 0.0001 | 0 |
| 20 | 4.04 | 3.09 | -0.0096 | 0.0624 | -0.0006 | 0.0001 | 0.0039 |
| 21 | 3.98 | 3.11 | -0.0696 | 0.0824 | -0.0057 | 0.0048 | 0.0068 |
| 22 | 4.07 | 2.98 | 0.0204 | -0.0476 | -0.001 | 0.0004 | 0.0023 |
| 23 | 4.09 | 2.89 | 0.0404 | -0.1376 | -0.0056 | 0.0016 | 0.0189 |
| 24 | 4.04 | 3.1 | -0.0096 | 0.0724 | -0.0007 | 0.0001 | 0.0052 |
| 25 | 4.11 | 3 | 0.0604 | -0.0276 | -0.0017 | 0.0036 | 0.0008 |
| Sum | 101.24 | 75.69 | | | 0.1494 | 0.3217 | 0.3173 |
| Mean | 4.05 | 3.03 | | | | | |
| | | | | | | | |
| r = 0.149376 / (0.321696^0.5 * 0.317256^0.5) = 0.467577 | | | | | | | |

$$r=\frac{\sum(x-m_x)(y-m_y)}{\sum(x-m_x)2\sum(y-m_y)2}\;\;\sqrt{r}=\frac{\sum(x-m_x)(y-m_y)}{\sum(x-m_x)2\sum(y-m_y)2}$$

| X Values | Y Values |
|---|---|
| $\sum = 75.69$ | $\sum = 101.24$ |
| Mean = 3.028 | Mean = 4.05 |
| $\sum(X - M_x)^2 = SS_x = 0.317$ | $\sum(Y - M_y)^2 = SS_y = 0.322$ |
| *X and Y Combined* | *R Calculation* |
| $N = 25$ | $r = \sum((X - M_y)(Y - M_x)) / \sqrt{((SS_x)(SS_y))}$ |
| $\sum(X - M_x)(Y - M_y) = 0.149$ | |
| | $r = 0.149 / \sqrt{((0.317)(0.322))} = 0.4676$ |
| | |
| | *Meta Numerics (cross-check)* |
| | $r = 0.4676$ |

## B) Spearman Co-relation

$$\rho = 1 - \frac{6\sum d_i^2}{n(n^2 - 1)}.$$

| Calculation | Result Details |
|---|---|
| R = CoVariance / ($X_{Ra}$ St. Dev. * $Y_{Ra}$ St. Dev.) | *X Ranks* |
| | Mean: 13 |
| Key | Standard Dev: 7.33 |
| | |
| $X_{Ra}$ = Ranks of X Values; $Y_{Ra}$ = Ranks of Y Values | *Y Ranks* |
| $X_{Ra} - M_x$ = X rank minus mean of X ranks | Mean: 13 |
| $Y_{Ra} - M_y$ = Y rank minus mean of Y ranks | Standard Dev: 7.35 |
| Sum Diffs = ($X_{Ra} - M_x$) * ($Y_{Ra} - M_y$) | |
| | *Combined* |
| | Covariance = 288.75 / 24 = 12.03 |
| | R = 12.03 / (7.33 * 7.35) = 0.223 |

$r_s$ = 0.22315, *p* (2-tailed) = 0.28363.

## 5   Is the airport financially viable?

From the table we conclude that out of 150 respondent, 88.7% response Yes and 11.3% response No for airport financially viable.

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Yes | 133 | 88.7 | 88.7 | 88.7 |
| | No | 17 | 11.3 | 11.3 | 100.0 |
| | Total | 150 | 100.0 | 100.0 | |

Table 5:- represent the frequency table for airport financially viable.
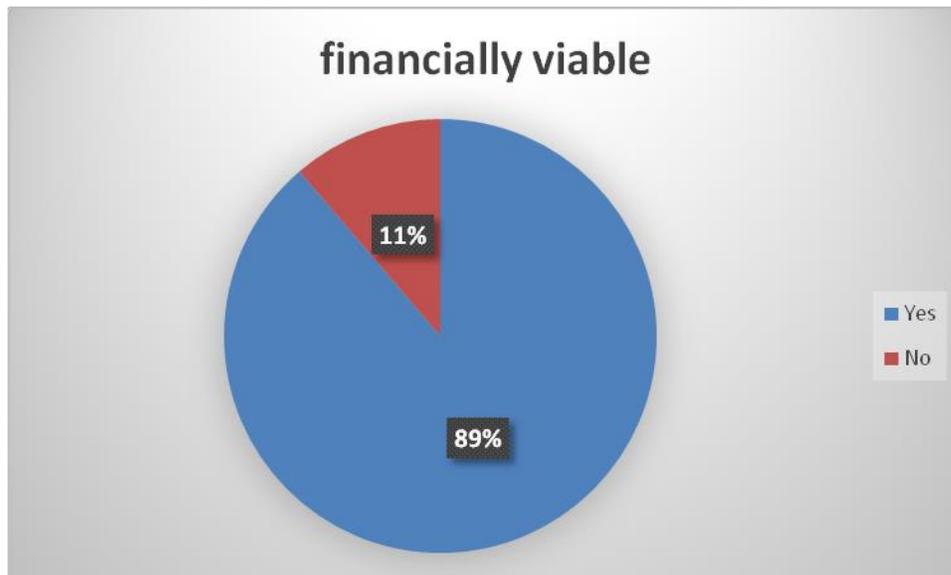


Fig 3:- represent the pie chart for airport financially viable.

## Regression Analysis

**Descriptive Statistics**

|  | Mean | Std. Deviation | N |
|---|---|---|---|
| Rate at present condition | 4.0496 | .45745 | 150 |
| Renovationandupgradation | 3.0291 | .61477 | 150 |

From the model summary table, the value of correlation coefficient (R) =0.250 between rating of facility and facility renovation and upgradation

The regression coefficient (R square) = 0.063 which show 6.3% of variation is explained by rate of facility on facility renovation and upgradation.

**Model Summary**

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate |
|---|---|---|---|---|
| 1 | .250a | .063 | .056 | .44440 |

a. Predictors: (Constant), Renovationandupgradation

From the table of coefficient, we found that beta value = -0.250 and value of t test = -3.143 with p value =0.002 which is less than 0.05 level of significance,.

**Coefficientsa**

| Model | | Unstandardized Coefficients | | Standardized Coefficients | t | Sig. |
|---|---|---|---|---|---|---|
| | | B | Std. Error | Beta | | |
| 1 | (Constant) | 4.613 | .183 | | 25.207 | .000 |
| | Renovationandupgradation | -.186 | .059 | -.250 | -3.143 | .002 |

a. Dependent Variable: Rate at present condition

# Chapter 5
## Research Findings, Interpretation, and Discussion

## 5.1 Discussion and results

### 1. Various types of air services taking place at the airport

Various kinds of services taking place at the airport; it showed that, 16% of the people were in favor of chattered commercial and commercial as a service at place in an airport. On the other hand, 13% of the respondents were highly believe on law enforcement and aerial resource management as a service and lower percentage of the people with 6% were in favor of military operations as service which take place in the airport.

Sign-T has been performed to test the consistent differences between observed pairs. Hence, when the Sign test has been performed on the services offered; the probability distribution and normal approximation results in the value of P to be 0.77

In Sign T

If   $P<0.05$, we reject the null hypothesis (No differences is observed in pairs)

   $P>0.05$, the alternate hypothesis is found (Differences in the pairs is observed)

Since the difference in services has been observed, it can be said that all services are operating independently and the performance of any individual service doesn't affect the remaining services but it will directly impact its respective field, its infrastructure and costs

2. **Facilities of the airport:**

While testing the variability and reliability of the data and information, it includes facilities of the airport by analyzing their present condition. The variable has been tested and it showed the value for Cronbach's alpha which in this case is .857 and reflects high reliability of the measuring instrument. Furthermore, it indicates high level of internal consistency with respect to the facilities rate of the airport according to their present.

Airport terminal, Parking, Periphery roads, Airport lighting, Aircraft hangers, Airport people movers, Airport apron, Airport movement safety area, security area, Airport surveillance, landing area and departure area are highly co-related and internally consistent with each other

Runways, Air-traffic control and aircrafts ground handling reflects its reliable internal consistency. Furthermore, the above services are operating all together with good relationship

3. **Airport infrastructures, facilities according to the need of renovation and upgradation:**

The effective rating of airport infrastructure and facilities as per the need of renovation and upgradation, the variable and information has been tested and showed the value for Cronbach's alpha which in this case is .918 and reflects high reliability of the measuring instrument. Furthermore, it indicates high level of internal consistency with respect to the airport infrastructures and facilities according to the need of renovation and upgradation.

Since the value of Cronbach's is nearer to 1 i.e., 0.918 this reflects strong agreeing and demand of renovation and upgradation.

**4. Correlation between the infrastructure of the airport and need for renovation and upgradation.**

On finding correlation between the data and results of operational facilities and need for renovation and upgradation; two tests namely Pearson correlation and Spearman correlation are performed.

As per the results of Pearson's correlation it shows R=0.46 which reflects that, there is a close positive relationship between them

As per the results of Spearman's correlation it shows R=0.223 which also shows the presence of close positive functional liner relationship

Hence, on correlation the research shows the need of upgradation of infrastructure of the airport

**5. Financial viability of the airport**

Making focus on the reliability of airport financially viability, it showed the result that out of 150 respondent, 88.7% response Yes and 11.3% response No for airport financially viable. Hence, it can be said that it is essential for the airport industry to arrange their financial resources in order to provide stretch of their financial viability in an effective manner.

By testing the collected value and hypothesis by using regression analysis, it showed the descriptive relationship between rate at present condition and renovation and upgradation situation of airport which showed the value of correlation coefficient (R) =0.250 between rating of facility and facility renovation and upgradation which show mildly strong relation between them. The regression coefficient (R square) = 0.063 which show 6.3% of variation is explained by rate of facility on facility renovation and upgradation.

In addition to this, to test the model summary of the variable, it was found that beta value was 0.250 and value of t-test was -3.143 which also include the p-value of -0.002 which is less than 0.05 level of significance, so it can be said that the variable has been accepted that there is significance relation between rate of facility and facility upgradation and renovation.

On the above statics, it shows that there is mildly strong relationship between airport infrastructure, finance and airport upgradation

## 6. Thematic analysis of answered statement

### i. Average per day passenger and aero plane traffic

Respondents mentioned that "900 and more" for average per day aero plane traffic at the airport. Similarly, another respondent reported that the average per day passenger traffic at the airport is "more than 40 thousand".

Chhatrapati Shivaji International Airport, at Mumbai was ranked 2nd (in India), with close to 48.49 million passengers per year.

**ii. As per the Air Traffic Report - August, 2018,**

- **Aircrafts Movements**

The international aircraft movements have seen an addition of 4.7 per cent

The domestic aircraft movements have seen an addition of 18.4 per cent,

Resulting into a 15.8 per cent growth in total aircraft movements during (April - August) 2018 - 2019 as compared to (April - August) 2017 - 2018.

- **Passengers**

The international traffic have shown an increase of 7.7 per cent

The domestic traffic have shown an increase of 19.4 per cent

Resulting in an overall growth of 16.8 per cent in total passenger traffic during the period (April - August) 2018 - 2019 as compared to (April - August) 2017 - 2018.

- **Freight**

The international freight traffic have shown a growth of 4.6 per cent

The domestic freight traffic have shown a growth of 12.8 per cent,

Resulting in an overall growth of 7.5 per cent in total freight traffic during the period (April - August) 2018 - 2019 as compared to (April - August) 2017 - 2018."

**7. Number of functional runways and terminals**

One respondent stated that "there are two runways and one is functional at a time, and in that respect are totally two runways available.

**8. Operations and Facilities of the airport**

Respondents typically stated that "Construction of the airport requires maximum budget. Maintenance, infrastructure and prompt services are the significant factors that affect the smooth and efficient operation of the airport. And the air transportation system always changes for the betterment, and particularly for better capacity, consumer satisfaction, safety, and security. The environmental factors are also considered."

Respondents also stated that "employee behavior and customer expectations are very important factors. And considering the structure, the facilities provided also play a vital role in affecting the operation of the airport. And more advanced systems are included as we need to upgrade with the introduction of new technologies. With this the customer experience is also enhanced."

**9. Comparison of Airports and Finances**

At the international level, the aviation sector in India raising working group and expanding middle class demography is estimated to increase demand. India projects to grow the number of airports to 250 by 2030 to cater to growing leisure & business travel. Nevertheless, the regime has been encouraging private sector participation.

There is an increase in investment, totaling USD 12.1 billion in the airport sector are likely to be produced during the 12th Five Year Plan (2013 - 2018); of these, private investments are required to total USD 9.3 billion.

On the domestic stage, due to growing domestic and foreign tourists, there is an improvement in tourism infrastructure, successful ad campaigns abroad, and the share of travel and tourism in India's GDP is likely to depict Year of Year growth of over 15 per cent in 2017; and is expected to rise at a CAGR of 7.2 per cent annum between 2017 - 2027.

Respondents also said that "Mumbai airport is getting along reasonably well, it is in second position after Delhi airport and doing very well. But the scope for improvement is always there".

# Chapter 6:

# Conclusion and Recommendations

## 6.1 Conclusion

As per the detailed information, it can be concluded that the usual techniques for sizing the more areas for consumer activities in airport terminals are not as much as scratch in that they without problems bring about mistakes. This research offers realistic measures for integrating stochastic issues into terminal layout. While making focus on the research and statics analysis, it can be concluded that:

1. It has been determined that various type of air-services i.e., Scheduled commercial, chartered commercial, freights, military services and others are observed, it can be concluded that that all services are operating independently and the performance of any individual service doesn't affect the remaining services but it will directly impact its respective field, its infrastructure and costs

2. It has been determined Airport terminal, Parking, Periphery roads, Airport lighting, Aircraft hangers, Airport people movers, Airport apron, Airport movement safety area, security area, Airport surveillance, runways, air-traffic control and aircrafts ground handling, landing area and departure area are highly co-related and found to be internally consistent with each other; this reflects its reliable internal consistency. Furthermore, the above services are operating all together with good relationship. Hence, it can be concluded that if one of the services needs upgradation or renovation, it affects the other services

3. Based on the survey statics results, it reflects strong agreeing and demand of renovation and upgradation of airport infrastructure. Also, it has been observed that there is increment in aircraft craft movement, passengers and cargo by 15.8 percent, 16.8 percent and 7.5 percent respectively this year which support the need for upgradation.

4. Based on the survey statics results it can be concluded that it is essential for the airport industry to arrange their financial resources in order to provide stretch of their financial viability in an effective manner.

5. Factors influencing the structure and design of airport terminals: In order to determine the various factors that highly affect the structure and design of airport terminal, it includes the space requirement which is based on the demand or capacity of the passengers. Cost is another factor that also affects the structure and design of the airport. The flexibility in design effectively reduces the cost/ investment: operational cost and in-turn would offer financial support in future for betterment of airport terminals and also during uncertainties or calamities.

The airport terminals constructed under flexibility-based designs would support in many ways: technical support, financial support, services and facilities, etc; hence while designing the terminals by properly and accurately measuring the areas (transportation, hold room, beverages and foods, baggage, pedestrians, parking, etc) as per norms and allocating for extension would also support the airport terminals in many ways for many years. Hence, all these factors highly affect the design and structure of the airport terminals.

**6.2 Recommendations and Limitations**

- The Aviation Industry in India is emerging exponentially; it gives way to numerous opportunities.

- It is essential for the industry to boost and develop their potentiality as an MRO (Commercial aircraft maintenance, repair and overhaul) business in India, which is worth US500 million as of 2016 and is estimated to raise over US 1.5 billion by 2020; more advanced systems, and engineering science, facilities and infrastructure has to be developed as per the demands"

- Leverage on non-aeronautical revenues, improving technology might develop airports and can now draw on wider revenues such as retail, advertising and vehicle parking.

- Moreover, the future operators will benefit from greater operational efficiency due to satellite based navigation systems like 'Project Gagan' which is in development stage should be completed soon.

## 6.3 Research Limitation

- Major issue was to collect data, facts, and figures from different sources. The different sources of information were limited in nature. This laid down hindrances in the conduction of research study in a limited way.

- The research also had to depend on the respondents for the accumulation of more data.

- The respondents were found to be varied in nature. More or less of the respondents actively participated and provided their valuable feedback

# References

1. ACRP Report, (2016). Airport Passenger Terminal Planning and Design Volume 1: Guidebook. Transportation Research Board of the National Academics.

2. ACRP, (2010), "Airport Passenger Terminal Planning and Design", Guidebook, Airport Cooperative Research Program- Report 25, Vol. 1, pp: 423.

3. Akyüz, M.K., et al (2017). Economic and Environmental Optimization of an Airport Terminal Building's Wall and Roof Insulation. Sustainability, 9(1849), 1-18.

4. Alnasseri, N., Osborne, A. and Steel, G. (2013). Managing and Controlling Airport Construction Projects: A Strategic Management Framework for Operators, Journal of Advanced Management Science, 1(3), pp 317-320

5. Alodhaibia, S. et al (2017). Framework for airport outbound passenger flow modeling, 2016 Global Congress on Manufacturing and Management, Procedia Engineering 174, pp 1100-1109

6. ARUP, (2016). Future of Air Travel. ARUP Report.

7. Ashford. N, (1988), "Level of Service Design Concept for Airport Passenger Terminals: A European View", Transportation Research Record, vol. 1199, pp: 19-32.

8. ASM, (2005), "Planning & Design for terminals and facilities", Airport standard manual, 1st Edition, Chapter 6, and pp: 16:37.

**9.** Bauer, G. R. (2014). Incorporating intersectionality theory into population health research methodology: Challenges and the potential to advance health equity. Social science & medicine, 110, 10-17.https://www.ncbi.nlm.nih.gov/pubmed/24704889

10. Besjak, et al 2013). Chhatrapati Shivaji International Airport—Integrated Terminal Building. Structural Engineering International, Technical Report.

11. Brinkmann, S. (2014). Interview. In Encyclopedia of critical psychology (pp. 1008-1010). Springer New York. http://vbn.aau.dk/en/publications/interview(dd9b25ab-1e54-468a-9af3-2b6ae00de9f8)/export.html

12. Brown, N. C., & Mueller, C. T. (2016). Design for structural and energy performance of long span buildings using geometric multi-objective optimization. Energy and Buildings, 127,748-761.
https://www.sciencedirect.com/science/article/pii/S2351978917305954

13. Bruin, P.W., et al (2004). Analysis of the Structural Bearing Capacity of an Airport Using Rudimentary Test Results as Input into the SAMDM. Proceedings of the 8th Conference on Asphalt Pavements for Southern Africa (CAPSA'04).

14. Brunetta, L, Jacur, G.R., (n.d.). A Flexible Model for the Evaluation of an Airport Terminal. Retrieved on 29th March 2018 from

https://pdfs.semanticscholar.org/c938/2e71ed2ccbebced4eb1907646cd9be6218a0.pdf

15. Burghouwt, G. (2016). Airline network development in Europe and its implications for airport planning. Routledge. https://www.amazon.com/Airline-Network-Development-Implications-Planning/dp/1138245739

16. CAAC, (2014), "Airport Construction and Management", China Civil Aviation Annual Report, pp: 68-72.

17. Canberra Airport Report, (2015). Passenger Terminal Facilities. Retrieved on 29th March 2018 from https://www.canberraairport.com.au/wp-content/uploads/2015/03/Chapter-8-Passenger-terminal-facilities1.pdf

18. Causon, J. (2011). 'Blue Sky' approach to customer service. Airports International, 44(5).

19. Choudhuri, S., Dixit, R. and Tiwari, R. (2015). Issues And Challenges Of Indian Aviation Industry: A Case Study, Pezzottaite Journals, 4(1), pp 1557-1562

20. Choy, L. T. (2014). The strengths and weaknesses of research methodology: Comparison and complimentary between qualitative and quantitative approaches. IOSR Journal of

Humanities and Social Science, 19(4), 99-104. http://iosrjournals.org/iosr-jhss/papers/Vol19-issue4/Version-3/N0194399104.pdf

21. Dang, G., & Pheng, L. S. (2015). Research methodology. In Infrastructure Investments in Developing Economies (pp. 135-155). Springer, Singapore. https://www.springer.com/gp/book/9789812872470

22. Davies, A., Dodgson, M., & Gann, D. (2016). Dynamic capabilities in complex projects: The case of London Heathrow Terminal 5. Project Management Journal, 47(2), 26-46. http://discovery.ucl.ac.uk/1482203/

23. De Neufville, R. (2008). Low-cost airports for low-cost airlines: flexible design to manage the risks. Transportation planning and Technology, 31(1), 35-68. https://www.tandfonline.com/doi/abs/10.1080/03081060701835688

24. Enciso, J., Vargas, J. and Martinez, P. (2016). Modeling and Simulation of Passenger Traffic in a National Airport, 14th LACCEI International Multi-Conference for Engineering, Education, and Technology: "Engineering Innovations for Global Sustainability", pp 1-8

25. Fife, W. And McNerney. M.T, (n.d.), "A Look into the Future of Airport Planning, Design, and Construction by Analyzing Current Issues", A1J07: Committee on Aircraft/Airport Compatibility, Transportation in the New Millennium, pp: 1–5.

26. Flick, U. (2015). Introducing research methodology: A beginner's guide to doing a research project. Sage. https://books.google.co.in/books/about/Introducing_Research_Methodology.html?id=-EeXiLAi4TgC

27. Forsyth, P. (2017). Replacing regulation: airport price monitoring in Australia. In The Economic Regulation of Airports (pp. 3-22). Routledge.

https://www.pc.gov.au/__data/assets/pdf_file/0019/20638/airportservices.pdf

28. Gaonkar, P.D., (2013). Analysis of airport ground accessibility in India by explicating the case of CSI Airport, Mumbai. International Journal of Scientific and Research Publications, 3(7), 1-7.

29. George.I, (2013), "Modified Importance - Performance Analysis of Airport Facilities- A Case Study of Cochin International Airport Limited", IOSR Journal of Humanities and Social Science (IOSR-JHSS), Vo- 17, Issue 4, PP 09-15.

30. Gil, N., & Tether, B. S. (2011). Project risk management and design flexibility: Analysing a case and conditions of complementarity. Research Policy, 40(3), 415-428. https://pdfs.semanticscholar.org/035c/ca0ba263d1fa43cebe567e4382ef354ed78a.pdf

31. Glesne, C. (2015). Becoming qualitative researchers: An introduction. Pearson. https://www.amazon.com/Becoming-Qualitative-Researchers-Introduction-5th/dp/0133859398

32. Graham, A. (2013). Understanding the low cost carrier and airport relationship: A critical analysis of the salient issues. Tourism Management, 36, 66-76.

    https://www.researchgate.net/publication/271583988_Understanding_the_low_cost_carrier_and_airport_relationship_A_critical_analysis_of_the_salient_issues

33. GVK, (2016). The Sustainability Report: Mumbai International Airport Pvt. Ltd. Retrieved on 29th March 2018 from **http://www.csia.in/pressrelease/SR_2016.pdf**

34. GVK, (n.d). Mumbai Chhatrapati Shivaji International Airport. Retrieved on 29th March 2018 from **http://www.csia.in/bizpressrelease/CommercialOpportunities/f8c376ba4a4d4c6483a532052a8d8850.pdf**

35. Hanaoka. S, Inamura. H and Ohi. T, (2009), "Passenger satisfication of low-cost carriers terminal, Kuala Lumpur International Airport", 13th World conference of air transport research society (ARTS 2009), pp: 1-13.

36. Harrison, A, (2015). Principles of Experience Design for Airport Terminals. PhD Thesis, Queensland University of Technology.

37. Harrison, A, et al (2011). Challenges in passenger terminal design: A conceptual model of passenger experience. DRS 2012 Bangkok.

38. Harrison. A, (2015), "Principles of Experience Design for Airport Terminals" Thesis on Information Technology Honours, pp: 245.

39. Haştemoğlu, H.S., Erkan, I, (2015). Evaluation of an Airport Terminal Building for Developing a Measurement of Passenger Satisfaction Standard in Turkey. International Journal of Innovative Research in Science, Engineering and Technology, 4(1), 18425-184322.

40. Horonjeff. R, McKelvey. F.X, Sproule. W. J and Young. S. B, (2010), "Planning and Design of Airports", Fifth Edition, Part II -Chapter 10, McGrawHill, pp: 383.

41. Horsfield, J., Stewart, D., Chalk, C., & Scott, D. K. (2018). Designing terminals that offer the flexibility to adapt quickly and cost-effectively to evolving processes. Journal of Airport Management, 12(1), 21-35.

   http://www.civilaviation.gov.in/sites/default/files/Final_NCAP_2016_15-06-2016-2_1.pdf

42. Hsu. C-I and Chao. C-C, (2005), "Space allocation for commercial activities at international passenger terminals", Transportation Research, Part E 41, pp: 29–51.

43. Humphreys. I, Francis. G and Fry. J (2002), "Performance measurement in airports: A Critical International Comparison", Public Works Management & Policy / April 2002, Airport Performance Measurement, pp: 264-275.

44. Humphreys. I, Ison. S. and Francis. G, (2006) "A Review of the airport-low cost airline relationship", The Review of Network Economics, Vol. 5(4), pp: 1-8.

45. Humphries, B. (2017). Re-thinking social research: anti-discriminatory approaches in research methodology. Routledge. https://www.taylorfrancis.com/books/9781351903592

46. Ihrig, W, (2017). Improving Intelligibility of Airport Terminal Public Address Systems. Airport Cooperative Research Program.

47. Jorge, J. D., & de Rus, G. (2004). Cost–benefit analysis of investments in airport infrastructure: a practical approach. Journal of Air Transport Management, 10(5), 311-326. https://ideas.repec.org/a/eee/jaitra/v10y2004i5p311-326.html

48. Kapanen. K (2014), "Airport Performance Improvement: Case Mikkeli City Airport, Thesis on Business Management, pages 95.

49. KBYTES, (2014). New Project - Mumbai's Chhatrapati Shivaji International Airport T2. Retrieved on 30th March 2018 from http://kohinoorgroup.co.in/kbytes/201407/02ef79.pdf

50. Ledford, J. R., & Gast, D. L. (2018). Single case research methodology: Applications in special education and behavioral sciences. Routledge. https://www.amazon.com/Single-Case-Research-Methodology-Applications/dp/0415827914

51. Lee. Y.H, Yoo.K..E and Park.C-H., (2000), "airport design and development", Transportation Engineering and Planning- EOLSS, Vol. 1, pp: 1-6.

52. Lees, E, (2016). A Better Way to Manage Airports: Passenger Analytics Insights from ICF International. ICF International, Inc.

53. Leva, M.C., Sordo, D.D. and Mattei, F. (2014), Day-to-day performance management in a small regional airport and management of change for safer operations, Springer - Cogn Tech Work, pp 1-12

54. Lewis, S. (2015). Qualitative inquiry and research design: Choosing among five approaches. Health promotion practice, 16(4), 473-475. http://journals.sagepub.com/doi/abs/10.1177/1524839915580941

55. Losekoot. E (2015), "Factors influencing the airport customer experience: A case study of Auckland International Airport's customers", Thesis on Information and Technology, pp: 186.

56. Mackey, A., & Gass, S. M. (2015). Second language research: Methodology and design. Routledge. https://www.routledge.com/Second-Language-Research-Methodology-and-Design-2nd-Edition/Mackey-Gass/p/book/9781138808560

57. Magalhães, L., Reis, V., & Macário, R. (2017). A literature review of flexible development of airport terminals. Transport Reviews, 37(3), 365-382. https://www.tandfonline.com/doi/abs/10.1080/01441647.2016.1246488?scroll=top&needAccess=true&journalCode=ttrv20

58. Magalhães, L., Reis, V., & Macário, R. (2018). A new methodological framework for evaluating flexible options at airport passenger terminals. Case Studies on Transport Policy.https://www.scribd.com/document/383786425/A-new-methodological-framework-for-evaluating-%EF%AC%82exible-options-at-airportpassenger-terminals-pdf

59. Mandic. A, Teklic. M and Petric. L, (2017), "The Effects of the Low Cost Carriers' Presence on Airport Performance: Evidence from Croatia", Tourism and Hospitality Management, Vol. 23, No. 1, pp. 17-34.

60. McLay, P, Reynolds-Feighan, A, (2006). Competition between Airport Terminals: The Issues Facing Dublin Airport. Retrieved on 30th March 2018 from

http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.543.7719&rep=rep1&type=pdf

61. Milbredt, O. et al (2017). Passenger-centric airport management via new terminal interior design concepts, Transportation Research Procedia, 27, pp 1235-1241

62. Mirkovic, B, Tosic, V, (2014). Airport Apron Capacity: Estimation, Representation, and Flexibility. Journal of Advanced Transportation, volume 48, pp. 97-118.

63. Mishra. L, (2014), "Manmohan Singh unveils new terminal of Chhatrapati Shivaji International Airport in Mumbai", Swanky terminal inaugurated at Mumbai international airport, The Hindu, Available at: http://www.thehindu.com/news/national/other-states/swanky-terminal-inaugurated-at-mumbai-international-airport/article5562635.ece

64. Moulds, J., & Lohmann, G. (2016). An analysis of future trends in non-aeronautical revenue: A case study from Adelaide Airport. Journal of Airport Management, 10(4), 343-358. https://experts.griffith.edu.au/publication/nf428aa5e5de9cf05574bfc677545a0fa

65. Mueller, C. T., & Ochsendorf, J. A. (2015). Combining structural performance and designer preferences in evolutionary design space exploration. Automation in Construction, 52, 70-82. https://dspace.mit.edu/openaccess-disseminate/1721.1/108253

66. Mumayiz, S.A., (2007).Development of airport terminal design concepts—a new perspective. Transportation Planning and Technology.

67. NCAIR, (2014). Economic Impact Study OfChhatrapatiShivaji International Airport. Report of National Council of Applied Economic Research.

68. Neufville De, (1994), "Designing Airport Passenger Buildings For The 21st Century", Transport Journal Proceeding of the Institution of Civil Engineers (UK), Paper 10284, pp: 1-27.

69. Neufville, R.D., (2008).Low-Cost Airports for Low-Cost Airlines: Flexible Design to Manage the Risks. Transportation Planning and Technology, 31(1).

70. Neufville. De, (2007), "Low-Cost Airports For Low-Cost Airlines: Flexible Design To Manage The Risks, Paper Prepared For Special Issue of Journal of Transportation Planning and Technology, Edited by Warren Walker and Vincent Marchau, pp: 1-24.

71. Odoni, A, Neufville, R, (n.d.). Passenger Terminal Design. Retrieved on 31$^{st}$ March 2018 from https://pdfs.semanticscholar.org/5355/f1c5625ee83b619e70abf233a5043f59c540.pdf

72. Odoni, A., & De Neufville, R. (2003). Airport systems: Planning, design, and management. McGraw-Hill Professional. https://dspace.mit.edu/openaccess-disseminate/1721.1/108253

73. Oum, T. H., Yu, C., & Fu, X. (2003). A comparative analysis of productivity performance of the world's major airports: summary report of the ATRS global airport benchmarking research report—2002. Journal of Air Transport Management, 9(5), 285-297.https://soaneemrana.org/onewebmedia/AIRPORT%20SYSTEMS%20(PLANNING, %20DESIGN%20&%20MANAGEMENT)%20BY%20RICHARD%20DE%20NEULFV ILLE.pdf

74. Panneerselvam, R. (2014). Research methodology. PHI Learning Pvt. Ltd.. http://www.scirp.org/(S(351jmbntvnsjt1aadkposzje))/reference/ReferencesPapers.aspx?R eferenceID=1770223

75. Pavlyuk. D, (2005), "Airport Benchmarking and Spatial Competition: a Critical Review", Transport and Telecommunication, Vol.13, No 2, pp: 123–137.

76. Perez-Valls, M., Cespedes-Lorente, J., & Moreno-Garcia, J. (2016). Green practices and organizational design as sources of strategic flexibility and performance. Business Strategy and the Environment, 25(8), 529-544.

   https://onlinelibrary.wiley.com/doi/abs/10.1002/bse.1881

77. Poh. E, (2007), "Airport planning and terminal design", Strategic Airport Management Programme, Civil Aviation Authority of Singapore, 9-13 April, pp: 1-28.

78. Prud'homme. R, (2004), "Infrastructure and Development", Paper prepared for the ABCDE (Annual Bank Conference on Development Economics), Washington, May 3-5, pp: 1-12.

79. Ramiro, E, Perez, J, (2014). Airport strategic planning in the context of low-cost carriers' ascendency: insights from the European experience. PhD Thesis, Massachusetts Institute of Technology (MIT).

80. Roosens, P. Congestion and Air Transport: a challenging phenomenon, European Journal of Transport and Infrastructure Research, 8(2), PP 137-146

81. Sarah, S. et al (2012).Flexible airport terminal design : towards a framework. In TANG, Loon Ching& Watson, Gregory H. (Eds.) Proceedings of the IIE Asian Conference.

82. Shalyal. C, (2012), "Mumbai airport to get satellite-based navigation system", The Times of India, Mumbai – City, Available at:

   https://timesofindia.indiatimes.com/city/mumbai/Mumbai-airport-to-get-satellite-based-navigation-system/articleshow/16344130.cms

83. Shareef, K.S. (2016), Common Problems Of Airport Passenger Terminal Operations, Southern Illinois University Carbondale, pp 1-45

84. Shareef, K.S., (2016). Common Problems of Airport Passenger Terminal Operations. Dissertation, Southern Illinois University.

85. Shuchi, S, Drogemuller, R, (2014). Process based synthesis to evaluate design flexibility in airport terminal layout. 46th Annual Conference of the Architectural Science Association, ANZAScA 2012, Griffith University.

86. Shuchi, S., Drogemuller, R., & Kleinschmidt, T. (2012). Flexible airport terminal design: towards a framework. In Proceedings of the IIE Asian Conference 2012(pp. 348-356). Department of Industrial & Systems Engineering, NUS. https://eprints.qut.edu.au/51567/

87. Shuchi, S.N., (2015). A Novel Concept for Airport Terminal Design Integrating Flexibility. PhD Thesis, Queensland University of Technology.

88. Silverman, D. (Ed.). (2016). Qualitative research. Sage. https://www.amazon.com/Qualitative-Research-David-Silverman/dp/1473916569

89. Singh, A. (2016). A study of Current Scenario of Aviation Sector in India, International Journal of Innovative Knowledge Concepts, 2(4), pp 92-98

90. Skidmore, Owings and Merrill, (2013). Excellence in Aviation and Planning. Retrieved on 29th March 2018 from http://www.som.com/FILE/19261/som_airports_04_29_13.pdf

91. Smith, J. A. (Ed.). (2015). Qualitative psychology: A practical guide to research methods. Sage. https://www.google.com/search?q=Smith%2C+J.+A.+%28Ed.%29.+%282015%29.+Qualitative+psychology%3A+A+practical+guide+to+research+methods.+Sage.&ie=utf-8&oe=utf-8&client=firefox-b-ab

92. Suchi. S (2016), "Airport terminal design", Week 6 Presentation on Airport Operations and Systems: ZEIT 3805, pp: 1-43.

93. Suryani, E., Chou, S. Y., & Chen, C. H. (2010). Air passenger demand forecasting and passenger terminal capacity expansion: A system dynamics framework. Expert Systems with Applications, 37(3), 2324-2339.

    http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.296.3978&rep=rep1&type=pdf

94. Taylor, S. J., Bogdan, R., & DeVault, M. (2015). Introduction to qualitative research methods: A guidebook and resource. John Wiley & Sons. https://www.google.com/search?q=Taylor%2C+S.+J.%2C+Bogdan%2C+R.%2C+%26+DeVault%2C+M.+%282015%29.+Introduction+to+qualitative+research+methods%3A+

A+guidebook+and+resource.+John+Wiley+%26+Sons.&ie=utf-8&oe=utf-8&client=firefox-b-ab

95. The Port Authority Of New York And New Jersey, (2013). Terminal Planning Guidelines. Retrieved on 30th March 2018 from https://www.panynj.gov/business-opportunities/pdf/panynj-terminal-planning-guidelines.pdf

96. The SCI, (2009), "Norms & Standards for Capacity of Airport Terminals", The Secretariat for the Committee on Infrastructure, New Delhi. pp: 1-17.

97. Torrisi. G, (2009), "Public infrastructure: definition, classification and measurement issues", MPRA Paper No. 12990, pp: 1-34.

98. Vaioleti, T. M. (2016). Talanoa research methodology: A developing position on Pacific research. Waikato Journal of Education, 12(1). https://researchcommons.waikato.ac.nz/handle/10289/6199

99. Vreedenburgh. M, (1999), "Airport Operational Efficiency", International Civil Aviation Organization Airport Privatization Seminar/Forum for the NAM/CAR/SAM Regions, Guatemala, pp: 1-25.

100. Wahab. H and Dulaimi. M, (2011), "Design Process and Stakeholders Management in Airport Construction", Article on Airport Construction, pp: 1-14.

101 Wikipedia, (2018), "Chhatrapati Shivaji International Airport", Available at: https://en.wikipedia.org/wiki/Chhatrapati_Shivaji_International_Airport

102 Wing, A.K., Cloutier, R.J. and Felder, W.N. (2015). Ramp Area Support System: Limitations of Modeling Approach to an Airport Apron Area, 2015 Conference on Systems Engineering Research, Procedia Computer Science 44, pp 354-362

103 Wirasinghe. S.C and Correia. A.R, (2005), "Development of level of service standards for airport check-in facilities", Revista TRANSPORTERS, Vol. 13(2), pp: 39-51

**Appendix: Questionnaire**

**Personal Profile of Respondent**

- **Gender** :_____

- **Educational qualification** :_____

- **Total years of experience in Aviation sector** :_____

- **Designation** :_____

1. **What is the average per day passenger traffic at the airport?**

   _____

2. **What is the average per day aeroplane traffic at the airport?**

   _____

3. **What are the various types of air services taking place at the airport? Please choose as many as applicable.**

   a. Scheduled Commercial

   b. Charter Commercial

   c. Air Ambulance

   d. Fueling

   e. Stay of Private aircrafts within the airport

   f. Cargo Freighting

   g. Commute of private aircrafts

   h. Fire Fighting

   i. Search and Rescue

j.  Reconnaissance

k.  Law Enforcement

l.  Aerial Resource Management

m.  Military Operations

n.  Emergency Management

o.  Others (Please Specify) _____

**4.  Please rate the following facilities of the airport according to their present condition as per your judgement.** *Put a (✔) mark to register your response.*

| Sl. No | Facilities | Very Poor | Poor | Average | Good | Excellent |
|--------|------------|-----------|------|---------|------|-----------|
| 1 | Airport Terminals | | | | | |
| 2 | Runways | | | | | |
| 3 | Parking | | | | | |
| 4 | Periphery Roads | | | | | |
| 5 | Airport Lightings | | | | | |
| 6 | Non Directional Beacon System | | | | | |
| 7 | Area Navigation System | | | | | |
| 8 | Lateral Navigation System | | | | | |
| 9 | Human Weather Observation System | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| 10 | Automated Weather Observation System | | | | |
| 11 | Airport Lounges | | | | |
| 12 | Air Traffic Controls | | | | |
| 13 | Aircraft ground handling | | | | |
| 14 | Aircraft hangers | | | | |
| 15 | Airport people mover systems | | | | |
| 16 | Airport Apron | | | | |
| 17 | Airport movement area safety system | | | | |
| 18 | Airport security system | | | | |
| 19 | Airport surveillance radar | | | | |
| 20 | Aviation light signals | | | | |
| 21 | Flight information display system | | | | |
| 22 | Landing area | | | | |
| 23 | Departure control system | | | | |
| 24 | Duty free shops | | | | |
| 25 | Automatic Terminal Information Service | | | | |

**5.** **Rate the below mentioned airport infrastructures and facilities according to the need of renovation and upgradation.** *Put a (✓) mark to register your response.*

| Sl. No | Facilities | Urgently Requires | Requires | Not Sure | Does not Require |
|---|---|---|---|---|---|
| 1 | Airport Terminals | | | | |
| 2 | Runways | | | | |
| 3 | Parking | | | | |
| 4 | Periphery Roads | | | | |
| 5 | Airport Lightings | | | | |
| 6 | Non Directional Beacon System | | | | |
| 7 | Area Navigation System | | | | |
| 8 | Lateral Navigation System | | | | |
| 9 | Human Weather Observation System | | | | |
| 10 | Automated Weather Observation System | | | | |
| 11 | Airport Lounges | | | | |
| 12 | Air Traffic Controls | | | | |
| 13 | Aircraft ground handling | | | | |
| 14 | Aircraft hangers | | | | |

| 15 | Airport people mover systems | | | | |
|----|------------------------------|---|---|---|---|
| 16 | Airport Apron | | | | |
| 17 | Airport movement area safety system | | | | |
| 18 | Airport security system | | | | |
| 19 | Airport surveillance radar | | | | |
| 20 | Aviation light signals | | | | |
| 21 | Flight information display system | | | | |
| 22 | Landing area | | | | |
| 23 | Departure control system | | | | |
| 24 | Duty free shops | | | | |
| 25 | Automatic Terminal Information Service | | | | |
| 26 | Others (_____ _____) | | | | |

**6. Is the airport financially viable?**

    a. Yes

    b. No

7. **Please shed some lights on the operations and facilities of the airport that require maximum budget allocation.**

_____

_____

_____

_____

8. **Please share your views on factors that affect the smooth and efficient operation of the airport.**

_____

_____

_____

_____

9. **What structural changes are done to facilitate better functioning of the airport?**

_____

_____

_____

_____

10. **How will you rate the airport in comparison to rest of the international airports of the country?**

_____

_____

_____

_____

11. **How will you rate the airport in comparison to international airports of other developed countries?**

_____

_____

_____

_____

**12.** **Any suggestions for improvement of structural design and performance of the airport?**

_____

_____

_____

_____

**13.** **Comments, if any,**

_____

_____

_____

_____