BRIDGE THE BORDER

A Border Crossing Complex across the Johor Strait

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ABSTRACT

This project started from the author’s dissatisfaction and frustration at crossing the border. In the current climate of global terrorism and security concerns, movement across the Singapore-Malaysia border is increasingly criminalised. Accordingly, the border crossing building is often authoritarian, represents its power and control, and renders one’s border crossing experience rather rigid and uncomfortable. It thus led to the initial idea of designing a border crossing building in the Republic of Singapore that could break away from the typically hostile characteristics of these buildings. This could be driven by a more inviting, contemporary, connective and symbolic architecture that serves as a gateway into the country rather than more austere functional requirements and utility.

However, as the author investigated the multiple dimensions of the border in relation to sentimental values, bilateral conflict and cooperation, it was realised that the international footprint of the border is far more complicated than the actual building itself. The border of Singapore and Malaysia marks a common history. It was built up, dissolved and then reformatted. This border today sees an immense amount of traffic, people and goods flow as a result of close social and economic relationships. Inspired by the open borders in Europe and based on the assumption that, in the future, a more open border will be developed between the two countries, the idea of designing a single border crossing building for the two countries emerged.

Essentially, the proposed design is an inhabited bridge. A bridge is a necessity for land entries as the border between Singapore and Malaysia lies in the narrow Johor Strait. The project thus endeavours to accentuate the importance of the bridge, not only as a physical link over the natural water obstacle, but also as a critical symbol of penetration and connection though the man-made barrier – the normally fortified border. Finally, it is proposed to integrate the bridge and the border crossing building together across the border land where the inseparable relationship begins.
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1.0 INTRODUCTION

“Constantly guarded, reinforced, destroyed, set up, and reclaimed, boundaries…exposed to the extent which cultures are products of the continuing struggle between official and unofficial narrative: those largely circulated in favour of the State and its policies of inclusion, incorporation and validation, as well as of exclusion, appropriation and dispossession.”

Minh-ha, ‘An Acoustic Journey’

The border crossing experience is a unique journey. When people cross a border, they move from one economic, social, cultural and political place to another. Identities are lost at departure and gained at arrival. The invisible border line, and its border land, always tries to draw some critical distance between two territories that shape the no man’s land; chaos is kept outside the line as much as possible. Metaphorically, border crossing buildings are the only ‘openings’ in the highly fortified border that filters and allows passage. All forces of movement, concentrated along the border, go through the border crossing building. The building can be both a barrier and a bridge between two countries; it facilitates or disables the crossing, and creates opportunities or eliminates them. The border crossing building is the visitor’s first encounter with the destination country. As a result, the building serves as a gateway to the country and plays an important ambassadorial role. The context of a border building could be rather intricate and present a very interesting topic for a conceptual design exploration.
1.1 Border in Our Contemporary Society

The term “border” goes beyond the traditional definition of the geographical boundary between two countries. It is also a cultural, economic, political and security division. On the other hand, borders have been constantly evolving throughout history: borders were walled up and subsequently dissolved, often followed by radical political, economic, and cultural changes. The recent history of the Berlin Wall and the Soviet Union is one of the examples of a border being walled up and then dissolved.

Border lands are sites and symbols of power. Heavily guarded towers and barbed wire may be the extreme marker of sovereignty, for example, the border land between North and South Korea area is probably the most fortified border in the world. In other cases, it is also quite natural that the border is less protected without endangering the territories, for example, the borders in the European Union are no longer barricades, but a representation of alliance.

As today’s society shifts towards globalisation, borders are undergoing another evolution: the constant flow of goods, people, information, currency are moving at a higher rate of flux than ever before. To a certain extent, the border is less fortified and more permeable – in the sense that the border is ‘blurred’ to a certain extent by border crossing activities. On the other hand, the spread of global terrorism, drug trafficking, illegal immigration, and territorial disputes render border controls obsessively necessary. This dilemma leads to a paradox that is, on the one hand trying to make the border a bridge of cooperative transition, and, on the other hand, trying to build a defensive wall.

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3 Donnan and Wilson, Borders: Frontier of Identity, Nation & State, 2.
Figure 1.7: Location Map

Figure 1.7: Location Map of the proposed project
1.2 Background Information on the Border between Malaysia and Singapore

This is a relatively young border. It only became highly significant in 1965 when Singapore became an independent sovereignty. The territorial border is located in the narrow Johor Strait that is approximately 1 to 2 kilometres wide, between Johor State of Malaysia and Singapore Island at the tip of the Malaysian Peninsula. Singapore and Johor shared a common history in Colonial times under the British. Until late in the Colonial period they were part of the maritime Malay world. Back then the Malaysian Peninsula received a vast number of immigrants from South India and South China. Singapore has always been the largest city and port in Malaya (then Malaysia), acquiring an ethnic Chinese Majority. In 1957 Malaya gained independence from the British without Singapore. In 1959, Singapore Island of 581 km$^2$ became self-governing. In 1963 Federal Malaysia was formed that included Malaya, Singapore, Sabah and Sarawak (now East Malaysia). However, Singapore exited from Federal Malaysia after two turbulent years of merger, mainly due to political differences.\(^5\)

There are two transport links between the two countries. Links across the border are usually uncritically associated with cross border ‘integration.’ However, the two countries share an often-strained formal bilateral relationship. The political elites on each side have often viewed each other with suspicion, and seen the other’s approach to the political economy of ethnicity as an affront.\(^6\) For example, the founding leader of Singapore, Lee Kuan Yew, has berated Malaysia with critical comments about the former Malaysian leaders during the period of merger,\(^7\) and commented that the Pro-Malay policy in Malaysia has marginalised the minority, the Chinese, in Malaysia. Likewise Dr. Mahathir, Prime Minister of Malaysia from 1981-2003, has similarly accused Singapore of marginalizing the Malay minority in Singapore.\(^8\) Apart from political differences, economic competition has also led to an effort by the Malaysian government to discourage shipment via Singapore Port. Active competition to facilitate the Johor Port includes the proposal of a bridge project to replace the old causeway, built under the British in colonial times. As Singapore was reluctant about the proposal, Malaysia then decided to build half of the project on the Malaysian side. The project was only

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6 Ibid., 289.

7 Ibid., 290.

abandoned with the new Prime Minister Abdullah Ahmad Badawi in 2006.9

Nevertheless, the border link between Singapore and Malaysia forms the economic tie between the two countries. Singapore is one of the most affluent countries in the world. The GDP per capita in Singapore is as high as SG$59,813,10 compared to RM$19,73911 in Johor (Singapore Dollar Currency is approximately double of Malaysian Ringgit). At present the largest movement across the border is semi-skilled Malaysian workers commuting from Johor to Singapore. Malaysia is the second biggest export-import partner for Singapore in 2009.12 As a result, the strong border interdependence across the border often coexists with the problematic bilateral relationship.13

1.2.1 Research Questions

This project is thus inspired by the term ‘border’ and the borderland. This research aims to investigate how architecture can be translated into a border crossing building that connects Republic of Singapore and Federal Malaysia, blurs the border and symbolizes the friendship of the two countries.

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13 Barter, “Multiple Dimensions in Negotiating the Cross-Border Transport Links That Connect and Divide Singapore and Johor, Malaysia.”
1.3 Scope and Limitations

The border crossing building is an assemblage of various functions and meanings. Apart from customs checking, the building also accommodates many governmental departments associated with goods inspections, security protection and customs regulations.

The proposed design is based on the utopian situation that the two countries are working together cohesively in one, single border crossing building. It hopes that in the near future this building will become a monumental museum once the open border is realised. A bridge building is chosen for its many meanings. The word ‘bridge’ is a metaphor for all kind of positive human activities – cooperation rather than conflict; helping, not hindering; linking, not sundering. As the American engineer Y.T. Lin wrote in his visionary notion of an “International Peace Bridge” across the Bering Strait between North America and Russia (back in the days of Cold War, let’s not forget): “bridges are far more than material connection between two points of land. Bridges also serve as profound links between society, cultures and political ideologies. Bridge project can not only span between poor and rich nations, capitalism and socialism, between democracy and totalitarianism”. Likewise, this project aims to translate the essential meaning of a bridge that is able to unite and span the gap between two countries and two systems.

At the same time, a bridge building triggers many other issues that demand greater exploration. Unlike an everyday bridge, the envisaged design is an inhabited bridge that combines the vehicular aspects and occupation space, and involves stopping areas that are mandatory to enable customs clearance. As a result, a much more complex structural and constructional technology is needed, which brings another level of sophistication to the proposed design. Subsequently, a question arises, could the spatial gap, evolving from the big scale structural systems, be utilised and integrated into the occupation space?

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15 Cited in ibid., 6.
However, due to the rise of terrorism, a very limited amount of literature on design floor plans, statistics, building information and functional requirements of border crossing buildings in Singapore and Malaysia, particularly regarding security issues, is publicly available for reference. Most data that would have a profound influence on the design, such as functional requirement and specific building programmes, are not available to generate a design brief. As a result, part of the information presented in this research is speculation developed from a number of online resources. To a large extent, the architectural strategies will draw upon the border crossing activities, mainly involving the checkpoint zone and customs control areas, which the public are familiar with.
1.3.1 An Architectural Approach to the Border of Dispute

Land reclamation around the perimeter of Singapore Island has brought vast opportunities to the country. In the last few decades, the island has grown from 581km$^2$ to 712km$^2$ (18.4%) due to land reclamation. However, the border of Singapore-Malaysia became a source of dispute as a result of these land reclamation activities. According to Malaysia, the narrowing of the strait near Singapore would endanger shipping and damage the environment. Yet, land reclamation is vital for the growth of Singapore. One third of the existing Woodlands border crossing facilities at the First Link were built on reclaimed land and the Tuas Checkpoint at the Second Link was built entirely on reclaimed land. The sand used in land reclamation is usually taken from the surrounding islands in Malaysia and Indonesia. This sand extraction has led to conflicts between Singapore and other countries. The whole marine ecosystem in the areas where uncontrolled sand extraction is taking place is being destroyed – tropical fish species and barrier reefs are dying and the region’s marine biodiversity is under threat. Malaysia and Indonesia have stopped exporting sand to Singapore for land reclamation. Later on, Cambodia and Vietnam also prohibited the export of sand to Singapore.

Land reclamation is still a vigorous growth strategy in Singapore Island, although it is getting more difficult to buy sand. It is not hard to predict that the future border crossing facilities will be built on reclaimed land on the Singapore side, as the island is already congested with a population of five million in 2010, which is about 20% of growth from four million in 2000. However, by using bridge construction methods, land reclamation is not necessary. In this way, the conflict arising from land reclamation can be eliminated through an architectural decision and its design strategies.

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16 Singapore Department of Statistics, “Key Annual Indicators” (accessed July 25, 2011).
17 Koen Olthuis and David Keuning, *Float!: Building on Water to Combat Urban Congestion and Climate Change* (Amsterdam: Frame Publisher, 2010), 224-26.
2.0 DEFINE PROJECT

A border crossing building is a highly specialised building. In order to create a design brief, it is essential to form a thorough understanding of the building’s attributes. Studies of the existing border crossing buildings in terms of functional aspects, traffic volume, and statistics of the complex, although not readily available, were carried out.

2.1 Case Study - The Existing Links and Border Crossing Facilities

There are two existing border crossing links between Johor and Singapore, which are known as First Link and Second Link. The First Link, spanning the centre of the Johor Strait, is a one kilometre long Johor-Singapore Causeway that was built in 1923 under the British. It serves as a road, rail and pedestrian link, as well as for piping water to Singapore. The second link was completed in 1998 to meet the increasing demand of border crossing activities.

There are very limited statistics published about the two links, mainly due to high security concerns of such facilities. The statistics used in this research are mainly based on the Singapore border crossing facilities. Little Malaysian statistics were obtained as the documents, if available, are in Malay. It is assumed that the statistics on the Singapore side reflect a similar condition on the Malaysian side.
Johor State (Malaysia)

Population: 3.2 million (Laporan Kiraan Permulaan 2010)

GDP per capita: RM$19,739 in Johor (Singapore Dollar Currency is approximately double of Malaysian Ringgit).

Land Area: 19,210 km² (Laporan Kiraan Permulaan 2010)

Climate: Average Temperature 29.7 °C.

Singapore

Population: 5 million

GDP per capita: SG$59,813 (Statistics Singapore)

Land Area: 712 km² (Statistics Singapore)

Climate: 25-31 °C.

Climate of Johor Strait

the prevailing wind: N NE (Dec-March)
S- SW (June-Sept)

Relative Humidity: 70% to 80%

Average Temperature: 25 to 31 °C

Tidal Difference: 2.3 m average

Monthly Rainfall: 150-280 mm

Figure 2.0: Background Information
Traffic Facts of the First Link

It is the most popular crossing between the two countries. The New Straits Times, says that 69 million people use the causeway alone each year. It also says that 57,000 vehicles, including 16,750 cars and 35,900 motorcycles use the causeway each day. This makes the First Link one of the busiest border crossings in the world, with an average of 945,000 traffic in one direction per day. The crossing between San Diego and Tijuana, sometimes said to be the world's busiest, has reported daily one-way traffic of about 110,000 persons.  

Figure 2.1: Traffic Volume Diagram (First Link)

Figure 2.2: Speculated Section of the Causeway

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19 Barter, “Multiple Dimensions in Negotiating the Cross-Border Transport Links That Connect and Divide Singapore and Johor, Malaysia.” 299.
Singapore Woodlands Checkpoint Complex (First Link)

The Woodlands Checkpoint Complex in Singapore was built in 1999 to replace the old checkpoint building that connected to the Johor Causeway. The complex comprises five building clusters, linked together to form a mega structure with an overall length of 400 metres and width of 280 metres, a total floor area of 132,000 m², built on approximately 15.4 hectares.20 The middle tower is a thirteen storey office building. Arrival and departure is arranged symmetrically. The complex houses a train checkpoint that is operated by both Singapore and Malaysia, a land checkpoint operated by Singapore only that takes care of various traffic types such as bus, lorry, car and motorbike.

Photo 1 and 2 was taken from the way towards the Woodland Checkpoint complex. The long corridors leading to the Immigration was cut from the exterior environment, only allowing ventilation through the louvres.

Photo 3. View of Woodlands Checkpoint Complex from the causeway. The building resembles a fortress guarding the gateway into Singapore territory.

Photo 4: No man’s land - the Causeway.

The causeway has constructed pedestrian walkway. However, the authority has advised walking is not an option and suggested taking the bus instead. The experience of the border is reduced to minimal as the bus drove past the causeway quickly.

Checking Procedure and Time at Woodlands Checkpoint Complex

Traffic leading to the Checkpoint building is firstly separated according to vehicle types. On the causeway there is one lane dedicated to motorcars, one for the trucks and one for the buses. The bus goes into the bus stop where passengers alight and head to the arrival hall. Trucks, cars and motorbikes drive through the building. The custom clearance on the Singapore side is further separated into two channel systems. The Green Channel is for people/passenger vehicles without any prohibited, controlled or dutiable goods. Random checks are conducted. If selected, one is directed to a checking booth for a secondary check. People/passenger vehicles with prohibited, controlled or dutiable goods proceed to the Red Channel. One is required to declare orally to customs the goods in your possession or produce to customs the prohibited or controlled items, together with the import permit. A random selective secondary check is conducted as well.

Checking time of a loaded cargo truck takes twice as long as for a passenger car at smooth traffic time as quoted by the Singapore authority:21

Clearance of Land Cargo: within 10 minutes for 95% of the time (inclusive of queue time), if no secondary inspection is required.
Clearance of Passengers: within 4 minutes for 95% of the time.
Clearance of Passenger Vehicles: within 4 minutes for 95% of the time.
Collection of Customs Duty/GST from passengers: within 8 minutes for 95% of the time.

Figure 2.4: Circulation Schematic through Customs

Circulation in the existing border crossing buildings is arranged symmetrically. The moment of arrival and departure is absent in the two identical enclosed space.
The proposed parallel circulation is exposed to the exterior environment. The moment of arrival and departure reveals different scenes.
Travel by Rail (First Link)

The rail station in Singapore originated in Tanjong Pagar Station, which is located in Singapore CBD. The land the rail occupies is leased to Malaysia for 999 years. For a long time, leaving Singapore by rail, one was granted entry to Malaysia first at the Tanjong Pagar Station, located deep in Singapore territory, before being granted exit from Singapore at the Woodlands Checkpoint Complex (First Link). On 1st of July 2011, the Malaysia Checkpoint moved to Woodlands Checkpoint Complex (which is still in Singapore land) and offers one stop checkpoint for the 2,000 passengers heading to Malaysia.22

Malaysia Checkpoint Complex (First Link)

On the Malaysian side, the Johor Causeway connects to the new Customs, Immigration and Quarantine Complex (CIQ), which was opened in 2008. The CIQ complex occupies a land area of 23 hectares. The complex was designed with 78 counters for vehicles entering Malaysia, and 39 counters for those departing from Malaysia. It also houses a number of departments that relate to border control activities such as Road Transport Department, Agricultural Department and so on.23

Figure 2.8: Photos of the Malaysian CIQ Complex
Figure 2.9: Aerial view of the Malaysian CIQ Complex

23 "Your Guide through Customs: Woodlands and Tuas Checkpoint."
The Failure of the Second Link

The second link is a 1.9 kilometres long, six lane bridge that connects Tuas, in West Singapore, southwest Johor. It was designed to handle 200,000 vehicles each day. The project symbolised cross-border integration, but the two different political regimes have rendered the cooperation difficult. The Malaysian side initiated a very high bridge toll and Singapore retaliated with a symmetrical toll, more than the market could bear. The toll for a large commercial truck is SG$14.70 (was SG$21 before 31 July 2010) compared to SG$2.40 of the First Link. As a result, the traffic on the link is, not surprisingly, low density. For example, more than a year after opening it remained at less than a third of the designed capacity.

Additionally, the low traffic volume of this link could also, perhaps, be attributed to the remote location of the bridge. Tuas is the industrial area in Singapore, and the largest movement from Singapore to Johor is for purposes of social visits and this link ends in the rural southwest Johor.

25 Ibid., 292.
27 Cited according to Barter, “Multiple Dimensions in Negotiating the Cross-Border Transport Links That Connect and Divide Singapore and Johor, Malaysia.” 292.
Figure 2.10: Second Link.

From left to right

1 -2: Tuas Checkpoint Singapore
3: Second Link Bridge
4: Malaysia Checkpoint roof plan
5: image of Malaysia Checkpoint
2.2 Brief & Site - The Proposed Third Link as Complementary to the Existing links

Based on the First Link, the total land area occupied by Singapore and Malaysia border crossing facilities is approximately 35 hectares. Given the constraint of a bridge building in terms of scale and structural needs, a new border crossing facility that serves both countries and generates a complete response to all vehicle types is neither feasible nor rational. It is also questionable whether the scale of the border crossing building would justify its purpose without considering the location and cooperative cross border governance, as in the existing Second Link example.

As a result, collaborative cross border integration is crucial for the success of the link between Singapore and Malaysia. Since the proposed bridge building is based on the assumption of close bilateral relationship, the primary intention of the proposed bridge building is to express an improved relationship between the two countries. The proposed building scale, the designated traffic types and the traffic volume needs to correspond to its specific site context and act as a complementary crossing to the existing links.

Figure 2.11: Proposed traffic capacity of the bridge building
Figure 2.12: Google earth image of the site
Figure 2.13: Site Images.

From left to right
1: Pasir Gudang port
2-4: Punggol Point (starting location of the proposed bridge connection)
3: Photo of Punggol Point 1.5km inland from the coast
Widening the Punggol Point Road - connection road to the proposed bridge

Propose Bridge Building

Border Line

Pulau Ubin Island (the last rural corner in Singapore)

existing residential towers

Proposed Light Rail

Passenger Train

to CBD (20 km)
to airport (10 km)

Figure 2.14: Site Context of Punggol Point
Figure 2.14: Site Context of Punggol Point

Figure 2.15: Site Context of Pasir Gudang
2.2.1 The Site and its Influence on the Designated Traffic

The chosen site for this proposed project is located in the east of the Johor Strait, between the Punggol Point in Singapore and Pasir Gudang industrial town in Johor, since the existing links are on the west and central Johor Strait respectively. Additionally, the existing traffic network is well established on either side. On the Singapore side it is close to the passenger train station, the airport, and the motorway that connects to the CBD and the rest of the island. A promenade is currently under development to create a waterfront leisure park in Punggol Point. The ultimate goal is to transform Punggol Point into a new waterfront residential town. On the Johor side the Pasir Gudang industrial town is under intense development and there is already a railway link in close proximity and a new motorway that leads to Johor CBD. The most prominent site feature is the Pasir Gudang Port, located a few hundred metres away from the proposed link.

The proposed primary traffic though this link would be mostly trucks exporting goods from Pasir Gudang industrial town to Singapore. This could also act as a faster route for Johor residents who use Singapore International Airport. Finally, it could also serve as an alternate route for Singapore residents visiting Johor CBD. It is unlikely that workers travelling via motorbike from Johor would use this link, since Pasir Gudang is an industrial town and away from the residential areas.

Therefore, the proposed traffic is mostly based on trucks, followed by motorcars and buses. Motorcyclists are eliminated on this link. By doing some reductions, the scale of the proposed bridge building could be much smaller than the existing examples. Some facilities in this building could be shared by the two countries, in this way the spatial requirements can be further reduced.

Figure 2.16: Estimate size of the bridge building.

The images show an estimate size of two Checkpoint buildings added together.
2.2.2 Spatial Attributes

Apart from traffic requirements, administration spaces are also part of the design brief. The possible governmental departments located in this building would be:

- Pedestrian/Bus Passenger Queuing, Processing, and Inspection Areas: (10,000m²).
- Vehicle Queuing, Processing, and Inspection Areas, including both departure and arrival customs of the two countries: Commercial: 52,000m².
  - Non-Commercial: 26,000m².
- Quarantine and Impoundment Areas (15,000m²)
- Offices (10,000m²)
- Laboratory (100m²)
- Holding Cell/Detention Areas: for holding detained travellers. (250m²)
- Toilets (320m²)
- General Storage Areas (1000m²)
- Emergency Parking Areas: 300m².
- Dog Kennels: dogs are used to search vehicles and cargo. (100m²)

Total: 115,070m² (11.5 Hectares)
Estimated building footprint: 75,000m² (7.5 Hectares)
2.3 Climatic factors

The climate in Singapore and Johor does not have distinct seasons. Singapore is just 1 degree north of the equator, the weather is characterized by uniform temperature and pressure, high humidity and abundant rainfall of 150 to 280mm per month. The average temperature is about 25 to 31 Degree Celsius. Relative humidity ranges from 70% to 80%.

There is also no clear cut wet or dry season. However, there are two main monsoon seasons that include Northeast Monsoon Season (December-March) and the Southwest Monsoon Season (June to September). The sunlight usually lasts around twelve hours for most of the year. The area is not subject to any earthquakes or typhoons.

The wind during the Northeast Monsoon is predominantly from north to northeast and is less than 5.4m/sec. The prevailing wind direction during the southwest monsoon is of south to southeast directions with speeds of less than 3.3m/sec. This implies the wind will penetrate into the proposed bridge building at an angle from both sides of the bridge.

The water temperature in the Johor Strait varies from east to west. Generally the east has a lower temperature. The mean temperature of the water in Johor Strait ranges from 27.6 to 31.8 Degree Celsius. Johor Strait is described as a relatively low energy zone, with a gentle tidal current (mean velocity 0.05-3m/sec). The average tidal difference is about 2.3m during spring tide, 1.0m during neap tide and a mean range of 1.7m. However, sometimes the tide can be as high as 3m.

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32 Ibid., 1018.
2.4 Precedent Survey

Precedents were evaluated for the following categories:

- Vehicular bridge
- Inhabited bridge
- Border crossing building examples
- Port terminals and airport terminals

2.4.1 Vehicular Bridge - Bridge Structure & Clearance

A bridge is perhaps the biggest spanning construction of all building types. Technology has enabled bigger spans than ever. There are two perspectives to a vehicular bridge that are relevant to this project:

- The clearance from water that allows shipping passage,
- The bridge structure in general.

The proposed bridge building needs to address the cargo ships travelling in and out of the Pasir Gudang Port. It is, thus, essential to understand the clearance of the bridge from the water and the implications for the structural needs. Everyday examples already in existence include the Auckland Harbour Bridge and the Sydney Harbour Bridge. One of the possible outcomes is that a bridge with multiple layers and a high clearance from the sea level might result in a very tall building that is structurally difficult and uneconomic.
The Forth Rail Bridge: Facts

Period of Construction: 1882-9
Location: Scotland
Total Length: 2.46km
Clear Spans: 2 x 521m
Height of Tower: 100.6m

Sydney Harbour Bridge: Facts

Period of Construction: 1924-32
Total Length: 1149m
Clearance from water: 49m
Clear Spans: 503m
Traffic Lanes: 2 railroad Tracks, 6 motor vehicle lanes, pedestrian and bicycle lane

Auckland Harbour Bridge: Facts

Period of Construction: 1956-59
Total Length: 1,020m
Central Span: 146m
Clearance from water: 48m
Traffic lanes: 8
Usage: 165,000 cars each day

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35 David Miller, Bridges (London: Compendium, 2006). 145
2.4.2 Inhabited Bridge

Living on bridges is nothing new. Occupation of a bridge makes it both a building and a bridge, which becomes another type of architecture. A precise English term for this type of bridge is called ‘inhabited bridge’, which can be broadly defined as a bridge that not only provides a link between two points for pedestrian and vehicular traffic but also supports a superstructure that can serve residential, commercial, industrial, religious or defensive purposes, thereby creating a continuity of the built-up area from one bank to another. In medieval times, the inhabited bridge sometimes could be described as a result of urban fabric extension. Those cities were often walled from outside threat. As a result, over time, the limited space in the city area became crowded. The river space, where the most central activities are found, enabled an inhabited bridge. It is similar in the case of Singapore Island. Although the island is not walled up it is congested with rapid population growth and other activities. Inhabited bridges have not yet occurred in this island. However, it is not hard to predict that inhabited bridges will spring up in various locations in the near future.

The scale of modern inhabited bridges has been increased many fold by comparison with the historical ones. Many of the projects have not been built. However, they share the same characteristics: the utilisation of technology and the integration of structure and building space. Most of them are big in scale and multifunctional.

Social Infrastructure by BIG

Slussen is the central traffic node of Stockholm. Its public space is surrounded by traffic, making the water front inaccessible for the people of Stockholm. The architects have decided to invert the situation that let the public space surround the traffic. The proposed bridge becomes an extension of the existing urban fabric. The infrastructure connection caters for both cars and pedestrian traffic.

Figure 2.22 (left): The partially ruined bridge of St – Benezet at Avignon, built 1226.

Bridges with a chapel in the middle ages were fairly common. The possible reason for constructing an expansive structure over the water is that, “when a bridge defying the raging fury of the waters flowing beneath it was viewed with a certain reverence”.

Figure 2.23 (right): New Castle Bridge upon Tyne, an inhabited bridge spanned over two authorities, 1754.

The medieval bridge was one of the most important examples of the living bridges in England. It is shared by the ecclesiastical and municipal authorities, namely the Newcastle authority on the southern side and the Bishop of Durham on the northern side (Scotland). A blue stone on the bridge marks the division between the two proprietors of the bridge. Urban development was dense on the southern sides and the density was extended onto the half bridge under Newcastle’s ownership. The occupation on the other half of the bridge is much lower, as shown. The bridge was damaged beyond repair in 1771 by floods. The interesting fact of the bridge is that, the division line was in the middle of the bridge and occupation from each side only stopped at the marked division. Nowadays, a division line or border line is so powerful that it renders the whole water body as the division and, therefore, becomes a no man’s land.

b Ibid., 37.
2.4.3 Border Crossing Building Examples

The U.S. and Mexican border is a controversial border. In order to prevent the influx of illegal immigrants, the U.S. government has partially built the planned 670 miles border fence, nicknamed the “Tortilla wall”.38 Most of the border crossing buildings, or ports of entry, are as unfriendly as the “Tortilla wall”. In the promise of the North American Free Trade Agreement, and within this context, the government has directed the General Services Administration (GSA) to begin a $353 million upgrade of more than 50 stations across the border, including 10 new border crossing facilities in 1988.39 Of all the stations, the winning design of 2000 President Metal, port of entry at Calexico – California is perhaps the most successful one.

The building utilises a tent like structure that reflects the regionalism of the area, the desert climate. The transition from the Mexican side to the U.S. is made natural with landscaping – a series of columns that lead to the building. The success of this building could also be attributed to the openness of this building; a characteristic most border crossing buildings struggle with, alongside the security concerns. Yet, transparency and openness is crucial to bring a more positive experience and image to the building than a heavily fortified concrete bunker.

Research into Asian border crossing buildings has also been conducted, but very limited resources on built examples were obtained. One possible reason is that governments are relatively conservative in dealing with customs buildings. However, currently there is a huge border crossing development going on between Hong Kong, Zhuhai (Mainland China) and Macao40 that involves a bridge construction and also border crossing building facilities.

The precedent chosen is the top student entry (figure 2.24) for the Idea Competition. The design was generated from the movement of people at different speeds which eventually influenced the form. The building form produced is rather organic and compelling. Similarly, movement for the proposed bridge could be investigated to achieve something similar.

40 Although Hong Kong and Macau are Chinese territories, the borders still exist under the ruling of “one country, two systems”. 
Figure 2.26: Hong Kong – Macau – Zhuhai border crossing facilities (HK) competition, student entry, first prize.
LIA Passenger Terminal Building

This is another unbuilt example as published by Arch Daily in July 12, 2011. The proposed border crossing building is located in the borderland between Hong Kong city and Shenzhen City (Mainland China), where the border is marked by a narrow river. Unlike the Hong Kong-Zhuhai-Maocau border crossing facilities, this proposed design is an integration of two customs buildings. It is described as visually striking landmark and acts as a gateway to the city. The beam shaped building, and a similar organic vehicular platform spanning over the water, is a reflection of the winding river. 41

Figure 2.28: First floor Plan, Perspective and Elevation of LIA Passenger Terminal
### 2.4.4 Port Terminal – The Yokohama Project

The Yokohama Project serves as an important precedent for a number of reasons. Like a border crossing building, it is the arrival point for international visitors and also houses arrival and departure customs functionality. More importantly, the project’s unique design features are a good reference for the proposed bridge building. The idea of continuity and the big long span space are particularly useful for this project.

The Yokohama Terminal building reveals three distinct surfaces, the roof, the terminal and the car park. There is no distinct separation between the building envelope and the structure. The interiors are column free, with vast open spaces, for example, the International Passenger Terminal areas are of 170mx60mx6.5m high.\(^42\)

The building structure is composed of two elements: the steel box girders sit approximately 35m apart in the transverse section, and the folded steel plate spans between the girders. A strong visual connectivity is achieved by the seemingly continuous surfaces of the building that extends into the structural girder that knits the roof, the terminal and the car park together. The space, bounded by the perimeter of the steel girders, becomes occupied space for such things as pedestrian ramps.

The Yokohama Project is an inspirational embedding of structure into a building. The structural members are used spatially, usefully defining functional elements of the building, rather than being freestanding separate objects. Like the Yokohama Project, the proposed “bridge building” revolves around the idea of connection and movement. Ideally, the bridge building should have a strong visual continuity that extends from one shore to the other. The differences are, the public use of surfaces of this building is more restricted, and movement of vehicles presents a totally different kind of experience. It was decided very early on that visual continuity should occur on the edge of the building floor plate in the long section, where the unusual characteristics of this building – a multiple level bridge where traffic separates and merges in the vertical direction - are more visible to the general public.

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\(^{42}\) Alejandro Zaera et al., eds., *The Yokohama Project* (Barcelona: Actar 2002), 143.
Figure 2.31: Structural Composition of the Yokohama Project

The spaces bounded by the perimeter of the girders are mostly used as pedestrian ramps.
The temperate of the steel girders across the building is a variation of different shapes that correspond to the curvy surfaces. The girders are composed of 1200mm of high box girders, with steel plate thickness ranging from 6mm to 40mm.3

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3 The Yokohama Project, ed. Alejandro Zaera; Farshid Moussavi; Albert Ferré; Foreign Office Architects (Firm) (Barcelona: Actar 2002), 107.
Services of the Building

A vast open space often conflicts with the requirements of fire compartmentalisation and also challenges conventional methods of ventilation. The FOA says the building has a number of “illegal aspects”, for example, the size of the terminal division: approximately 9,200m², which has exceeded the fire compartment size of 500m² many fold. Special disaster planning in terms of material design is being developed to attain building safety.

Lighting and Ventilation

The building is fully glazed around the perimeter, however, the interior of the building relies heavily on artificial lighting. The steel girders, and the occupation of the girder, blocks most of the natural lighting. The project has not considered any natural ventilation option. However, the building uses displacement ventilation methods, where the air conditioning unit is embedded in the raised floor void.
The deepest depth of the triangular folder steel plate dimension is $1750\text{mm}^4$. On the edge of the building, the folded plate reduces to a depth of $150\text{mm}$. The finished floor thickness on the edge is only $525\text{mm}$.

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d  Ibid., 113.
Figure 2.35: Signage of the building

The signage of the building includes information signage and circulation signage. It was painted directly on the surface of the building. Positioning of the signage was carefully designed to follow the rather irregular geometry of this building. In this way the building information is integrated with the surfaces of the building. FOA describes the signage as being like tattoos on the skin of the building.\(^e\)

\(^e\) Ibid., 245.
2.5 Literature Survey

2.5.1 Hyper-border: The Contemporary U.S. – Mexico Border and its Future

Mexican architect Fernando Romero was commissioned to build a 656-foot-long pedestrian walkway spanning between the United States and Mexico. It is a single building for two countries that also serves as a museum of immigration. The bridge from El Paso, Texas, to Ciudad Juarez, Chihuahua, has not been built yet. His interest then moved into investigating the border experience, which led to a book, *Hyper-border: The Contemporary U.S. – Mexico Border and its Future*. The book started by examining various international borders across the world, from the most fortified border between North and South Korea, ethnic division between Israel and Palestinian, contrast demographic border between Spain and North Africa, to the more collaborative borders between Germany, Switzerland and France (the Tri-Nation). Then, he zooms into the borders between Mexico and U.S. Like many international borders, the U.S.-Mexico border facilitates a significant economic tie and strings of social activities. However, it is particularly troubled by drug trafficking and illegal immigrants moving from Mexico to U.S. Under such a dilemma, Romero projects 38 future scenarios of border development in a 50 year timeframe, some are positive and some are negative. Through the scenarios Romero wants to show that the borders of the future should promote solidarity and equity among people rather than division and inequality.

2.5.2 Open Borders: Absurd Chimera or Inevitable Future Policy

John P. Casey is an associate professor in School of Public Affairs, Baruch College, City University of New York. In his paper, Casey explores the arguments in favour of open borders as future policy option of the globe. While accepting the free flow of immigrant under current situation is impossible, the universal open border as a future vision is inevitable due to the long-term consequences of globalism. According to the author, the policy of border control, which we consider a norm in our current society, was only shaped in the 1970s to restrict the movement of the low skilled and poorer people. In the past border control was about religious and racial-ethnic exclusions. Until World War I border controls in European countries were weakly

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46 Ibid., 14.
exercised. It was not until 1914 that use of passports became an international identification. Nowadays, the movement of people across the border for tourism, or other simple purposes, is becoming more restrictive, bureaucratic, and burdened by security concerns.

However, open borders might bring immense benefit to the participating countries. Apart from the global trade gains, there are a number of positive benefits. For the rich countries, the fear of immigrant influx will be eventually levelled as immigrants tend to circulate between the origin and destination countries. There are probable economic benefits as a result of the immigrant related economic activities. The poor countries will enjoy benefits, such as technology transfer. Global equity will be more fairly distributed as there is an increasing imperative to invest in the poor countries. Last, but not least, open border policy will also encourage human rights and democracy in some countries. In some contexts, open borders are seen as an instrument of economic cohesion, development, and integration of political and social values. The European Union, the Caribbean Community, the Nordic Council, and the Trans Tasman Travel Arrangement between Australia and New Zealand are examples of working models of open borders that already exist. It took 70 years for open borders in Europe to become a reality. To speculate on the future open borders may be more commonplace, perhaps by 2060, or even by the beginning of the twenty-second century.

47 Ibid., 19.
48 Ibid., 16.
49 Ibid., 24.
50 Ibid., 27.
51 Ibid., 29.
52 Ibid., 31.
53 Ibid., 33.
54 Ibid., 16.
55 Ibid., 22.
56 Ibid., 41.
3.0 PROJECT DEVELOPMENT

The design process is divided into three stages. Each phase is concluded with evaluation and feedback from various architects, studio tutors and university professors. The project development features an explorative process using various media, such as conceptual sketches, model making, and computer generated models as well as detailed drawings.

3.0.1 Guiding Concept

Separate but Together

The proposed bridge building design acknowledges that the two countries are independent sovereignties and that they need separate checkpoint area to suit their own regulations. The “one building” concept could be achieved where the two spaces join together at the “borderland”.

Parallel Equality

The design intent is about bringing equality and cooperation, not competition. The architectural decision is to employ a parallel design strategy. Distinctness and contrast between the two are avoided.
Fusion of a bridge and a border crossing building

Bridge is used as a positive metaphor for this project. The envisaged design will have a fair share of the characteristics of a bridge and a border crossing building. A bridge is often linear, offering no points for stopping, whereas a border crossing building involves several stopping points and even a rejecting lane if entry to the country is denied. It is also big in scale, as is evident in the existing border crossing facilities which occupy approximately 20 hectares of land for one border crossing facility. Two border crossing facilities together would form an artificial island in the Johor Strait. In order to avoid the “Island Effect”, the widest part of bridge building is set under 120m. This is about four times that of a standard six lane bridge, as in the existing Second Link. The resultant design could be a sleek, multiple layer bridge building.

Bringing a positive experience to cross the border

The proposed design also aims to bring openness and transparency as the main design principle, which could possibly generate a more positive psychological experience for people crossing the border - in the sense that people are no longer confined to the building; rather, they could relate to the exterior environment and also witness movement from another side.
Figure 3.0: One building concept

1: Proposed bus journey, offering one stop

2: Standard bus journey
3.0.2 Design Context

Apart from the conceptual design guidelines there are several physical factors which will have significant effects on the building design. These are highlighted below:

**Pasir Gudang Port:**

The Pasir Gudang Port means a busy water transport underneath the proposed bridge. It thus adds a vertical dimension to the bridge – the bridge must have a high clearance (at least 50m) from the water.

**The Traffic facts**

- This project aims to turn mobility and velocity into a stimulating event. Mobility is a major border crossing activity and has the potential of transforming the proposed bridge into something spectacular, by showcasing vigorous movement at multiple levels as a result of various traffic types and speeds.

- Since this building caters more for truck crossings, more space allowance for trucks is critical. Extra space considerations are also needed for trucks as a result of the time taken for a truck crossings being usually twice as long as for passenger vehicles. For example, at the current Woodlands Checkpoint, truck waiting time at peak hours is up to two hours, compared with the one hour waiting time for the motorcars.57

- Designing for the traffic has profound influences on this project in terms of ceiling height, driving path width and turning circles.

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Physical Constraints

The constraints identified at this stage are:
- the road connection points at either ends;
- the width (1.2km) of the Johor strait at the chosen site;
- the depth of the strait so as to avoid bridge piles at the deepest water;
- the low lying context – the bridge will be much higher than the surrounding context. Thus a smooth transition from land to the bridge has to be considered.

Figure 3.1: Motorcar dimension
The turning radius of a large commercial vehicle is about 8m, a kerb radius of 11m will be needed for such vehicles to maintain a constant distance from the kerb while turning the corner.

Figure 3.2: Typical recommended dimensions for use in urban areas.

Figure 3.3: Truck dimension
3.1 Design Stage One – Knotting Two Countries into One

Design Stage One shows a process of development of schematic approaches. The initial design is a metaphorical exploration based on the bilateral relationship of the two countries. A knot mirrors the relationship of Singapore and Malaysia to a large extent. In the media the separation of the two countries was portrayed as being like a divorced couple: “full of interdependence, disagreements and pain.”

Inspired by the inseparable and complicated relationship, the initial design attempts to knot the two countries together. Likewise, the word “knot” in the dictionary is defined as:

“Something forming or maintaining a union, a bond or a tie”.

“a difficulty; a problem”

3.1.1 Create Space from Mobility – knotting the traffic routes

Crossing the border can be exciting. The sheer unprecedented amount of mobility can be articulated into a special event. In the conceptual design of Hong Kong–Zhuhai-Macau border crossing bridge, NL architects proposed inter-crossing bridges to solve the issue of traffic travelling on the left in Hong Kong and on the right in China. Conventionally, the traffic switch is usually resolved though a simple intersection. The architects, however, have expressed the change explicitly and turned the moment of swapping into a monumental episode.

Similarly, mobility is one of the driving factors for the proposed crossing. The initial concept one, as illustrated (figure 3.4), entails two routes that start as a whole on either side, diverge into two different paths on the water, and then meet at the borderland, separate again, and then merge back into a single path on the shore. In this case, the interweaving paths form the perimeter of the building footprint.

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However, the concept reveals two buildings, where the two wings at each end, ie. the “borderland” is more dominating than the narrow central shared space, and therefore it does not reflect the “one building” concept. The alternative is to emphasize a strong centrality, as illustrated in figure 3.5. Yet, concentrating the events in the middle of the bridge has reduced the experience of the bridge as a journey.

3.1.2 Create Central Space via Knotting

The next step aims to combine the interweaving traffic routes, as investigated in figure 3.4, a central integrated space as shown in conceptual figure 3.5, and an added vertical dimension. Traffic from each direction is broken down into two routes, as shown in figure 3.7. One express path is dedicated to traffic that requires little customs declaration, and a slow path for vehicles that requires customs declaration. Consequently, there are four major traffic paths, which mingle horizontally and vertically to generate the building space.

Symmetrical geometry is used to represent the two countries. The two wings of the central, shared space accommodate entry and exit checkpoints for the lorries and passenger cars. Hierarchy occurs where the two elements meet at the “borderland” that forms a central, shared space, where the passenger hall is also located. In this way travel via bus is made comfortable, with one stopping point and a shorter walking distance. In this way the two countries are separate but together.

The resultant building design ends up having four levels arising from the four inter-weaving paths; each level is about 10 metres high, allowing a double decked coach to pass with ease. Sub-levels can be inserted into the high floor to floor space. The bridge path goes up and down. The heightened position offers users a glimpse of the destination. The winding route alters one’s view from one side to another.

Finally, the concept is evaluated against the spatial attributes for traffic flow, checkpoint counters, waiting area, passenger hall and spaces dedicated to customs requirements, structural issues, and also the internal requirements of the building.
Figure 3.6: Proposed Hong Kong border crossing bridge

Figure 3.7: Conceptual Design 3 – proposed traffic routes
Figure 3.9: Perspective of the conceptual design
Figure 3.10: Section of the Conceptual Design 3
3.1.3 Design Evaluation

Evaluation of the initial design ideas are concluded as follows:

A puzzling concept

The knotting concept has stimulated a complicated initial design that is difficult for further development. The bridge path interweaves several folds horizontally and vertically and creates a relatively tight space. It is not quite functional as the traffic has to make large turns to reach the checkpoint booth as indicated in the drawings (plan). Consequently, a large portion of the bridge is not suitable for checking booths as they would be inaccessible. A more linear and straightforward vehicular route is more favourable as it would enable a smoother journey.

Weak Section

The structure of the proposed bridge building will have a significant influence on the building design and, in this case, the design has neglected very serious structural considerations and is driven solely by horizontal planning.

Lacking Research Statistics Input

It is unclear how the statistics of traffic volume, traffic types and others relates to the initial design and, therefore, it is difficult to accurately evaluate the design.

Doubts over Symmetrical Design

The two symmetrical wings that are occupied by the two countries are more dominating than the crucial element of the design: the central block where the two wings overlap. The two identical wings by the borderland make the bridge appear rigid and monolithic. It is recommended that an asymmetrical approach, alongside parallel equality, is perhaps more flexible for the project.
3.2 Design Stage Two

A number of changes were undertaken in Design Stage Two in response to the feedback of the initial architectural strategies. Some of the design principals in Design Stage One were abandoned. The guiding conceptual principles, however, remain unchanged.

The major change in decision at the beginning of Design Stage Two is:

- To unknot the complexity of initial design into a simpler organisation. The interweaving concept is abandoned as it adds to the complication.
- Sectional planning becomes the primary design tool as it relates to the building structure.
- Greater emphasis is placed on the dynamic that exists between the movement of people, bus, cars and trucks. This is the main design generator of the building form, alongside the guiding concept.

The first exploration undertaken in Design Stage Two is an investigation of simplifying the inseparable two countries from a knot to a more comprehensible relationship. The “one building” is divided into two elements and re-united at the borderland to form a strong, interlocking bond. Each element extends into the other party’s territory. In this manner the exact boundary line no longer applies to this building. Arguably, the intensified connection of the two countries also blurs the border to a certain extent.
3.2.1 Embrace the Bridge Structure into the building

The previous design was largely based on horizontal planning and, therefore, has neglected the most important component of a bridge: the structure. Essentially, the bridge is a structure. As a result, the appearance of a bridge is very dependent on the aesthetic expression of its structure. Design Stage Two thus begins to explore rigorously the structural system of a bridge. It is hoped to attain a corresponding relationship between the bridge and the inhabited space.

3.2.2 Investigating Arch Bridge Typology

It is decided that arch bridge is the most suitable structure form for this building. It has the potential of producing a smooth building outline and, therefore, echoing the idea of smooth transition from one end to another. The subsequent investigations thus aim to explore how that space could be created, by combining multiple arches not only in the horizontal plane but also the vertical direction. The conceptual models in figure 3.15 and figure 3.16 reveal a series of abstract curvy lines by combining the arches together. However, it is unclear how occupation can possibly occur within. The next investigation thus starts by inserting the building mass into the curvy lines (figure 3.17).

Figure 3.12: Zhaozhou Bridge, completed in 605, Hebei province China

It is the earliest known fully-stone open-spandrel segmental arch bridge. The bridge span is 37.5 m and the arch only rises to a height of 7m. Two pairs of small arches on both side of the bridge not only lighten the pressure on the abutments but also allow additional flood water to pass through. 6

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Bridge typologies are being investigated in relation to the proposed design.

1. Arch bridges: there are many types of arch bridges. The common characteristic lies in the natural strength of the arch. In the past arch bridges were built of stone, but today most arch bridges are made of steel or concrete, and they can span up to 500m as in the case of the Sydney Harbour Bridge.

2. Suspension bridges: suspension bridges can span huge gaps, sometimes up to 7000 feet (2133 metres). One problem that may arise is the bending and twisting of the decks. Additionally, suspending multiple level decks as proposed, if possible, would result in a very tall suspension tower, which makes this option less favourable.

3. Cantilever bridges: the truss bridge consists of an assembly of straight, steel bars in a triangular pattern. The bridge usually projects out from the top and the bottom of the pier, and supports a third central span as illustrated.

4. Cable-stayed bridges: similar to a suspension bridge, but the cable supports the bridge in a different way. The cable runs directly from the road way up to a tower, forming a unique ‘A’ shape. It is one of most popular bridges for medium length spans.
A number of fixed anchor points, or foundation pier locations, are first established. Simple arches are then placed on the fixed point. A continuous curve is generated by manipulating the arch curvatures and the continuity. Following that, the arch is then lowered to water level to create an image as if the proposed bridge building was leaping from one shore to the other.
Figure 3.15: A Schematic section of the Concept Design 4

The concept of vertical layering of the bridge building leads to the move of adding gentle arches on top of each other. The span length and height of the arches increase gradually from the Singapore shore and culminate at the fourth arch, which is 50m high above the water level, allowing cargo ship traffic. Then, the arch is narrowed down again and descends gracefully to the Malaysian shore.

The building space created can be categorised into three zones. The central space located at the border line is dedicated for the two countries. This is also where the interlocking of the two countries occurs. Traffic movement is separated according to declaration and non-declaration level.

Method of manipulating the arch

The bottom five arches and the highest points generated by the arches are the control points of the splined curves, which constitute the curvature of the floor plate. The curvature of the floor plates is governed by other factors such as vehicle ramps as the design progresses. Nevertheless, these control points provide a geometrical consistency among the floor levels.
Figure 3.16: Explorative models of the arches
Figure 3.17: Investigations of building mass under Concept Design 4

Model 1: Space is created from one arch in relation to another. A strong layering effect is produced as the higher level reduces in size. In the short section the spatial levels resembles a stacked cake. However, the massing model has lost some of the qualities of the previous model. It is a very linear journey that does not reflect the fact that the border crossing building involves several stopping points.

Model 2 & 3: These models are a portion of the bridge that aim to investigate how the layering can be investigated to produce a less linear route for the traffic. The journey should provide opportunities to change visual sequences as one’s position on the bridge changes horizontally and vertically.
3.2.3 Making Space among the Two Countries

The widest part of the bridge is 120m wide. It is essential that natural air and light are able to penetrate into the middle part of the building. Penetration of this building should also enhance the architectural space as well. The design thus starts with treating the two countries as two individual elements. By separating and connecting the two, a building void is created. 3.2.4 Building Organization

Figure 3.18: Conceptual sketch

Location of the void is firstly identified at the top of an arch in an attempt to reduce building load at this location.
This is an investigative process of identifying the building void by the arrangement of the two elements representing the two countries. The space is created when the two elements touch each other and then separate, resulting in a gap between them.
Figure 3.20: Floor planning established from the previous Sketch and Model.

It is proposed to have two bridges about 8m wide in the atrium space that facilitates the movement between these two elements. It is also proposed that the bridge accommodate the lift core serving the two countries.
Figure 3.21: Detailed flow plans
Figure 3.21: Detailed flow plans
Figure 3.22: Transverse section – The junction of traffic separation and merger
Figure 3.22: Transverse section – The junction of traffic separation and merger.

Figure 3.23: Schematic of movement of the proposed design.
Figure 3.24: Long section

This is a flow section that shows the usage of the levels. Two levels are dedicated to trucks as this bridge expects more truck crossings than any other type of traffic. The motorcars and buses share a level below the truck crossings. At the same level, there are bus stops allowing passengers to get on and off the bus. The passenger arriving by bus will complete the customs checks of both countries a level below.
Figure 3.25: Aerial view of the proposed building
Figure 3.26: An attempt to mirror the building
Figure 3.27: Refining the curvature of the floors

This aims to re-establish the visual continuity of the longitudinal section. The curvatures of the floor space are adjusted and refined.
Asymmetric Geometrical Arrangement/Symmetrical Political Arrangement

The circulation in the existing Malaysian CIQ complex (First Link) and the Singapore Woodlands Checkpoint complex (First Link) are arranged in a symmetrical manner, with one side dedicated to departure and the other for arrival. From the perspective of a passenger in a vehicle crossing the CIQ complex, the arrival hall and departure hall can be seen as two large enclosed spaces, equipped with identical interior fitouts, perfectly symmetrical and homogenous. One could not differentiate the two if it was not for the signage\(^{60}\); as a result, the sense of arrival and departure is absent.

The proposed building spatial design focuses on the checkpoint area for the traffic. Throughout the project, occupation on the bridge takes place in the space bounded by the four arches. The space near the Malaysian shore is dedicated to Malaysia and constitutes five levels. The space near the Singaporean shore is allocated to Singapore and consists of only four levels. The two are arranged parallel to each other, revolving around the central space that accommodates both countries. Within the central space, the two countries’ spaces are arranged asymmetrically and divided by a large central void. The central space itself is about 120m wide and contains seven floors (Figure 3.20).

Vertical Distribution of Traffic

In a traditional border crossing building the separation of traffic is distributed across a horizontal plane. Traffic is separated according to different motor vehicle types: trucks, motor cars and buses. In this proposed design, separation of the traffic is effected in a vertical manner. The traffic occupies three gently sloping levels of the upper layers of the bridge (figure 3.24). The battered vertical layering starts where traffic diverts into the different levels or the traffic merges together (figure 3.22). Unlike a vehicular bridge without a turning point, all traffic levels have included a return path that allows traffic to go back to the departure shore if rejected by the destination customs officials.

This design intends to limit the number of motorcars using the proposed bridge building by reducing the customs checking facilities. Declaration and non-declaration of the passenger cars operate on the same level in the proposed design.

\(^{60}\) Photographs of the interiors are forbidden.
3.2.5 Design Evaluation

The design evaluation is concluded as below:

- Design Stage Two focused on the arch bridge geometry. The design started with a bottom arch structure. Gentle arches were then added on top of the bottom arch structure to create the different levels. Later on, the floor levels, as formed by the gentle curves, were flattened to maximise the occupational floor area for the traffic and the offices. The implications of this decision caused a reduction in its visual continuity, particularly when the proposed bridge building is viewed from the side elevation.

- The structural concept of utilising a bottom arch structure will not provide sufficient strength to hold the building up. Vertical supporting columns have been inserted into the building to support the layers of road way. However, the rigid columns contrast with the proposed flowing organic building form.

- Several functions, such as lift cores and traffic ramps as well as a pedestrian bridge, have been integrated in the building void. This has greatly narrowed the width of the void and subsequently defeats the original purpose of allowing entry of light and fresh air.
4.0 REFINING DESIGN

In Design Stage Two, the departure checkpoints for each country were located in the central shared space and arrival was located near the shore. The proposed bridge building is mirrored to reverse this, and, therefore, the arrival spaces, which often require more customs checking areas, are relocated in the central space.
4.1 Structural Evolution

The next design resolution targets the production of an aesthetically pleasing structure that will not conflict with the organic visual form of this proposed bridge building. There was an obvious solution shown in the previous design (Figure 3.24) to support the floors with straight columns, however, as pointed out, this is not consistent with the flow of the curved edges of the floor in the longitudinal direction, or the visual continuity of the building. A more interesting possibility is to try to develop a structural system that corresponds to the language of the organic building form.

Essentially, the building can be seen as a gigantic truss system. Within the truss, there are two structural subsystems: the primary bottom arch structure and the secondary undulating eye-shaped structural beams. Building load is transferred through the undulating beams and onto the bottom arch structure, which is connected to the foundation piers.

The proposed structural design started with two sets of undulating beam structures, running on the perimeter of the building and the void. These two sets of beams resemble a basket that curves inward as the floor plates are battered inward as they rise upward (figure 4.4).

Figure 4.0: Model – an attempt to build the bottom support arch

Figure 4.1: Transverse section

It is a conventional structural resolution with beams and columns. This investigation was not taken further as the structural language does not correspond to the bridge building design.
Figure 4.2: Research picture of the eye-shaped truss

Figure 4.3: An exploration of the pattern of the eye-shaped truss within the building
Figure 4.4: The structure can be viewed as a gigantic truss
Figure 4.5: Exploded axonometric structural support members
Joints between the undulating support beams and the floor plate

The initial idea was to sandwich the floor plate between the undulating beams. The difficulties encountered here were that the traffic flow was restricted where the undulating beams touch the floor (Figure 4.3). In order to enable a smoother traffic flow, the bottom parts of the undulating beams are embedded in the floor, and joined to other undulating beams a level below, as shown in figure 4.6.

An assessment of the Structure

A desk review was conducted with Holmes Consultant Structural Engineer, Jeff Mathew. It was evident that in the wider part of the building, such as the checkpoint area, the separation distance between the undulating beams was more than 40 metres. As a result, additional sets of supporting structures were necessary.

As inspired by the idea of occupying the structural space in the Yokohama Project, the initial attempt was to embed bearing walls into the rectilinear shaped checking booth office. This implies that the position of the check booth offices on the three vehicular levels must be located on top of each other. Some of them interfere with the traffic flow. Subsequently, the decision was made to insert additional sets of undulating beams into the space. In addition to this, the width of the undulating beams was increased from 1m to 3m, in order to accommodate the check booths (figure 4.7 & 4.11). The ceiling height was designed to accommodate the traffic, therefore, a second and third level have been inserted into the offices.
Figure 4.6: Proposed space concrete frame system
Figure 4.6: Proposed space concrete frame system

Barricade

Railing System

Concrete Space Frame Spanning both direction

1000mm deep Undulating Beam

Road Shoulder

200mm Concrete Topping

Traffic Path

Figure 4.7: Proposed space concrete frame system with occupation
Figure 4.9: Long section showing the building void/cut-out/light well
Figure 4.10: Zoom in long section
Figure 4.10: Zoom in long section

Figure 4.11: Interior perspective – the check booth office
Floor edge needs to be tapered

Figure 4.12: Initial proposed floor section
4.2 Spatial Planning

4.2.1 Vehicular Traffic Level

The detailed spatial programme is based on a much more simplified customs checking procedure, as the whole building design was built on the assumption that the two countries are working together towards a more open border policy. In the refined design of the vehicular flow plan (figure 4.13), the primary check and secondary check as presented in Design Stage Two (figure 3.12) are combined into one.

4.2.2 Pedestrian, Cyclists and people travelling by Bus.

Each direction of the bridge starts with three vehicular lanes. Pedestrian and bicycle lane is located on both sides of the bridge. The width of the pedestrian and cyclist path started at four metres and increased up to twenty five metres on top of the primary structural arch. The generous space offers a stopping point for the travellers (figure 3.21).

The arrival/departure lobbies (figure 4.14) in the central shared space are one-stop checkpoint areas for the pedestrians, cyclists, and people arrived on bus. After departing the home country, a traveller cross the “border bridge” located in the central void, which also marks the international border line, to the checkpoint area of the destination country. It is a unique experience, the bridge is within the building but at the same time it is exposed to the sky (38m up) and the sea (40m down).
Blue Floor - Cars and Buses

Bus Stop area

Inaccessible area for the traffic. Occupation area/office

Non-habitable area due to low ceiling height

Entry

ML Departure

Exit

Reject Lane

Exit

Reject Lane

Office and Toilet

Lift core

Bus Stop area
Checkpoint Capacity: Approx 20 trucks/10 mins, 120 trucks/hour, 2880 trucks/24 hour

Figure 4.13: Vehicular Flow level Plans
Figure 4.14: Passenger Arrival/Departure Hall of the two countries
Figure 4.15: Site plan

Quarantine Area

Pedestrian Access

International Border Line

to Malaysia inland

Traffic Direction

To Malaysia Inland

0 50m

Legend:
- Roof
- Truck - Declaration
- Truck - No Declaration
- Car/Bus/Bus Stop
- Pedestrian Route/Checkpoint
- Quarantine
Figure 4.16: Understanding the building though progressive transverse sections
Figure 4.16: Understanding the building through progressive transverse sections

LIFT CORE
Figure 4.17: Perspective view from Malaysian water (developing computer model, for the purpose of showing the building form only)
4.2.3 Shops and Cafeterias

In order to bring a different atmosphere into this building, some of the bubble-like space formed by the undulating structural beams on each traffic floor will house food and duty free stands. These places offer a short break for the drivers. The bigger shopping area and other casual places are designed mainly for people arriving without a vehicle, who will potentially remain in the building for a longer period.

The bottom level of the central, shared space and the island platform where the bottom arch structure meets offers a good location for shops and cafés. This also brings the people in direct contact with the water and the international border line.
4.3 Other Design Elements

4.3.1 End Conditions

Punggol Point is the future residential town in Singapore. At the moment it is lush, natural landscape. The surrounding site of the proposed bridge building, less than two kilometres inland, is of very low density compared to the rest of the island. On the Malaysian side, Pasir Gudang is an industrial town. The two ends of the bridge thus feature different end site conditions.

However, the proposed bridge building does not intend to bring the two differing end conditions onto the bridge. Throughout this project, the design focuses on the international border, trying to blur it by creating a strong connection. Should there be a lack of consistency in the proposed building design where either half of the bridge varies, it will very likely create two different buildings, which are only joined together because of their close proximity.

The context of the proposed bridge building is also arguable. It is more of a literal bridge; differences between the two countries are minimalised. It is also a metaphorical connection of the two countries, rather than merely connecting the immediate site conditions. Further, the bilateral relationship between the two countries has always been problematic. Therefore, it is necessary to avoid design difference in this proposed bridge building that might result in a rivalry between the two sovereignties.

Therefore, the end conditions of the proposed bridge building are restricted to the consideration of the entry design of the bridge (figure 4.15). The two ends of the bridge will provide easy access to the pedestrian and cyclists at the land-sea boundary. Entry of traffic is pushed further away inland (figure 2.14). During heavy traffic periods, queuing traffic occurs on the road, rather than on the bridge. The border crossing journey only begins on the bridge and culminates in the central shared space, at the border transition itself.
4.3.2 Ramps

In Design Stage Two the connection between the vehicular levels (level 4 to level 6) and the quarantine level (level 2), was facilitated by the ramps running on the perimeter of the central void. However, it was realised that the turning radius of the ramps are too tight for a large commercial vehicle. The dimension of the central void is also reduced to a considerable extent, which defeats the purpose of drawing light and air into the building. Additionally, there is only limited space on the quarantine level for both countries. Therefore, the quarantined area is moved to the shore (figure 4.15).

4.3.3 Railing System

The railing, or the balustrade, is designed for vehicular traffic as well as pedestrians. The traffic demands a solid barricade, while humans require a much lighter railing system. The initial design was to place solid concrete barrier on the edge of each floor for the safety of the traffic and people. However, the design outcome is that the floor appears much thicker as viewed from outside. The elegant free flowing outline of the curved floor edge deteriorates.

A more acceptable solution is to integrate the barricade for the traffic into the building. As inspired by the floor edge design of the Yokohama Project, where the large steel folded plate beams disappears in the edge that creates a slim floor edge. It was decided to use a different floor finish level (similar to the road kerb), as the safety measure to separate the traffic and people. A row of solid barriers of 600mm on the edge provides further safety measures. A railing system is then added to the barricade. At the same time, the structural system supporting the floor system reduces the depth to provide a slim edge (figure 4.6).
4.3.4 Circulation Signage

The design process has used analogical colour schemes to enable an understanding of the various building functions. It facilitates the communication of a complex building to other people. Therefore, it can be useful to carry the colour scheme into the signage of the building. Placement of the signage can be done in two ways: by hanging them down from the ceiling and painting the sign on the driving path, or by painting them on the surface of the building.

4.3.5 Water Interface

At the very beginning of the design, it was the intention to lower the arch to the water level and, therefore, the building is able to interact with the water. The building void in the central shared space also opens directly onto the water, offering a glimpse of the building interior to the water traffic passing by. The island formed by the bridge pier foundation, where the bridge arch sits, can be extended into a water front cafeteria with stunning views in a very sensitive area where the border line passes.
4.4 Building Environment Consideration

Ventilation and cooling of this proposed bridge building is structured into four zones. Within the four zones, two separate systems cater for the vehicular floor levels and the office space floors.

4.4.1 The vehicular floor environment

Ventilation of the building on the vehicular floor levels is a combination of natural ventilation and active mechanical ventilation. The bridge building is almost completely open, which means winds are able to pass through freely. The building void in the central shared space runs from the bottom level to the roof, acting like a chimney, drawing fresh air into the building.

As mentioned above, the regional wind directions are either southwest or northeast. Two way supply/exhaust mechanical system will be constantly extracting vehicle exhaust out of the building. The contaminated air is likely discharged at roof level since the wind direction alters during the seasons. Night purge mechanical ventilation is employed to cool the concrete mass at night time where appropriate.

The environment of the office booths located in the vehicular floor levels is isolated from the rest of the space. A localized air conditioning vent is proposed to keep a comfortable working environment.

4.4.2 The office floor environment

The proposed office floor will be fully air conditioned via air/water Variable Air Volume (VAV) system. The refrigerant chillers will be placed at the bottom floor of the four zones. Each floor will have an Air Handling Unit (AHU) that distributes cold air into the working space.

The lighting of the indoor zone will generally use florescent tubes for the traffic floor areas. An even lighting is desired. However, a more complicated lighting design is suitable for the passenger arrival and departure hall.
Figure 4.18: Mechanical Ventilation Schematics
Figure 4.19: Air-conditioning in office areas.
**Vibration issue**

The bridge will experience significant amounts of vibration caused by the traffic. The issue can be resolved by installing a floating floor system in the office booth.
5.0 CONCLUSION

There are a number of challenges faced by this project. The idea of putting two border crossing buildings into one is perhaps not acceptable in the current political climate. This project is a literal expression of the indispensable relationships between the two countries and a gesture of moving towards an open border. The amount of integration between the two countries is carefully considered. Each country still has individual space, but is bonded together by the arrangement of the building space. It has not combined the two totally, as they are still independent sovereignties.

The design also struggled with the scale of the building. The height of the bridge should not intrude upon the low lying context, and a large building footprint is environmentally damaging, posing as a barrier to the water flow. The final design is an elongated building to reflect the often linear bridge prototypes. The proportion of the bridge thus influences the length and width ratio. Within the tight space the project thus struggles to accommodate a reasonable amount of traffic. Traffic manoeuvring space also has a profound impact on the bridge structural design. The location of the structural members is carefully arranged in the building so that they will not pose a hindrance to the traffic.

The checkpoint of the border crossing is designed predominantly for traffic, particularly trucks. If it was only designed for pedestrians and motorcars, the building dead load and live load would be reduced many fold and the structural system would have been much lighter. The structure of the building becomes a major design problem. The project has managed to design the primary and secondary structural system. Detailed design of the structural system is virtually impossible without a heavy input of proper structural expertise. It is said that bridge design is a combination of art and science. Designers excelling in both, such as Calatrava, are able to produce the most beautiful bridges in the world. The aesthetics of his bridges come from a truthful expression of structure. In most architectural practices, the architect’s role includes the conceptual design, selection of bridge system, material, dimension, the surrounding landscape and environment. The scale of the proposed bridge building is impossible to realise without traffic engineers, structural engineers and mechanical engineers. Although there was very little engineering input, it was aware of the potential impacts on the building brought by the traffics. Within this limitation, this project is has successfully created a concept design, especially for dealing with the visual aspects.
This proposed bridge poses a strong symbolic statement about the Johor Strait and also the two countries. The bridge appears as if it was leaping across the water. The border is literally blurred by intensified connection. The building itself offers a destination for people. Interaction with the water and the border offers a pleasing and perhaps emotional experience for some people. The border, after all, perhaps, does not need to be aggressive. Cooperative governance at the border crossing might promote trade, traffic and perhaps the relationship between the two countries. No two nations should stand alone in the world. In the face of globalisation, the survival of a small nation like Singapore will depend heavily upon the neighbouring country. The older generations perhaps will still have vivid memories of the day the border was established. The younger generation perhaps wants something more positive than a fortified border.
6.0 BIBLIOGRAPHY


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Sketch was traced over, Peter Murray, *Living Bridges: The Inhabited Bridge: Past, Present and Future* ed. Peter

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Irina Vinnitskaya, “Lia Passenger Terminal Building,” http://www.archdaily.com/147827/lia-passenger-
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"Pearl River Necklace, Project by NL Architects" http://cubeme.com/blog/2010/06/30/pearl-river-necklace-
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APPENDIX

CONCRETE BENT

TYPICAL REINFORCED CONCRETE SLAB
(Type B)

Figure 13.3H

Source: Montana Department of Transportation. “Structural Systems and Dimensions.”
<table>
<thead>
<tr>
<th>Type</th>
<th>Structure Description</th>
<th>Subgroup</th>
<th>Range of Girder or Web Spacing</th>
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<td>1.5 m to 4.5 m</td>
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<tr>
<td>B</td>
<td>Reinforced, Cast-in-Place Concrete Slabs</td>
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<td>D</td>
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<tr>
<td>E</td>
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<td></td>
<td>2. Tri-Deck</td>
<td>1.6 m to 2.6 m</td>
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GIRDER SPACING RANGES

Figure 13.3E

Source: Montana Department of Transportation. “Structural Systems and Dimensions.”
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<th>Sub Group</th>
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<th>False Work Required?</th>
<th>Maintenance</th>
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*Descriptions in column are for continuous structures. Simply supported structures are always poor.

** Good if weathering steel is used. Expensive (i.e., Poor) if painted.

**

SUPERSTRUCTURE CHARACTERISTICS

Figure 13.3F

Source: Montana Department of Transportation. “Structural Systems and Dimensions.”
### Span Length Ranges (in meters)

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*Note: See Section 13.3.2 for more precise span ranges.*

**SPAN LENGTH RANGES**

**Figure 13.3C**

Source: Montana Department of Transportation. “Structural Systems and Dimensions.”
<table>
<thead>
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* "Depth" refers to the total structure depth at the point of maximum positive moment, including the deck, where composite. "Span" is defined as the distance between center lines of bearings or the centerlines of piers where double bearings are present or the neutral axes of the vertical components where bearings are absent.

Note: $L = \text{Span Length}$  
$S = \text{Slab Span Length}$
TYPICAL FOUNDATION TYPES

(a) PIER OR FRAMED BENT SUPPORTED BY SPREAD FOOTING.
(b) PIER OR FRAMED BENT SUPPORTED BY DEEP FOUNDATIONS.
(c) EXTENDED PILE BENT.

Figure 13.4E

Source: Montana Department of Transportation. “Structural Systems and Dimensions.”
FINAL PRESENTATION
BRIDGE THE BORDER
- a border crossing complex between Malaysia & Singapore

Daicai Lai
TRAFFIC FLOW PLAN

BUILDING INFORMATION

1: Checkpoint Office
2: Prolong Traffic Checking Area
3: Return Path
4: Vertical Circulation
5: Inaccessible Area for the Traffic
6: Non-habitable Area
7: Administration Office Area

Car & Bus Floor

Unloaded Truck Floor

Loaded Truck Floor

Traffic flow Plan

Administration Area
Yellow Floor: Loaded Truck Checkpoint
Red Floor: Unloaded Truck Checkpoint
Blue Floor: Cars & Buses
Green Floor: One-Stop Passenger Arrival/Departure Hall
 Quarantine Area on the Bridge

Singapore Passenger Hall
Border Bridge on the Border
Malaysia Passenger Hall

PROPOSED SPACE CONCRETE FRAME SYSTEM

Concrete Space Frame Spanning both directions

200mm Concrete Topping

Road Shoulder

Traffic Path
Load bearing concrete cantilevered fillet

3000mm UNDULATING BEAM

1000mm deep

700mm BARRICADE

Railing System

CONCRETE SPACE FRAME SPANNING BOTH DIRECTIONS

MOVEMENT SCHEMATIC

11: Shops
10: Ramp to Bus Stop (Blue Floor)
9: Toilets
8: Cafe
7: Offices
6: Non-habitable Area
5: Malaysia Arrival Custom
4: Malaysia Departure Custom
3: Border Bridge
2: Singapore Arrival Custom
1: Singapore Departure Custom