The Ideas to Design the International Airport of Hong Kong on an Artificial Island

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Abstract. The region of Hong Kong is one of the two special and divisional regions in Republic of China. Since China is one of the world major economies, the airports are of high importance in this country. Hong Kong City had an Airport named Kai Tak, which was famous because of the air flows of mountain around and closeness to the people's residence. The airport was closed in the year 1998 as it was dangerous as well as not being able to respond to the passenger’s needs. The thought of building a new airport was shaped in the minds of the experts and it was to build an airport between the two islands in the Sea (artificial island). This study is trying to investigate the airport in terms of some construction characteristics as well as an inspiration source and encourage the engineers to take advantage of the experiences of other countries in the construction industry and interdisciplinary interaction.

Keywords: Hong Kong Airport, Airport design, selecting the location of the airport, the impact of the climate on the airport

INTRODUCTION

The value and importance of airports in this world is to the extent that some economic experts describe airports as economic locomotive of each country. They also consider the existence of a thriving and efficient airport as an economic growth factor and sustainable development. In the speeding up world, resolving rapid transportation issues can be considered as the central attention of all people associated with this speed. The airports which are playing a fundamental role in all transportation aspects are responsible to transfer the goods and people to their final destinations (Rahimimehr, 2013). The Hong Kong International Airport (Chek Lap Kok) is one of the most successful airports which in Skytrax Institute survey in the years 2001-2005, 2007-2008 and in 2011 was known as the best airport in the world. It is worth mentioning that the airport was designed by a well-known company (Norman Foster and Partners).

General characteristics of the airport

The new Hong Kong International Airport (HKIA) was opened in the old city of Kai Tak in the year 1998 due to the dangerous location of the previous one (figure 1 and 2). The new airport’s name in the local language is Chek Lap Kok which is mostly because the HKIA is located in Chek Lap Kok on the North coast of the Lantau Island.
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The Hong Kong new airport in Chek Lap Kok is located on an artificial island with the size of 6 in 3.5 km. The first phase of the airport was completed in the year 1998. After the completion of the Airport Terminal No. 2 in the year 2040, the airport will host 87 million passengers a year (238000 passengers per day). In other words, the number of the passengers in this airport will be as many as the total passengers of London's Heathrow Airport and New York's J.F. Kennedy. The length of the Terminal No.5 is 1.1 kilometer in which passengers can move by train, conveyor as well as taking a walk. Norman Foster in his design for the world's largest airport, has used 3D metal frame as a cradle vault with a thickness of 36 meters which cover the roof. Concrete pillar bear the load of the roof respectively (Ghobadian, 2008)

One of the distinguishing features of this airport is the vast space in terminal no 1. This Terminal which has been built at 464000 square meters, is one of the largest airports in the world in terms of its size. It is worth mentioning that despite the great size of the airport passengers have no problems finding their ways since the simple design and the appropriate and effective use of signs prevent the occurrence of any problem. There are also automated passenger transport system which facilitates the passengers’ transfer inside the Terminal. Hong Kong airport has two parallel runways with the length of 3800 and width of 60 meters which makes the huge airplanes to land and take off very easily. All in all the runways of the airport allows more than 60 flights to land and take off in an hour (Monthly paper of the main company of the specialized airports of the country, 2009).

In each of the main enclosures, the glass walls, light and water specify the borders through clever and subtle changes in the space. They form a key connection which is the main essence of the project: the connection between the Hall and the airport, between the level one and other levels, between the passengers who want to work and those who are going to have a rest. Different sorts of these kinds of luxury, is not just limited to a few unique movements but also it plays a main role in the qualitative improvement of the available surroundings as well. Not only through using a stylish sofa in which the body is relaxed, but also through peaceful prospect in order for the eye and mind to rest, some places to eat, drink, bathe, relaxation or study, in compliance with wood, glass, steel, stone and leather are carefully formatted as well. The originality of this space is intensified due to the contrast which it has with the artificial environment of the modern airport (Architecture Magazine, 2000) (Figure 3)

The architectural style of the airport

The Hong Kong airport building has a unique architectural style and Foster, the designer of the airport is one of the well-known architects of unique style.
Principles and design of this style can be summed up in the following ten cases: (Ghobadian, 2008).

- Positivism insights and optimism to science and technical and scientific progress;
- Showing technology as an extract and achievement of new age;
- Showing the process of construction;
- Making transparent, layered as well as showing the movements in the building;
- Showing the structure and components within the building in exterior design of the building;
- Using bright and simple colors;
- Using structures as a decoration;
- Using the stretching style of the components;
- Separating the service receiving sections from the service provider ones
- Designing the building's roof as the fifth view;

**Figure 3.** Maps and the picture of resting places in Chek Lap Kok airport

**Selecting the location of the airport**

Overall, the effecting factors in choosing the right location of the airport are as follows: (Saffarzadeh and Masoumi, 2004).
- How to develop the surrounding area
- Climate conditions.
- Access to the ground transportation system.
- Enough land for the development
- The other airports and accessibility to the air space in the area.
- The obstacles around.
- Economic issues of the construction.
- How and possibility of providing installation services
- Closeness to the regions with high demand of air travel.

At the Hong Kong International Airport some factors needed a different thought than the other airports in the world. The first one was platform for the airport and the second was the specific climatic conditions of the regions which both will be explained in detail later on.
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**The airport platform**

Population abundance and lack of space have made the developing countries of Eastern Asia to make optimum use of all water and soil spaces. Of course, this issue (use of water spaces) was witnessed for the first time in Kansai Airport, but as clear it is any project has its own specific time and location requirements.

As noted, Hong Kong Airport was built on an artificial island. The airport is about 12/48 square km which is built on two artificial islands (Chek Lap Kok and Lam Chosa) (figure 3). This island is connected to the northern part of Lantau Island through a thin land line. HKIA airport is actually replaced (KaiTak) the former Hong Kong International Airport. KaiTak airport was located in the vicinity of Colon city which was close to the residential regions. The construction of the airport was part of a project which led to the construction of new roads, rail lines, bridges and the tunnels which connected the airport to the land.

![Figure 4. The construction location of Chek Lap Kok airport between two islands.](image)

In order for the airport's platform to be ready, two islands were exploded, flattened and the distance between the two islands was filled with the materials coming from the explosion. But the soil between the two Islands was marine soft clay which was inappropriate for the platform of the airport (it had to be emptied). The engineers were inspired by the world first sucker pump (A 800 years old water pump) and tried to empty the marine clay (in depth of 20 m) between the two islands by the use of ship and build the hard platform for the airport which lasted till 1995 for the construction of the airport itself (The international airport of Hong Kong, National Geographic) (Figure 5 and 6)

![Figure 5. Airports platform preparation through explosion and flattening the islands](image)

![Figure 6. emptying the marine clay (in depth of 20 m) between the two islands](image)
The effect of climate on the designing process of Hong Kong international airport

Airports are basically divided into two different parts (Ground section, Air section):

A) Ground section: Set of buildings, installations and equipment which are blocked by physical borders or security control stations which are separate from the related levels to the airport. This set is responsible to provide the customers with services on behalf of the city and the airplanes on behalf of the terminals.

B) Air section: Set of lands, borders, installations and equipment which are in direct physical connection to the services related to the takeoff and landings, stop and departure of the airplanes. They are blocked by borders as well as being separated through security control stations of ground section (Technical affair and compiling criteria, Road ministry, 2000). The connection gateways of airplanes in terminal buildings are located in the two above mentioned sections respectively (Saffarzadeh and Masoumi, 2004).

In general, the effect of climate on the airports can be evaluated from the following perspectives.: the climate effect on ground section and the climate effect on air section

The effect of climate on ground section: The effect of climate on ground section is the same climatic considerations section on each area of the country that influences the ground section buildings such as the placement of the building according to the geographical locations.

The effect of climate on air section: The environmental conditions within the airport affect the length of the runway. Some of the most important environmental conditions include temperature, wind conditions at the airport, runway slope, airport height and conditions of runway surface. The effect of these conditions on the calculation of the runway length is somehow relative (Rahimimehr, 2013)

Hong Kong airport needs specific design in both air and ground section as it is located in the middle of the sea as well as facing severe storms.

The impact of climate on the air section of Hong Kong Airport

Since the airport is located between mountains and sea, the normal wind pattern changes did not include in the airport. Rapid changes of wind affected the aircraft's wings while taking off in a way that their speed used to increase or block which resulted in severe danger. But the new airport's safety in terms of directional changes of the wind which is all due to the relationship between the engineering groups with wind instruments group is more than 150 which proves the Doppler theory. Doppler theory goes like this, whenever a receiver goes towards a source of sound which is sending the sound waves, the sound frequency which it receives is more than the time when the sound source is stable. And if it gets away from the source of sound, it receives the sound with low frequency. If the source of the wave also gets away or closer to it, the sound frequency which the listener hears decreases and increases respectively. (Figure 7.8)
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Through using the Doppler Effect, the airport is in safety from directional changes of the wind (Figure 9, 10, 11)

Doppler radar is a tool through which the speed of objects in long distances can be converted into data. Doppler radar does this by sending microwave signals to the intended target and receiving its reflection. Doppler radar analyses the reflected signal changes to the main signal. The changes in the frequency of the signal show the direct and exact amount of intended speed compared to radar source as well as microwave beams. Doppler radar is used in the aviation industry, audio satellite; speedometer cameras of objects, radiology and etc.

Figure 9. The alarm system of directional changes of wind according to its interference with water drops.

Figure 10. Using light in the alarm system of directional changes of wind in arid climate .

Figure 11. The performance of the alarm system of directional changes of wind (Doppler radar) according to its interference with water drops.

The impact of climate on the ground section of Hong Kong Airport

In a transportation industry, terminals are the bridges which connect human beings to the giant airplanes. According to the air traffic, a large span and the high Hall for the gathering of the passengers and their companions are needed. The interaction between the structure and the architecture can also be effective and make the airport to be seen as part of an important and
effective structure. The structure as a factor in airport's designing is the power of the intended city. As mentioned earlier, the Terminals are considered to be part of the ground component and the roof is one of the components of the structure for which the designers were inspired by sea waves. (Figure 12, 13)

Figure 12. The constructed roof  

Figure 13. The constructed roof inspired by sea waves  

This roof is one of the largest and lightest indoor roofs in the world with a length of 1 km and the width of 700 m. Such a roof requires giant pillars but the designers did not want a heavy structure to bleak the light style of the Terminal. The construction work of indoor roof took about three years. To build such structures the designers were inspired by an old Second World War bomber. A solution to a solid body is how the metals are used together in forming the structure (Figure 14)

Figure 14. How the metals are used together in forming the structure, an inspiration source for the airport's roof.

The light roof is being held by low diameter pillars which are placed far from each other. The roof is made from reclining metals and each distance of 36 meter is supported by this structure. The way to build such structure is how to put these metals together in the structure itself (The international airport of Hong Kong, National Geographic)(Figure 16, 15)
As this region is exposed to the severe typhoons, this roof required special measures. The typhoons could have devastating impact on tall and big buildings with flat sides and curved roof. The Tropical typhoon with the speed of 250 kilometer per hour could take the roof off. Winds put different pressure on the roof and take the roof off when the severe winds hit the curved roof. These pressures which were on two different directions made the designers to think of flexibility. Like sternum which allows moving up and down. But the hinges are designed for the three types of movements. The source of these hinges' inspiration was shock absorber of 1930 sport car. Since the shock absorber only moves up and down, instead of two movements, three movements were thought of in order for it to be more flexible. Over all 1,300 sternum hinges help the flexibility of the roof against typhoons. Three movements of the roof and their reaction against typhoons are as follows:

1-The roof moves upward in the severe storms and the hinges allow the roof to move upward and downward (Figure 17)
2-The roof moves towards glass wall toward the sides in the severe storms and the hinges allow the roof to slide to the sides as well (figure 18)
3-The roof may have rotational movement in the severe storm and the hinges allow such rotational movement (Figure 19)
Advanced Scan of the suitcases

The airport services which are providing the necessary conditions for a safe flight is one of the criteria based on which the airports' classification and ranking takes place. One of the airport services is the luggage service.

The Airports in the world are using barcode in order to recognize the passengers' suitcases which have been successful for about 85%. Hong Kong International Airport moves 40 million bags and suitcases as well as moving 3.5 tons of cargo annually which keeping track of all this is a difficult task. Using the old method in Hong Kong international airport could have resulted in missing of 6 million bags and suitcases as well as loss of 0.50 tons of cargo. In order to prevent such a trouble they used an advanced scanning system of bags and suitcases which could scan them from the distance. They were inspired by a spying system of cold war. It was a hidden microphone, hidden in the sealed Eagle icon in an American Embassy which could work without any source of power (figure 23, 24). Through using this method in scanning the suitcases, 97% of them were properly classified (The international airport of Hong Kong, National Geographic)
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CONCLUSION

Development and economic power of each country is in direct relationship with its transportation system efficiency. As a result applying new ideas on the architecture of the building cause better performance since the airports make better use of the buildings as well as users satisfaction. As it is known, Iran's privileged geographic position in the region as a connection bridge between the East and West as well as the Middle East and Central Asia and as one of the most important stations of Silk Road needs having international airports with amenities for passengers and greeters. As a result, through using industrial countries' experience and through matching selected old methods in the past with the needs and circumstances of the day, we can have an advanced country.

REFERENCES

[1] Architectural Magazine.(2000). Pacific halls, Chek Lap Kok airport. Technical affair and compiling criteria, Road ministry, Guidelines for planning the ground surroundings of the airports, leaflet197Tehran, Budget and planning organization, 37,98.
[9] Technical affair and compiling criteria, Road ministry. (2000). Guidelines for planning the ground surroundings of the airports, leaflet197, Tehran, Budget and planning organization 13
[10] The international airport of Hong Kong, National Geographic