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Principles of Airport Design in Hot and Humid climates with a Focus on Lightweight Structures as a Design Element in Architecture

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Abstract

Passenger terminals and modern airports are symbols of progress and renewal in any city or country. In this context, architects bear the significant responsibility of integrating this structural change with factors such as precision, speed, order, and aesthetics. It should be noted that many of these airports and their terminals are quite old and were constructed and utilized according to past standards and knowledge. Therefore, with the passage of time and considering all structural changes and even public perceptions, the renovation and updating of these places (with modern knowledge) is unavoidable. A suitable and well-designed terminal at an airport can significantly enhance passenger satisfaction at first glance and play a crucial role in representing the culture of a region. An airport design that considers the structure from the outset, with attention to structural calculations and placement during the design phase, is essential. This study focuses on the integration of structural considerations into architectural design to ensure that these two aspects are not separated but merged. The use of lightweight structures is examined in this research with regard to seismic activity and preventing harm to individuals regularly present in these spaces. Therefore, Utilizing the environmental conditions of Bushehr (a city with a hot and humid climate in southern Iran), such as high humidity and proximity to the sea, is a crucial factor. Choosing the appropriate structure can enhance the sustainability of the airport. This research analyzes covering and lightweight structures for large spans (novel structures) by reviewing existing documents and case studies.

Keywords: airport design, design and architectural structure, lightweight structures, structural architecture, novel structures

1- Introduction

Today, especially in developing countries, defining various projects requires special attention and precision. In these countries, the focus on prioritizing the execution of projects is often reduced to profit and need. It is crucial to ensure that cultural and social projects, and similar initiatives, can only gain acceptance and be successful in society if the groundwork for their acceptance has already been laid. Otherwise, past experiences have shown that the mismatch between these projects and the economy of these countries raises doubts about their feasibility. It may be more useful to integrate advancements in both culture and civilization, as well as in technology and engineering, into these projects in a subtle and tangible way, while pursuing values at the core of needs and operations.

In today's industrial world, where technology takes precedence, the urgency and impatience for speed in work is undeniable.The development and progress of information transfer in today's era has led to it being referred to as the Information Age. Therefore, it is essential to recognize that the need for high speed can be of utmost importance and worth discussing. When considering transportation, the focus on airplanes as the fastest means of travel leads us to access to airports in today's world. Airports, regardless of the high economic demand and efficiency, are structures that can provide an appropriate platform for showcasing a society's cultural products on one hand and, on the other hand, serve as a suitable venue for demonstrating the advancements in technology and art, both in the fields of architecture and construction, as well as in other industries, particularly aviation, electronics, and telecommunications, which themselves symbolize and represent today's world. The statement argues that airports serve as significant cultural and symbolic gateways for cities, impacting the perception of foreign cultures more than other types of functional spaces.

This underscores the airport's role not just in transportation but in creating memorable experiences and preserving cultural identity. In this article, we will follow this path to present this controversial and relatively prominent space:

1- Discussing the airport and its types, including the considerations for choosing the type of structure and related issues.

2- Analyzing the main components of the airport, identifying the weak points, strengths, threats, and issues within the airport site and space from an architectural perspective.

3- Recognizing and analyzing significant architectural points, and their impact on the design process.

4- Introducing the terminal as the main building of the airport, examining its components in terms of dimensions, psychological impact, and their role in achieving the main objectives of the plan.

5- Studying successful examples worldwide, analyzing these cases in terms of progress and failures related to the project goals. In order to standardize and use the necessary equipment in airports, guidelines have been issued by various international organizations, including:

1- The International Civil Aviation Organization (ICAO), which issues instructions and standards, including those published in documents such as Annex 14 and Advisory Circulars. These publications are revised periodically and republished.

2- The Federal Aviation Administration (FAA), which collaborates with ICAO and issues standards related to airport operations. The last reference publication related to airport architectural design was issued on April 22, 1988, under the title "Airport Architectural Designing," which includes standards and documents.

3- In Iran, the management and planning organization has published all topics related to airports in two documents: Number 197 (Regulations for the Use of Land Around Airports) and Number 223 (Regulations for the Design of Airport Grounds).

2. statement of the problem:

In this research, the discussion of incorporating structural perspectives into architectural design is intended to ensure that these two elements (structure and architectural design) are not separated but integrated with each other. In the past, architects designed not only the building itself but also its structure. In the modern era, architecture and structure became distinct specialties. Structure was placed in civil engineering departments, while architecture was housed in art faculties. After the separation of structure and architectural design, new disciplines emerged that aimed to bridge this gap and bring the two fields closer together.

For example: between the fields of architecture and comprehensive studies, which includes comprehensive studies of architecture, comprehensive studies of space in architecture, and etc. Additionally, between architecture and psychology, such as environmental psychology.

In the modern era, a project designed by an architect is calculated by structural engineers and constructed by a third party, whereas in the traditional era, these three roles were combined into one. In the past, the architect was also responsible for the design of the structure and the execution of the building. However, in the modern era, building design, structural design, and execution have become distinct roles.

This research highlights the problem where these three aspects design, structure, and implementation have lost their interconnection. In architecture today, there is often a focus on aesthetic beauty, while builders are concerned with durability. Ideally, architecture should integrate all three aspects simultaneously: beauty, structural integrity, and construction. This means considering both the stability of the building and its aesthetic qualities.

In this research, the issues between the fields of structural engineering and architecture are explored and analyzed.

3. Theoretical studies:

This section discusses the fundamental issue that the interdisciplinary relationship between architectural design and structural design has been neglected, creating a gap between the two disciplines. Also, the symptoms of the problem can be expressed as follows: the lack of integration and unity between structural and architectural design, the separation between structure and architecture, and the resulting low quality of constructions. This issue arises from the lack of coordination and harmony between the structure and the space, as different offices and engineers handle them separately, leading to poor quality in buildings, whether for airports or residential buildings .

This research identifies the problem factors as: the specialization of fields, the gap between architectural and structural research areas, the divergence between structure and architecture, the lack of unity between architectural and structural faculties, and the absence of defined interdisciplinary projects. It should be noted that improving the quality of structural design, aligning architectural and structural design, integrating space and structure, and enhancing both architects' understanding of structural elements and structural engineers' familiarity with architectural design are key outcomes of addressing the problem. One issue in contemporary architecture is the integration of structure with technology, making an understanding of technology essential.

Historically, architecture was linked with art; today, it encompasses both art and the technological aspects of science and industry. This research aims to explore the perspective on the structure. During its useful life, a structure is always subjected to external forces such as earthquakes and wind. As these forces act on the structure over time, there is a potential for damage. Therefore, it is crucial to use methods to reduce or neutralize these forces. The climate adaptation of the black tent is considered one of the most significant, ancient, and widely used forms of nomadic housing. The natural heating and cooling methods employed in these tents have been investigated, and understanding these practices can contribute to sustainable development.

This knowledge may also aid in replicating these lightweight and mobile dwellings in similar environments. Solutions for utilizing these tents effectively are also discussed. However, the behavior of tent structures remains largely unknown to many architects, and there has been little effort to explore this area. Despite their temporary, mobile, and seemingly vulnerable nature, these tents are actually safer and more reliable than many traditional systems due to their lightweight, portability, and integrated, flexible waterproof shell.

The use of this type of structure has few restrictions and can adapt its shell according to environmental conditions. Notably, this structure reduces energy consumption and is less vulnerable to earthquakes, which annually cause significant damage. Its lightweight fabric necessitates only lighter metal profiles, and since the entire roof system is prefabricated, the overall project execution time is considerably shortened.

3-1 Theoretical Principles of Airport Design:

Transportation is one of the main foundations of economic and social development for any country. In fact, the progress and economic power of each country are closely related to the efficiency of its transportation system. The ever-increasing development of the aircraft industry and the growing tendency to move and transport passengers and goods in the shortest possible time have significantly advanced the air transportation industry, with airports playing a crucial role. Air transportation is a significant component of infrastructure and plays a crucial role in the production and consumption cycle within the service sector of national economies. In Iran, according to official statistics, direct transportation activities contribute more than 9% to the national gross product, 15% to the total gross capital in business machinery and equipment, and support nearly 3 million employees in the country.

Coordinating and controlling project progress, collecting information, studying plan details, and managing cargo operational, complementary equipment, communication systems, contracts, and specifications are critical aspects that should be carefully considered before planning and design.

3-2 Theoretical foundations of structural design:

Throughout human history, there have always been buildings constructed primarily from structural elements, such as Eskimo houses and Indian tents. In today's fast-paced society, the close cooperation of architects and structural engineers, or the involvement of an engineer skilled in both architecture and structural design, is essential for an integrated and simultaneous design process. Therefore, this article emphasizes the benefits of non-traditional structures, such as building stylization, structural integrity, and the avoidance of internal complications. These benefits include cost reduction, diverse creativity, and the creation of attractive visual landscapes through architectural forms. To fully appreciate the aesthetic dimension in structural design, cooperation between structural engineers and architects is crucial. Unfortunately, in Iran, these issues are often overlooked, leading to several problems due to the lack of integrated systems.

In this regard, this article explores the root of this deficiency through academic discussions in universities. Such discussions lead to the creation of structures like the wings of the Milwaukee Art Museum or the covers of Jeddah Airport, which serve as fundamental examples of the intersection between structure and architecture. This approach, termed 'structure as architecture, integrates the structural and aesthetic aspects of a building, emphasizing the importance of both technical and architectural features. Therefore, it is crucial that architects and structural engineers work as one. By combining these roles, one can comprehensively address all design aspects, including space design, human needs, the psychology of space, and how users interact with the structure and its spatial form, as well as other principles of architectural and structural design.

3-3 Understanding and Structural Behavior:

Understanding the behavior of structures is essential for accurate comprehension, correct design, and the reliable and safe implementation of buildings. This understanding is crucial throughout all stages of building design and construction from the initial architectural design phases to structural calculations and the final implementation. Particularly, during the selection of an appropriate building system, recognizing structural behavior is a key factor in ensuring proper selection, accurate calculations, effective design, and secure implementation.

Architects and structural engineers urgently need this knowledge. Additionally, a fundamental grasp of building behavior is necessary for effective coordination between architectural design and structural calculations. Successful architecture cannot be achieved without a detailed understanding of structural behavior.

The process of visualizing or imagining a structure is an art that is essentially achieved through inner experience and direct understanding, and is never the result of mere reasoning and analogy. (Edward Truja)

Construction technology is a branch of science, but shaping it is an art. (Roderick Mills)

Structure and architectural design are inseparable, whether in a simple shelter or in an enclosed space for worship or business. In any case, a building must be composed of materials that are resistant and stable against natural forces such as weight, wind, and fire. As Vitruvius commanded in Ancient Rome: Architecture must have stability and strength (structural durability), usefulness (functionality), and attractiveness (beauty). Among these three factors, stability and strength are the primary criteria. The need for stability and durability is addressed through construction methods. The notion that structural correctness is a basic condition for successful architecture is somewhat seductive.

There are many examples where designers have ignored general principles of structural design to achieve aesthetic and functional goals, similar to works of sculpture where support systems or construction methods are hidden or camouflaged. This is often seen in small buildings where meeting structural needs is relatively simple. In these cases, structural requirements might be met in various ways, some of which may be ineffective or inappropriate in terms of structural principles. However, in larger buildings, it is impossible to overlook the principles of structural design and systems, which significantly impact the design's performance and beauty.

In traditional architecture, the architect was known as the primary builder of the building and was responsible for designing the overall form and basic parts of the structure. This was due to the use of traditional structural systems and the experiences gained from previous buildings. The Industrial Revolution led to the construction of larger and more complex buildings. With the introduction of space frames and elevators, these buildings became taller, and with the use of steel and concrete beams and columns, electric lighting, and mechanical ventilation, they became more expansive.

As a result of this increased complexity in building design and implementation, it became impossible for a single person to design the entire architecture, structure, materials, and mechanical systems. The architect's role evolved to that of the head of a design team, working with consultants and technical experts. Strengthening the leadership role of the design team and managing the design process at all stages requires that the architect be knowledgeable about building and structural design principles. There are three reasons for this. First, knowing the architect allows for better communication with the consultants. Second, the architect can incorporate the consultants' opinions into different parts of the plan and manage budgetary and completion issues.

The most important reason is that the architect can oversee the technical documents from the initial stages of design until the overall shape and geometric order of the building are finalized.

3-4 Structural design for architecture:

Today, in most countries with a rich and advanced architecture and structural industry, architecture and structure are often complementary and integrated. Advances in technology and modern sciences aim to achieve works that are both aesthetically pleasing and structurally sound. This integration reduces the separation between structural design and architecture, leading to more efficient use of time, space, and energy. Clear examples of this integration can be seen in architectural works where the coordination of structural components with architectural design is evident. This harmonious blend can be observed in ancient Iranian architecture, where architects skillfully combined structural engineering with attractive design, creating buildings that were both strong and visually appealing. Everything that exists in the world has a structure.

An inseparable part of architectural design involves considering space coverings, foundations, slabs, columns, and roofs. The combination of architecture and structure integrates art, aesthetic values, and technology, taking into account materials, their behavior, performance, and implementation.

Structural design can be seen as the process of arranging materials in three dimensions to achieve predetermined goals with maximum efficiency. Many people are familiar with the phrase "form follows function," recognizing that the type of structure used is related to its intended function in buildings like bridges, dams, sports facilities, power plants, hospitals, and silos. However, focusing solely on how functional needs determine the artistic engineering of structures yields significant results. Research shows that the main goal of architectural design is to create forms that meet both the functional needs and aesthetic standards of a building. Similarly, the goal of structural design is to create forms that meet practical needs while efficiently supporting applied loads. When structure and design are seamlessly integrated and fulfill the design idea effectively, it results in outstanding performance. This unity of idea, structure, and form can create enduring landmarks, such as the Eiffel Tower in Paris, the Sydney Opera House, and the Azadi Tower in Tehran.

The structure in architecture is considered a fundamental aspect of establishing space. The primary function of a structure is to bear and transfer loads, which ultimately shapes the main framework of a building. Historically, the relationship between structure and architecture involved using materials based on their stability to influence the shape of the structure. What made a building a masterpiece in its era was the integration of modern technology to achieve both beauty and stability. In past architecture, beauty, stability, and structure were not viewed as separate categories; structural efficiency and aesthetic appeal were achieved simultaneously. In the contemporary world, the role of structure in architecture has expanded with the Industrial Revolution, mass production of iron, scientific advances in materials, and the development of structural engineering.

As structural science progressed and specialized, technical requirements often dictated the final form of a building, placing the relationship between structure and architecture at the forefront. Sometimes technology, in addition to playing a role in the stability of a building, exposes parts of the structure, giving it a sculptural quality. This can make the structure a symbol of modern science and technology, or, inspired by nature, a representation of natural forms. Additionally, modern technologies provide architects with greater freedom to create diverse elements and forms, allowing the structure to be integrated in a less visible way within the building.

3-5 The role of structure in architecture:

Architecture is influenced by many factors, including ideological ones. Buildings are also recognized as objects of beauty, often carrying symbolic meaning. Central to the book's argument is the notion that the contribution of structure to achieving architectural goals is significant. The relationship between the structure and non-structural elements of a building can vary. Additionally, some buildings feature widely enclosed elements of space, such as walls, floors, and ceilings.

Figure1 : The Hong Kong Bank building, designed by architect Norman Foster, features an exterior and interior structure that stands out prominently. This design directly contributes to the building's appearance. (Foster and Hunt.1998)

3-6 Structure design in nature and architecture:

Structural design in architecture has always been influenced by structural design in nature at various levels. Understanding the relationship between these two fields is crucial. This framework paper aims to connect them and establish a theoretical basis. Structural design variables are developed, with each variable in nature being examined in architectural structures. This analysis helps us determine which variables to emphasize in architecture and consider future directions for structural design. (Collins &Mosser, 2004)

Humans have caused more damage to nature than any other species on the planet. Notably, a significant part of this destruction is due to neglecting environmental issues in design and construction. We can mitigate much of this damage by adopting architectural practices that aim to reconnect with nature. Architecture can serve as a tool to achieve the goals of environmental protection, and contemporary architectural approaches, such as ecological design, environmental design, green design, sustainable design, and ecological sustainable design, are all aligned with these goals. These approaches share common features in their commitment to sustainability.

So, each of these approaches aims to achieve a mutually beneficial relationship between nature and humans, addressing human needs while protecting nature. In other words, emphasizing the combination and harmony between human environments and nature is natural.

In architecture, various approaches to incorporating nature can be observed and followed, with nature being adapted in different ways across various components of architecture.

For example, using nature in architectural design can imitate the geometry, form, and structure of animals and plants. In this regard, natural processes may be utilized. It should be noted that these approaches are not completely separate and share many common aspects. To effectively incorporate nature into architectural designs, extracting principles and foundations from nature is a suitable approach. In the process of creating an architectural work, achieving a cohesive and simultaneous design of both structure and architecture has consistently produced successful results. Architectural and structural designers are now exploring how to integrate natural structures into their designs. This approach can yield unique patterns and potentially optimal results in architectural and structural design.

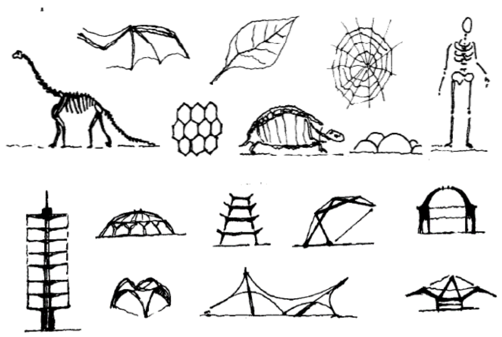


Figure 2: Examples of structural systems in nature. (collins،mosseri،2004).

Nature is an exceptional designer and master engineer, selecting the most suitable forms and shapes for objects based on their needs. It uses the simplest, most appropriate, and effective mechanisms for stability and durability. Interestingly, in nature, the form of an object and its supporting components mutually define each other.

By the end of the 20th century, advancements in technology and research by architects and engineers enabled the construction of lightweight structures. This achievement was largely inspired by natural structures and principles. Generally, architecture can follow three approaches: 1- Formal Approach: In this approach, nature is used symbolically in architecture.

2- Constructivist Approach: This view examines natural objects from a structural perspective to understand how they withstand forces.

3- Evolutionary Approach: This approach incorporates models of natural growth and development into architectural design.

Design variables represent the designer's freedom of choice and serve as a tool for comparing designs in nature with those in architecture.

This comparison helps in understanding the structural systems of both domains and in identifying key lessons learned from nature. These variables are not necessarily independent and often interact.

They are related to the designer's decisions about design and construction. The methods and technologies used in natural systems can influence the design and construction processes of architectural projects. This process is akin to biological development, where tissues and organs evolve from cells. (collins،mosseri،2004)

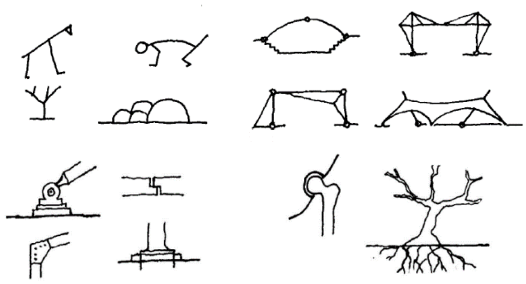


Figure 3: General structural geometry, and Structural Relationships in Nature and Architecture.

3-7 Structure, architectural form and construction technology:

Before discussing the form and structure and their relationship, two crucial categories, the presence of technological phenomena must be assessed and measured. It is noteworthy that the period, time, and place of the architectural study do not matter. To evaluate architectural works from different periods and understand the presence of structure and the relationship between structure and form, the type and extent of technology used during that time must be considered. For this reason, technology has two complementary and distinct aspects that affect the amount of form and structure innovation:

- Construction and implementation technology

-Materials technology

In construction and implementation technology, various factors such as the science of calculating building stability and handling design geometry are crucial.

The implementation of any type of geometry or model depends on the amount and type of scientific knowledge that affects the stability of the structure.

Accessing this knowledge, whether experimentally or formally, has significantly impacted the shape of structures, thanks to advancements in computer technology that allow precise stability calculations.

3-8 Philosophy of Aesthetics in Architecture:

Nature is the primary source of inspiration, and humans achieve beauty through their interaction with it. Aesthetics, the science that deals with art and the perception of beauty, plays an essential role in our lives. The philosopher and theoretician Plato is one of the greatest aesthetes who understood beauty in its logical concept, as seen in the school of idealism and the thinkers of later periods. Vitruvius states that in architecture, one should focus on strength, usefulness, and elegance. Beauty is achieved when a building has a pleasing appearance and the symmetry of its components is accurately calculated. A building and its hall are considered beautiful when the proportions between its components adhere to specific rules. Relying on Plato's and Kant's theories, Hegel distinguished between two types of beauty: natural beauty and artistic beauty. He considered artistic beauty to be superior because it is found in the soul and can be learned. In modern architecture, these two types of beauty are evident in the works of Frank Lloyd Wright and Le Corbusier.

Wright's concept of beauty in organic architecture is derived from nature, while Le Corbusier incorporates forms from modern industry, reflecting contemporary techniques. Architecture aims to evoke emotions through its forms, but the connection he creates with this approach seems to challenge this theory. He intends to present a framework for measuring the world system.

4. Airport architecture:

In the design of a typical parking lot, attention must be given to the dimensions of the car, the angle of rotation, the parking method, and the space required for pedestrian movement.

These factors have always been crucial and debated, so it is important to acknowledge that considering the aircraft's dimensions, movement, and parking, especially in the context of designing flight process components, plays a significant role. Therefore, this chapter will discuss the details of these issues from various perspectives and their effects on architectural design.

4-1 Airport Design Principles:

Airports are classified in various ways to provide services for international or domestic passengers.

These classifications are managed by different institutions, such as the International Civil Aviation Organization (ICAO), the Federal Aviation Administration (FAA), and the United States Air Force. Some classifications are based on the length of the airport runway. For instance, airports can be categorized from D to A, where D represents the shortest runway length and A the longest.

Type-A airport - ocean transport
The minimum runway length is 2550 meters
The minimum width of the runway is 60 meters
Permissible weight for each aircraft wheel is 45 tons
The minimum distance between two track charts is 450 meters
The minimum building distance is 225 meters

Table one: (13)

Type-B Continental Transportation Airport
The length of the runway is at least 2150 meters, at most 2550 meters
The minimum width of the runway is 60 meters
The acceptable loads per wheel of 35 tons
The minimum distance between two track charts is 450 meters
The minimum building distance is 235 meters

Table two: (13)

Type-C airport for international transportation
The minimum length of the runway is 1800 meters The maximum length is 2150 meters
The minimum width of the runway is 54 meters
The acceptable load for each wheel is 27 tons
The minimum distance between the Axes of two parallel runways is 450 meters
The minimum building distance is 225 meters

Table three: (13)

Type-D airport for domestic transport
The minimum length of the runway is 1500 meters and the maximum is 1800 meters
The minimum width of the runway is 45 meters
The acceptable load per wheel is 20 tons
The minimum distance between the center and center of the runways is 450 meters
The minimum building distance is 225 meters

Table four: (13)

4-2 Choosing the location of the airport:

Choosing the location of the airport is subject to the following conditions:

1- generalities

1-1 Topography

1-2 Geology

1-3 Meteorology, condition of surrounding built areas

1-4 Proximity to existing transportation networks

1-5 possible development in the future

1-6 Issues such as runways, airplane traffic routes, terminal buildings, protection and maintenance area, fuel storage, and etc.

1-7 Full use of the airport: It is necessary and obvious that the location of the airport for small cities should be chosen in a way that allows it to serve two or more cities. In the design of airports, the expansion plan, which should project at least 20 years into the future, must be kept in mind and revised regularly to accommodate changes in air traffic volume and nature due to advancements in aviation and other innovations.

4-3 Design of various airport systems:

Generally, two air transportation systems are considered worldwide, which include single airports and scattered satellite airports.

4-3-1 Single airports:

The rapid expansion of air transport to save time and travel costs increases each country's need to develop its air transport fleet, which in turn leads to greater pollution from vehicle traffic and noise. Consequently, this disrupts the region's ecosystem. This type of airport should be used primarily for long-haul flights and is less suitable for domestic routes.

4-3-2 Satellite scattering system:

As described in case A, concentrated airports are not very suitable for short domestic flights. If the increase in air transportation in a city requires the development of an airport, there are practically two solutions:

First: Creating a new airport separate from the old one.

Second: Expanding the existing airport.

Satellite airports rarely reduce air traffic significantly. Experience shows that if 30% of air traffic is handled by satellite airports, they may only reduce the overall air traffic by 20%. Additionally, the high cost of investment in such airports, combined with low user acceptance, often leads to financial restrictions and economic losses that can result in rapid failure and bankruptcy. To effectively reduce air transport traffic and utilize satellite airports, the following suggestions are proposed.

1- air traffic control

2-The separation of domestic and foreign flights

3-The use of scattered airports for cargo transportation.

4-4 Airport Architectural Design Studies

The main job of the airport is to transport passengers through air travel.

Airport planning should be done in the following order.

4-4-1 preliminary research on:

A- Physical issues (land boundaries - topography of the region - geology)

B- access to space (by air and land)

C- The environment in relation to the urban context (noise, pollution, landscape)

D- Resources: including financial resources, human resources, materials, economic evaluation, demographic characteristics, population

E- Prediction of traffic needs

4-4-2 Preliminary design (based on priorities)

A- Drawing the plan for the whole airport (spotting)

B- Drawing a plan for each of the relevant parts with regard to air and ground movement. In this part of the airport terminal, the space has been divided into two parts, which are common on the ground side and the air side, and each has its own standards and equipment.

C- In the aerial plan, pay attention to the design of the runway-crawl runway and... .

D- In the ground plan, the following issues are raised:

- Passenger terminal with park area

- Ground transportation

- Airplane cargo terminal

- Aircraft storage area

- Airplane food preparation

- car rental place, hotel, offices which actually all of them lead us to (subsections)

4-5 Types of airports based on passenger volume:

Airports are categorized based on whether they handle international or domestic flights. In these airports, operational units, such as rooms and offices, should be available as described below.

4-5-1 Class 1 airport:

If the control tower anticipates another operational unit called the approach control along with approach radar, in that case, special rooms and offices will be required in the building under the tower.

4-5-2 grade 2 airport:

The volume of traffic and the operational needs require that the unit approach flight control by knowing the positions. Air control should be performed in a limited operation without using approach radar.

Flight approach units, telecommunications, and related electronic equipment should be provided on three floors below the tower.

4-5-3 grade 3 airport:

In a Grade 3 airport, due to its proximity to a larger airport and limited operational needs, there is no dedicated flight approach control. Therefore, the operational control of the airport is limited and managed by the flight control tower.

4-6 Airport Classification Based on Airspace:

The airspace of each airport is classified into three categories: grade, group, and class.

4-6-1 Grade: This classification is based on the length of the runway and is divided into four grades, from 1 to 4.

4-6-2 Group: Airports are classified into groups A through F based on the dimensions of the aircraft, such as wingspan and wheel distances. Airports that do not fall into these classifications are divided into six additional groups.

4-6-3 Class: Navigation devices are assigned for aircraft approaches based on these classifications.

- Airspace rules for approach runways without devices and runways

- Without precision approach and flight runways with precision approach are different.

The above classification depends on the following:

1- Obstacle limit surfaces: It means all surfaces that must be free of obstacles for the flight or landing of the aircraft.

2-Conical surface: It means a sloping surface that starts from the environment of the internal horizontal surface and goes towards it.

3- Internal horizontal surface: It means the surface that is located horizontally above and around the airport.

4-Transitional surface: a combination of a compound inclined surface, including a concave side and a part of the side

located on the surface of approximation and the inner horizontal side

5-Internal transfer level: It is a level similar to the transfer level but close to the lower band.

6- Level of refusal to sit: It is a plane inclined from a certain distance after the threshold line

started and continues between two internal transfer levels.

4-7 Selecting a Suitable Site for an Airport:

In general, choosing the right site for a city's airport depends on the following factors:

1- The maximum distance from the airport to the city center should be 30 km.

2- For small cities, try to choose a centralized location for the airport, if possible.

3- The site must meet the following conditions:

The runway location should be such that, in the direction of take-off, the slope is 2% up to a radius of 15 km. In the approach direction, the slope should be 2% up to a radius of 3000 meters. Beyond this radius, there should be no obstacles up to 3600 meters with a slope of 5%, and from 3600 meters to 8400 meters, the slope should be 0%. The runway direction should align with 95% of the prevailing wind. If local climatic conditions do not necessitate this, select two or more runways depending on the direction of the dominant winds.

5. Airport structures:

5-1 Truss system:

Being technically correct in architecture results in a kind of grammar, similar to how grammar is essential for effective writing and reading. Trusses, which consist of tension and compression members, are interconnected in a triangular configuration with joint connections. Their internal forces are entirely axial, meaning they handle pressure or direct tension without bending or cutting. Triangular geometry is fundamental to truss behavior because a triangle is inherently geometrically stable. The shape of a triangle changes only by altering the length of its sides. Therefore, due to hinged connections, a truss only needs to resist tension and compression (without bending) in its triangular members for stability. In contrast, polygons with more sides require one or more rigid connections to maintain their shape, which can introduce bending. If truss connections are frictionless or perpendicular to the members' axis, secondary bending can occur. This bending is typically minimal compared to the axial forces in the truss members and is often ignored.

5-2 Cable structures:

The beauty of cable structures lies in their functional and aesthetic proportions. Metal wires, strings, and bars are examples of tensile members that function like cables. A classic example of a load-bearing structure is a cable that supports a weight hanging from it. The weight is distributed along the cable, which is stretched in a straight line between the connection points and the weight.

A more practical example is a cable structure between two supports, designed to support a suspended load in the middle of the span. Under such a load, the cable bends and each support bears half of the total weight. Since the weight of the cable is insignificant compared to the load it supports, the cable forms a V-shape.

The tensile force in the cable depends on the load and the cable's slope. If the supports are close together and the cable's slope is steep, the tensile force in the cable is approximately equal to half the load (with each side of the cable supporting half of the load). Conversely, if the supports are far apart and the cable's slope is shallow, the tensile force in the cable will be significantly higher.

5-3 Trusses:

A truss is a structural framework composed of triangular shapes, which support loads through a network of interconnected members. In a truss, the members experience only axial forces tension and compression, while shear and bending are minimized. Although some bending stress might occur due to friction and distributed loads, it is generally considered alongside axial forces in practical analyses. The triangle is the fundamental geometric unit because it maintains its shape without altering side lengths, unlike other polygons such as rectangles, which can be unstable. When a cable is stretched between two fixed points, the horizontal forces are balanced by the supports. If one support is hinged and the other is a roller, the system may become unstable, as the roller support can only react to vertical forces, while horizontal forces could cause movement.

5-4 Tensile system:

Structure with the shape of a rope curve (known as form active) of the structure. There are those that use a combined form against incoming loads make that tension the resulting internals should only be in the form of direct pressure and tension. Consider a cable between two supports Sometimes it is stretched and bears a load. The cable takes a V- shape under the load that enters from below and is only under tension. If another load is added to it, the form of loading changes and it is divided into three sections, each of which carries a part of the load They are divided. Other additional loads increase the number of divisions to become the full curved form that performs the distribution function. In any case, the cable is only under tension.

5-5 Cable structures:

The best engineer in the animal world is a spider, whose web is as soft as water and as flexible as a tree. This web is an amazing structure that showcases all these skills. "Horst Burger"

5-5-1 curved wire ropes: The catenary is a form of a rope curve for a cable under no external load other than its own weight (and only the weight of the cable) which creates a curve. A parabola, on the other hand, describes the curve of a suspended cable with uniform loading along the horizontal span, regardless of the cable's weight. When the span-to-rise ratio exceeds 5, both forms are closely similar, and simple mathematical calculations can be used to determine and analyze their shapes.

5-6 Design of Membrane Structures:

Horst Berger, an engineer known for his work on tent structures, notes that despite significant advances in building materials and technology, many architects still lack a basic understanding of the design and behavior of tent structures. He points out that terms like 'shell' and 'tent' often obscure the fact that these structures can be highly reliable and safe, sometimes more so than traditional systems. Modern tent structures benefit from advanced technologies such as 3D modeling for design and internal tensioners to calculate stresses. For durability against wind forces and to extend the structure's lifespan, it is crucial that tents are designed with double curvature. Some tents, supported by cables and towers, resemble bridge structures in their design and stabilization.

Picture 4: Sea World booth. (1980, San Diego, California; Structural Engineer: Horst Berger). Note that the compression bars used to maintain the vertical lines of the roof have eliminated the need for a central post. Additionally, the requirement for rope cables stretched under the perimeter structure has been removed, thanks to the horizontal restraint bars, which have resolved the issue of internal thrust forces. (16)

5-7 Compressed air structures: (pneumatic structures)

Compressed air structures rely on internal air pressure to maintain their shape and transmit loads. Unlike cables, these structures primarily transmit tensile forces through the surface of the shell. The design of compressed air tanks involves forming them to carry loads and regulate the air inside, often resulting in a curved, rope-like shape.

Understanding how internal air pressure affects the shell is crucial for structural design and analysis.

5-8 Shell systems:

Shell structures are usually classified according to their shape. They can be classified as follows:

Synclastic (or clastic) shells, such as domes, have two curvatures with lines of curvature being similar in each direction. Expandable shapes, such as cones or cylinders, have curvature in one direction and straight lines in the other direction, and are created by bending in a flat plane. Anticlastic shells, such as horse saddle shapes including conical, parabolic, hyperbolic, and pseudo-hyperbolic forms, have double curvature with curvature lines in opposite directions. Additionally, there are free-form shells that are not derived from mathematical calculations.

5-9 Folded plate structures:

The use of thin, flat surfaces in construction is limited on a small scale. The strength and rigidity of these surfaces can be enhanced by folding them, which increases their effective cross-sectional height and bending strength. A folded sheet structure, with its flat, folded surfaces, transfers loads through tension, compression, shear, and bending that occurs only at the folded parts. While the space between the folded sections may be small compared to the overall opening, resulting in relatively low bending forces compared to tensile and compressive forces, folded sheet structures are effective, particularly in applications like roofs where loads are uniform and widespread. These structures are commonly made of reinforced concrete, but materials such as wood, metal, and plastic are also used, especially where large openings are not required.

5-10 Stretch fabric structures:

In this type of structure, the relationship between force and geometry determines the shape not solely by the structural engineer or architect, but through their interaction with the fabric and its supporting structures. Since the fabric cannot withstand shear and bending stresses, the incoming loads turn into tensile internal forces, which minimizes the dimensions of the structural members.

This reduces material usage, resulting in a more economical, stable, innovative, and aesthetically pleasing structure. Optimization of fabric structures begins with initial shaping and continues through detailing under design loads. Previously, balanced shapes were achieved through complex physical modeling, but advancements in technology now allow numerical methods to determine the stable shape of the structure. Tensile fabric structures, also known as membrane structures, are a subset of the larger category of tensile structures due to their purely tensile behavior under forces. They are classified as lightweight structures because of their low weight.

This structural system uniquely combines architecture and engineering in a single design. One of the most attractive features of fabric ceilings is their ability to transmit light, creating bright and lively interior spaces during the day and making their forms appear shiny and bright from the outside at night. Although the light behavior is complex due to the interaction between various fabric properties and light sources, a key feature of structural fabrics is their light transmittance. This means the fabric's ability to directly transmit part of the light that hits it to the space behind it. The light transmittance of structural fabrics, such as PVC-coated polyester and Teflon-coated fiberglass, typically ranges from 5 to 25%. This property significantly aids in providing natural daylight, which has led to the widespread use of these fabrics in sports venues, exhibition halls, and atriums, among other applications. It functions as a type of skylight ceiling.

6. Review and Analysis of Case Studies

There are few topics in architecture that are completely novel and unprecedented. As a result, different architects offer various solutions to the same issues, and their approaches to solving problems and addressing similar challenges enable new designers to tackle subsequent issues more freely.

Studying executed works is particularly important because they reveal real conditions, and examining the presence of people within architectural spaces and their interactions can help identify potential issues in the project.

The presented examples examine various approaches, including

1-Responsiveness of the design plan to performance

2- Regulation of environmental conditions

3- Quality of indoor space and circulation

Each of them can be discussed in its position as an idea maker.

6-1 Recognition and analysis of similar architectural examples

6-1-1 Name of the airport: TWA Terminal (International)

Airport location: New York City (USA)

Location: Kennedy International Airport

Name of the architect: Erosarnin and colleagues,

Name of structural engineer: Aman and Vetini

Year of construction: 1961

General explanations about the plan:

Movement, dynamism, and anti-static are concepts that EruSarnin, the main architect of this project, mentions in his design. He explains in the context of the airport design:

"Kennedy Airport is the first airport to have terminals designed for a pleasant trip."

It is separated, which allows for the determination of the specifications of the cargoes that were made independently. The result has been a 'clash of riddles' between competing plans and methods. A relatively small building in the heart of TWA's complex of buildings and terminals, it is the most visually appealing structure.

The design features two main curves forming a volume that rises from a single point and soars around, reminiscent of the wings of a bird ready to fly (the bird's flight theme relates spatially to the airport). This beautiful and simple sculptural form illustrates the unique complexity required to create such a work.

Structure and Components: The building resembles a large bird ready to fly and consists of four Y-shaped concrete shells. Each shell is separated from the others by a row of windows. The two larger shells of the arch are elevated from the support members, while the adjacent, smaller shells are placed lower to allow movement of the larger shells. In total, 635 tons of steel and 3058 cubic meters of lightweight concrete were used in this beautiful airport.

- Regarding the topic of environmental conditions and light, the use of transparent windows in all directions allows for the effective use of natural light.

- Concerning sound, the large volume of the terminal space helps to reduce the impact of undesirable sounds. As a result, noise pollution is somewhat reduced. However, the glass walls of the building easily transmit aircraft engine noise, and the extensive transparent walls allow infrared rays from the sun to enter the space. This additional heat places a considerable load on the building's HVAC systems due to the design of the space.

Picture 5: Interior and Exterior facade view of the international airport. (TWA Skyliner Magazine 1964-04-13)

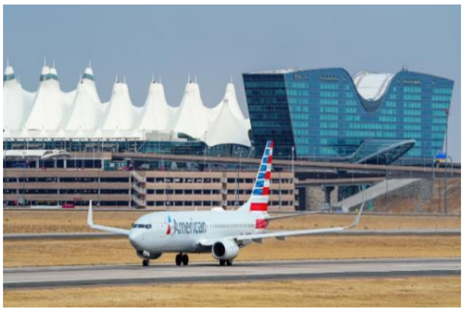
6-1-2 Name of the airport: Denver International Airport.

Designer: Santiago Calatrava.

Location: United States of America.

Structural engineer: Sarood and colleagues.

This project includes the construction of a railway bridge, a train station, a 500-room hotel, a conference center, and spaces for urban gatherings. The central square, hotel, and railway station will be located within a single complex. Calatrava describes the project as follows: "My goal in placing the train station next to an iconic structure is to create a center with an independent character. It is also my hope that this facility will not only meet architectural considerations and requirements but also make Denver Airport a distinctive international hub.




Picture 6: Interior and Exterior facade view of the Denver airport.

The fabric roof was chosen for its beauty, lightness, and speed of construction. Similar to the snow-covered peaks of the Rocky Mountains, the peaks of this building are supported by 34 main steel columns, each 150 feet (45 meters) tall and spaced 60 feet (18.3 meters) apart.

The fabric curvature between the peaks spans 240 feet (630 meters) across the main hall. The roof's fabric covering is reinforced by cables that traverse the ridges and depressions, bearing the highest tensile loads.

The suspended ridge cables support the weight of the building and the snow, while stabilizing cables connect the concave lines at intervals of 40 feet (12.2 meters) to the reinforced fabric roof.

7. Climatic Analysis and Understanding:

Bushehr, in the climatic classification of Iran, is located in a hot and humid climate. In this climate, the sea plays a significant role in the regional climatic conditions.

The climatic characteristic of the Earth's seas is that their water reacts differently to solar heat compared to land. Specifically, water heats up more slowly than land under the same conditions and also retains heat longer.

Consequently, the air near water and land is influenced by this particular situation. The atmospheric elements that are commonly considered in climatic discussions include temperature, humidity level, wind, and precipitation.

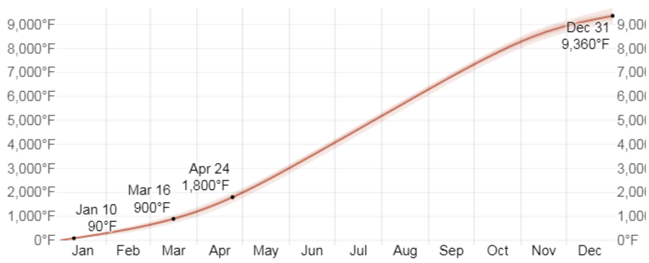


Diagram 1: The average growing degree days accumulated over the course of the year, with 25th to 75th and 10th to 90th percentile bands.

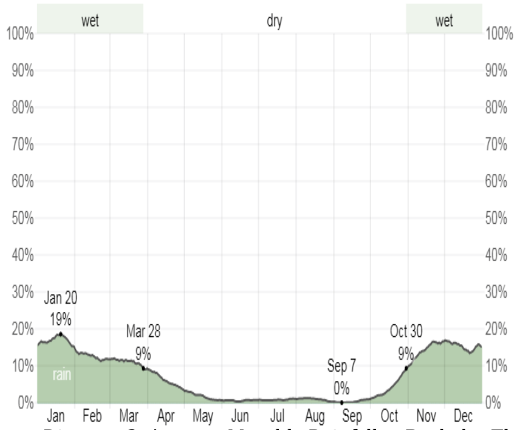


Diagram 2: Average Monthly Rainfall at Bushehr. The percentage of days in which various types of precipitation are observed, excluding trace quantities: rain alone, snow alone, and mixed (both rain and snow fell in the same day).

Although the coastal regions of the Persian Gulf, including the shores of Bushehr Province, are situated in a temperate zone and should, in principle, have four seasons, studies and meteorological data reveal that in practice, there are only two distinct seasons in this area: a relatively cool winter, covering the month of December, and January, and a hot summer, covering the rest of the year. The autumn and spring seasons along the Persian Gulf coasts, including Bushehr Province, are typically brief, fleeting, and not very noticeable.

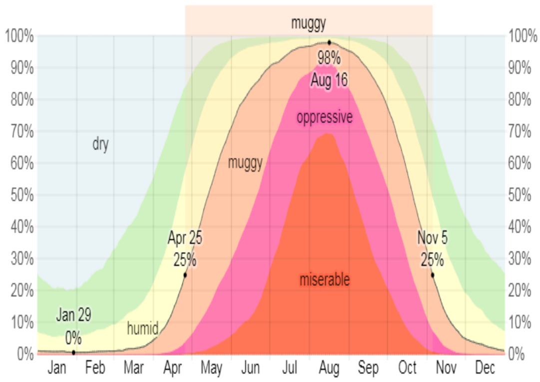


Diagram 3:Humidity Comfort Levels at Bushehr. The percentage of time spent at various humidity comfort levels, categorized by dew point.

In the coastal regions of the province, the temperature difference between day and night and between seasons is minimal due to the proximity to the sea. This is because the humidity from the Persian Gulf prevents a significant drop in temperature during winter and excessive increases in summer, creating conditions for high humidity. The increase in air humidity through water vapor and the influence of local winds are other impacts of the Persian Gulf.

8. Conclusion:

The process of visualizing or conceiving a structure is an art that is fundamentally achieved through inner experience and direct understanding, rather than through mere reasoning and analogy. Structure and architectural design are inseparable, whether in a simple shelter or an enclosed space for worship or business. In any case, a building is composed of materials and must be resistant and stable against natural forces such as weight, wind, and fire. Architecture must encompass stability and strength (structural durability), usefulness, and attractiveness. The discussion of integrating structural considerations into architectural design is important because these two aspects, structure and architectural design, should not be separated but combined. In the past, architects designed both the building and its structure. However, in the modern era, architecture and structure have become distinct specialties. Structure is taught in Civil Engineering faculties, while Architecture is taught in faculties of Arts.

This separation has led to a disconnect among design, structure, and execution. Currently, architecture often focuses solely on beauty, while builders consider only durability. In reality, architecture must address stability, beauty, and functionality simultaneously. Additionally, instead of relying on heavy and expensive materials that can cause severe damage during earthquakes, new and lighter materials can be used to reduce earthquake risks. Also, the use of lightweight structures has also proven to be cost-effective. The issue can be summarized as follows: In architectural design, architects should not only focus on plans and layouts but also consider structural aspects. Architectural and structural design should be integrated and not treated as separate processes.

The recommendation and experience gained from this project highlight the importance of climate considerations. Many architects today design buildings uniformly across different regions of Iran. However, attention should be given to the climate, culture, and comfort of the specific area where the design is implemented.

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