Motorization and Pedestrianization Issues based on Design Standards in Planned Neighborhoods in Jeddah City, Saudi Arabia

Rahif MADDAH*, Junhwan SONG**, and Atsushi DEGUCHI***

Abstract
One of the most traditional and growing major cities in Saudi Arabia, Jeddah City established building design standards for villas and apartments in 1960. These design standards have changed several times in response to population increases. However, these standards have had adverse effects on streets: 1) motorization has created pressure on planned neighborhood streets, which resulted in an unsafe environment for pedestrians who must share the road with vehicles. 2) Because of the lack of availability of apartments in mixed land-use neighborhoods, the municipality has allowed apartments to be built in desirable villa neighborhoods. Apartment and villa neighborhoods had been separated until 2007 because of privacy concerns. The new combination of buildings has resulted in a loss of privacy in villas overlooked by apartment buildings. Apartment residents are also parking their cars in villas’ front yards because of a parking shortage. This study aims to 1) make spatial configuration arrangements of design standards, 2) define the spatial configuration combinations of streets and residential buildings by analyses of the expanding urbanization process, and 3) identify the issues with streets and determine a method to avoid such issues in future neighborhood planning. This study found: 1) a reality gap in design standards, such as the setback line and its relation to parking spaces, 2) unsuitable assumptions regarding car ownership per household, which resulted in a parking shortage, and 3) that resident use of sidewalk spaces as a semiprivate space negatively impacts the pedestrian environment.

Keywords: Public space, Pedestrian environment, Street, Semiprivate space, Residential building type

1. Introduction
1.1 Research Background
Saudi Arabia is an Islamic country. Muslims pray five times a day as part of their daily religious activity, in addition to their daily activities such as working, shopping, going to school, and jogging. Most of these prayers are performed in a mosque, which means that they are one of the main elements of each residential district. These activities increase the importance of the pedestrian environment; however, because of the lack of a safe pedestrian environment, pedestrian casualty rates have increased in some Saudi Arabian cities. Most of these cities have experienced motorization and have been transformed into car-oriented urbanized cities. Nowadays, the car ownership ratio in Saudi Arabia is 0.349 motor vehicles per capita (by

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http://dx.doi.org/10.14398/urpr.3.187
comparison, Japan has 0.559 motor vehicles per capita\(^1\)), which is expected to increase significantly over the next 20 years in parallel with population and economic growth\(^2\).

Jeddah City plays an important role, not only as part of the Makkah region, but also as the second biggest city in Saudi Arabia from a cultural and economic perspective. The city has an important position in Saudi Arabia, partly based on its origin 2,500 years ago as the oldest fishing settlement in the region and its location on the shore of the Red Sea. Jeddah City has become a gateway for pilgrims to Makkah and Medina via Jeddah Port. The city is distinguished from other Saudi Arabian cities by its historic area (Al-Balad; Fig. 1, left map). This area is characterized by its pedestrian-oriented and organic urban fabric, a response to social needs, and its unique building elements, a response to residents’ needs (Fig. 1).

![Fig. 1 Map of Saudi Arabia (right), including the Jeddah Governorate area (left)](image)

### 1.2 Urban Development History of Jeddah City

Al-Balad was a walled settlement between 1509 and 1947\(^3\). In 1947, the central government removed the wall so that the city could be expanded. The growth of the city was restricted to the northern and southeastern areas by geographical constraints: the Al-Sarawat mountain chain in the east, the Red Sea in the west, and the naval base in the south. Since the city wall was removed, the population of the city increased from an approximate population of 35,000 in 1947 to 3.3 million in 2010, and it is projected to grow to 5 million in 2029. Urbanized areas have increased from 300 hectares in 1947 to 176,500 hectares in 2009\(^3\). Jeddah City transformed from a pedestrian-oriented walled settlement into a car-oriented urbanized modern city, which led to an increase in the rate of car ownership. Recently, the Jeddah municipality has begun following the world trend in creating pedestrian-oriented cities and this is reflected in its policies and strategies; however, there are several issues involved in the application of these policies\(^2\).

Mosques are important elements in the neighborhoods that are divided into villa or apartment neighborhoods. However, the existing pedestrian environment in Jeddah City does not support convenient and safe movement according to the Jeddah municipality; this is reflected in its high pedestrian casualty rates. Around 1,165 pedestrian causalities were reported in 2006, of which around 139 were fatal. In 2007, the number of fatal car accidents increased by
6.4% to 170\(^2\). In addition, Jeddah City faces a shortage of parking areas in neighborhoods, which led to an increase in illegal parking\(^2\).

1.3 Research Objectives
In the light of the abovementioned trends of increasing population, rates of car ownership, and the rate of fatal car accidents caused by the coexistence of motorists and pedestrians, it is necessary to improve the following issues: 1) spatial configuration of design standards, and 2) defining street use, such as parking on pedestrian sidewalks.

This study aims to clarify street uses between residential buildings in neighborhoods in Jeddah City that were planned and designed based on design standards, identify their characteristics, and suggest the related issues for future neighborhood planning. The spatial configuration of design standards that are discussed in this study include items such as some articles in the Jeddah City residential building regulations that define the design of residential buildings, e.g., floor number limitation, building-to-land area ratio, building-to-roof area, setback lines, fences, or car parking.

The specific objectives of this study are: 1) to make spatial configuration arrangements in design standards and open spaces, including streets in planned neighborhoods, by chronologically analyzing design changes since the 1960s (sections 2 and 3); and 2) to define the combinations of patterns in the spatial configuration of streets and residential buildings by analyzing the expanding urbanization process. This research intends to clarify the process of construction for each planned neighborhood following the spatial configuration patterns of the design standards (section 4). 3) clarify street use characteristics based on the spatial configuration patterns; identify issues for existing streets; and suggest future neighborhood planning issues for in Jeddah City (section 5).

The planned neighborhoods that discussed in this paper are neighborhoods that were created based on the PMPRLS (Procedure Manual for Preparation of Residential Land Subdivision) which was issued by the Ministry of Municipals and Rural Affair in Saudi Arabia.

1.4 Research Methods
To accomplish the abovementioned objectives, interviews were conducted and data were collected from several competent authorities. The methodology was sequentially performed as shown below.

1.4.1 Chronological Table
This chronological table shows the historical transition of design standards, open space-related standards and design guidelines, population census, future projected population, the housing shortage faced by the city, and the projected future housing demand. The table was produced using data collected from the Jeddah City municipality, the Saudi Arabian Ministry of Municipal and Rural Affairs, and the Central Department of Statistics & Information. In addition, to identify the changes in spatial configuration arrangements in design standards, which have not been identified previously, it was necessary to interview the department heads of the Local Planning and Regulation of Residential Buildings departments at the Jeddah City municipality (sections 2 and 3).

1.4.2 Map of Chronological Growth of Neighborhoods
A map of the chronological growth of planned neighborhoods and typology of residential buildings was created by overlapping the results of the field investigation in Jeddah City to clarify the planned neighborhoods and typologies, which were based on the spatial
configuration of the design standards to which each neighborhood was built. The investigation was performed between 21 and 28 March 2015. These results were added to a chronological city growth map supplied by the Jeddah municipality as a base map, which shows the expanding city boundaries from 1955, 1964, 1971, 1979, and 2007. In addition, the area of each type of planned neighborhood in each period was calculated based on the AutoCAD drawing map of Jeddah City supplied by the Jeddah municipality (section 4).

1.4.3 Field Survey
A field survey was performed for each planned neighborhood to clarify the real-world uses for each type of spatial configuration (section 5).

Based on these items (1–3), this study suggests that the pedestrian environment issues are due to trends in motorization.

1.5 Previous Studies
Several studies of Jeddah City have been performed previously. Some were based on specific locations, such as Al-Balad[5], [6], the waterfront[7], planned neighborhoods[8], and commercial areas[9]. Some were based on urban processes, such as urban growth[10], [11], [12] and city planning implementation[13]. Some were based on housing, such as the housing shortage crisis[14], affordable housing[15], and residential locations from a city-scale perspective[16]. Some are related to disasters, such as flooding[17] and environmental problems[18]. However, there is a lack of research that considers the spatial configuration of design standards and their effects on street uses. Design standards directly influence peoples’ lifestyles and needs; therefore, it is necessary to verify to what extent the design standards, lifestyles, and residents’ needs match each other using the methodology described earlier.

2. Jeddah City Residential Areas
2.1 Characteristics of Unplanned Settlements
Jeddah City residential areas are divided into unplanned settlements and planned neighborhoods. The unplanned settlements occupy over 4,800 hectares (16% of the urban area) and they appeared over two stages. The first stage was from 1947 until 1964 around the Al-Balad area after the city wall was removed. This area is characterized by a dense population of 300–500 people per hectare, a pedestrian-oriented organic urban fabric, and it is inhabited by low-income Saudi people and foreign workers. The crime rate is notably high in the unplanned settlements compared with the urbanized city areas. The second stage was from 1971 until 1980 in areas outside the city boundary, which led to the original city districts to become surrounded by urbanized areas in the process of urbanization[2].

2.2 Characteristics of Planned Neighborhoods
Planned neighborhoods began to form after the first city structure plan was applied in 1964. Jeddah City neighborhoods are divided clearly into villa neighborhoods with a population density of 50–100 people per hectare, and apartment neighborhoods with a population density of 100–300 people per hectare. However, these density variations were a result of changes in floors limit regulation in response to an increased population[19]. We focused on studying planned neighborhoods because of the current high crime rate in unplanned settlements.
2.2.1 Changes in Villa Design Standards

The head of the Local Planning Department of Jeddah municipality noted in an interview that villa neighborhoods were originally extended from Al-Balad, where each family used to live in their own building. Thus, this type of building became popular in the Jeddah City culture. In 1960, after the first villa design standard (VT1) was established, rich families living in unplanned settlements moved to the new northern planned neighborhoods (Fig. 2). The villas in these planned neighborhoods used a simple two-floor design on 60% of building-to-land ratio, and some included a third-floor addition using a 25% building-to-floor ratio. The head of the Residential Building Regulation Department at Jeddah municipality noted in an interview that the Jeddah municipality increased the ratio of the third floor building-to-roof area to 50% (VT2) in 2008 as part of a solution to the housing shortage problem. Therefore, villa buildings could house two generations (Fig. 3).

2.2.2 Changes in Apartment Design Standards

In 1960, apartment buildings (AT1) were constructed for people with a limited income. They were two-floor buildings with an average of four units for four families. Since 1992, Jeddah City has experienced a shortage of housing because of the population increase (Fig. 2)\(^2\). In 1995, the Jeddah municipality modified their building floor limitations to add another floor to allow three-floor apartment buildings (AT2). In 2005, the demand for apartment residential units increased because of the increase in land prices in villa neighborhoods located in the northern part of the city, which was a result of a bid-rigging scheme between real estate companies. This demand led the Jeddah municipality to modify the floor limitations up to four floors in addition to two villa rooftop floors (AT3). The residential building regulation required that the apartment owner should occupy the villa rooftop. However, the Jeddah municipality changed this regulation to limit the floor space to four and a half floors (AT4) in 2012 because of an increase in apartment owners who rented their rooftops illegally (Fig. 3).
2.3 Changes in Design Standards and Related Factors
In 2009, the Jeddah municipality performed a study to clarify the extent of the housing shortage that the city has experienced since 1992. The study also projected the future housing demand in relation to an increasing population (Fig. 2). However, the lack of revision of the AT1 design standards over 35 years was one of the main reasons for the housing shortage that emerged in 1992. In 1995, AT2 was designed in response to the housing shortage; however, this housing design could not compensate for the housing shortage, which led to the implementation of AT3 and AT4. Because of the increase of the value of land in villa neighborhoods, the Jeddah municipality allowed apartment buildings to be built in these areas. In the process of changing design standards, several street-related standards and guidelines were included to improve the quality of streets (Fig. 2).

3. Spatial Configuration of Design Standards
3.1 Characteristics of Building Patterns
3.1.1 VT1 : Villa Type 1 (1960–)
The average lot area in villa neighborhoods is between 500–600 m². The villa design (VT1) consists of two floors with a building-to-land ratio of 60% for each floor in addition to an attached building-to-roof ratio of 25% floor space (Fig. 3). The parking area for the building is located in a 4-m area behind the setback line. The architectural laws in Jeddah City required that the minimum number of parking spaces from 1960 to 2006 was one space per villa; however, in 2006, the minimum was changed to one parking space per 250 m² of total gross floor area. For example, for a 500 m² land area, the total gross floor area is 675 m² because 600 m² is divided between the ground floor and first floor, in addition to 75 m² for the attached third floor. Therefore, this requires space for 2.7 cars, which is rounded up to three parking spaces.
3.1.2 VT2 : Villa Type 2 (2008–)
The only difference between the VT1 and VT2 designs is the increased building-to-roof floor ratio, which became 50% instead of 25% as in the VT1 design. The calculation of the required parking lot size is similar to that described for VT1, requiring three parking spaces (see VT2 in Fig. 3).
3.1.3 AT1 : Apartment Type 1 (1960–)
This type of apartment mainly consists of four units, with each unit occupying an area between 165–210 m² because the average area for apartments in Jeddah City is between 550–700 m². In this apartment type, one parking lot must be provided for each unit in the area behind the setback line using a perpendicular parking system (see AT1 in Fig. 3).
3.1.4 AT2 : Apartment Type 2 (1996–)
The floor area limitations for apartments increased to three floors with one attached floor with a building-to-roof ratio of 10% in response to Jeddah City’s population growth. The average number of units in an apartment building increased to seven units. At least one parking space was required for each unit (see AT2 in Fig. 3).
3.1.5 AT3 : Apartment Design (2006–2012)
Because of a bid-rigging scheme between real estate companies, Jeddah City has experienced a housing crisis since 2005. Therefore, the land prices in the villa neighborhoods located in northern Jeddah City have increased, which subsequently produced a high demand for apartments. The Jeddah municipality increased the number of floors to four floors in addition to two floors of villa rooftop space using 50% of building-to-roof ratio to fulfill the demand for
apartments. The villa rooftop space could not be rented or sold and its main purpose was to provide extra space for the owner. The Jeddah municipality changed the parking lot regulations because of the increase in the number of units in this type of building to require: a) one parking space per 150 m² building area, or b) parking space for each unit, which means that a large number of parking spaces must be required. The area for parking must take up 60% of the ground floor space (see AT3 in Fig. 3).

3.1.6 AT4 : Apartment Type 4 (2012~)

According to Jeddah municipality, so many apartment owners illegally rented their villa rooftop spaces (AT3) from 2006 until 2011 that the municipality had to update this regulation to exclude villa rooftops. The car park requirements were similar to those for the AT3 design (see AT4 in Fig. 3).

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<thead>
<tr>
<th>Legend</th>
<th>Perpendicular Parking</th>
<th>Sidewalk</th>
<th>Car-way</th>
<th>Open space+Entrance for Service Floor</th>
<th>Parking Floor</th>
</tr>
</thead>
</table>

Fig. 3 Types of Spatial Configuration based on Design Standards in the case of minimum street width (sections and plans)
3.2 Elements of Spatial Configuration of Planned Neighborhood Streets
As shown in Fig. 3, the spatial configuration components of design standards were mixed between public and private land (street, and residential buildings). Therefore, it is necessary to analyze the spatial configuration components to analyze these elements (Table 1). Floor number limitation, setback lines (whether on land along a one-way street or a corner), concrete fences (whether prohibited or required), parking location, and width of street and sidewalk are the main elements that comprise the spatial configuration of neighborhood streets. For example, based on building standards, building a fence is obligatory in villa neighborhoods, but it is prohibited for apartment buildings to allow the residents to use the space behind the setback line as a parking space. Apartment buildings on corners are supposed to include a setback line 3 m from the second side, which means that they have a decreased building-to-land ratio.

Table 1: Elements of spatial configuration of planned neighborhood streets

<table>
<thead>
<tr>
<th>Element Type</th>
<th>Floor limitation (maximum)</th>
<th>set-backs, minimum (m)</th>
<th>Concrete Fence</th>
<th>Parking location</th>
<th>Street (Minimum)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>One way land</td>
<td>Corner land</td>
<td></td>
<td>Side walk location</td>
</tr>
<tr>
<td>VT1</td>
<td>2F+1F(25% of 2nd F)</td>
<td>4</td>
<td>2</td>
<td>○</td>
<td>Behind the villa fence at property</td>
</tr>
<tr>
<td>VT2</td>
<td>2F+1F(50% of 2nd F)</td>
<td>4</td>
<td>2</td>
<td>○</td>
<td>Perpendicular parking at set-back area</td>
</tr>
<tr>
<td>AT1</td>
<td>2 F</td>
<td>1</td>
<td>2</td>
<td>×</td>
<td>Perpendicular parking at 60% of ground floor</td>
</tr>
<tr>
<td>AT2</td>
<td>3F+1F(25% of 3rd F)</td>
<td>3</td>
<td>2</td>
<td>×</td>
<td>Perpendicular parking at 60% of ground floor</td>
</tr>
<tr>
<td>AT3</td>
<td>5F+2F(50% of 5th F)</td>
<td>5</td>
<td>2</td>
<td>○</td>
<td>Perpendicular parking at 60% of ground floor</td>
</tr>
<tr>
<td>AT4</td>
<td>5F+1F(50% of 5th F)</td>
<td>5</td>
<td>2</td>
<td>○</td>
<td>Perpendicular parking at 60% of ground floor</td>
</tr>
</tbody>
</table>

Note: the locations of I, II, III, and IV are shown in the plans for each type in Fig. 3. ○ is an obligation and × is a prohibition.

3.3 Street Issues in the Spatial Configuration of Design Standards
This section summarizes the changes in design standards from 1960, 1996, 2006, and 2012. The main goal for these changes was to alleviate the housing shortage that Jeddah City has experienced since 1992. The villa and apartment standards share the common element of a minimum sidewalk width of 1.5 m (3 m total for the sidewalks on both sides of a street). In analyzing the design standards, two issues were identified: 1) the 4-m setback space in AT1 and AT2 is not enough for car parking because the average car length is approximately 5 m, which will negatively impact the pedestrian sidewalk space; 2) The entrance to the parking floor for each building in AT3 and AT4 disrupts the continuity of the sidewalk, which also disrupts the continuity of pedestrian sidewalk space. Both issues do not support the need for walkability in planned neighborhoods.

4. Urbanization Process of Spatial Configuration Patterns
4.1 Characteristics of Urbanization Process
The shape of Jeddah City is surrounded by several geographical constraints, such as the Al-Sarawat mountain chain to the east, the Red Sea to the west, and the naval base to the south. Pilgrims go on pilgrimages to Makkah City, which is located in southeastern Jeddah City; therefore, Jeddah City mainly expanded towards its northern and southeastern edges.

Until 1947, Jeddah City experienced growth difficulties because of limited tax revenues in the city, which comprised fees collected from commerce and pilgrim services. However, after the Second World War (post-1945), oil was discovered in Saudi Arabia and the Kingdom started receiving oil revenue in 1946. This led the government to remove the city wall and...
expand the city. Several investments were made in the city’s basic infrastructure, such as roads, public hospitals, and the airport. However, until 1964, the lack of a city master plan was the main factor for the appearance of the early unplanned settlements located around the Al-Balad area. These unplanned settlements were physically characterized by their organic urban form, narrow public spaces between buildings, differentiation in floor numbers, lack of land titles, and poor-quality construction materials (Fig. 4).

1964 was a turning point for Jeddah City because of the first city master plan. This master plan laid out the characteristics of the existing linear grid pattern of the city and the location of the airport. After the application of the first master plan, illegal unplanned settlements began to appear outside the urbanized area in 19712). As the city became more urbanized, these unplanned settlements were surrounded by planned districts (Fig. 4).

During the urbanization process, the area outside each urbanized boundary was a good investment opportunity for businesspeople, who bought and sold large areas of land. Because the design of villa was popular, most of the businesspeople chose to build villa neighborhoods during the government’s process of ruling on land use. As a result, villa neighborhoods comprise approximately 63% of the planned neighborhoods in Jeddah City today (see VT1 in Table 2).

In 2006, because of the Saudi Arabian stock market crisis, real estate companies began a bid-rigging scheme, which increased the value of the villa neighborhoods located in northern Jeddah City. Therefore, the growth trend changed gradually to focus on the vacant lots in the urbanized area in the middle of the city, and the demand for apartment units increased.

4.2 Expanding Spatial Configuration Patterns
Based on a field survey performed in 2015, planned neighborhoods in the city were sorted into types based on the spatial configuration patterns of their design standards (VT1, VT2, AT1, AT2, AT3, and AT4). By overlapping the survey results on the Jeddah City chronological growth map created by the Jeddah municipality, the chronological growth of the planned neighborhoods in the city is shown based on the spatial configuration patterns of design standards (Fig. 4). The chronological growth map shows the expanding city boundary for 1955, 1964, 1971, 1979, and 2007; therefore, Fig. 4 shows just these periods in addition to 2015 when the survey was performed. By applying the survey results to the AutoCAD data supplied by the Jeddah municipality, we calculated the area of each type of planned neighborhood in the city (Table 2).

By 1955 and 1964, the city growth was more toward the southeast of Jeddah City because the unplanned settlements were spreading (Fig. 4). When Al-Madinah Road was established as the main road leading to the airport, it divided the city into eastern and western parts. As a result, along Al-Madinah road from the south to the north, the types of neighborhoods sequentially changed from AT1, AT2, AT3, to AT4, and combinations of these designs appeared, such as AT1+AT2, AT1+AT3, AT1+AT4, and AT2+AT3. The combination designs usually appear when a new type of design standard is introduced into the building regulations by the municipality and applied to vacant lots in a neighborhood that includes residential buildings already built to an earlier design standard. The majority of apartment neighborhoods were located along Al-Madinah Road toward the eastern part of the city because the value of the land is lower than the western part of the city and it is closer to the corniche that borders the city to the west.
As shown in Fig. 4, the majority of villa neighborhoods are located in the western part of Al-Madinah Road along the Red Sea. The western part of the city is popular because it is close to the corniche, which is used as a gathering place for leisure and entertainment. This increased the land value so that it was only affordable for mid-high to high income people, who prefer to live in villas. The villa neighborhoods located in northern Jeddah City started to appear in 2007.
but they lacked many services. Initially they lacked infrastructure such as sewage disposal and purified water supply systems as well as city-scale resources such as commercial, entertainment, and educational facilities. Despite these deficiencies, the land value is high compared with neighborhoods in the urbanized area, which was because of the bid-rigging scheme between real estate companies. Recently, Jeddah City’s growth has changed gradually from outward to concentrate in the inner city and demand has increased for apartment units as permanent places to live.

4.3 Residential Patterns and Related Streets Future Issues

Table 2 shows that 63% of planned neighborhoods are villa-only neighborhoods, 36% are apartment-only neighborhoods (resulted from AT1, AT2, AT3, AT1+AT2, AT1+AT3, AT2+AT3, AT4, AT1+AT4, AT2+AT4, and AT3+AT4), and 1% are neighborhoods that combine villas and apartments (resulted from VT1+AT1, and VT1+AT3). As discussed in section 3, the design of AT1 and AT2 forces cars to use the sidewalk space because of the lack of space to accommodate car dimensions in car park spaces. Therefore, no sidewalks are available in 16.4% of planned neighborhoods (total area of AT1, AT2, and AT1+AT2). However, 12.1% of the current planned neighborhoods, appeared after 1996 due to motorization. Furthermore, 9.8% of planned neighborhoods (total area of AT3, AT4, and AT3+AT4) have discontinuous sidewalks because they are interrupted by car park entrances. In addition, 10.3% of planned neighborhoods used a combination of villa and apartment designs (total area of VT1+AT1, VT1+AT3, AT2+AT3, AT1+AT4, and AT2+AT4), so sidewalks were unavailable or discontinuous. In addition to the street-related issues in the abovementioned 10.3% of planned neighborhoods, 0.8% of the 10.3% (total area of VT1+AT3) experiences invasion of privacy because the 4-m setbacks for villa designs mean that apartment buildings overlook these spaces, which reduces their privacy. This type of combination is expected to continue in future neighborhoods.

Table 2: Planned neighborhood areas in the city urbanization process (unit: hectare)

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<tbody>
<tr>
<td>VT1 (1960)</td>
<td>35.8</td>
<td>61.6</td>
<td>166.8</td>
<td>1,205.7</td>
<td>6,410.6</td>
<td>5,804.6</td>
<td>13,685.1</td>
<td>63.0%</td>
<td></td>
</tr>
<tr>
<td>AT1 (1960)</td>
<td>188.5</td>
<td>236.1</td>
<td>424.6</td>
<td>12.0%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AT2 (1996)</td>
<td>79</td>
<td>2,179.7</td>
<td>373</td>
<td>12.1%</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>AT3 (2006)</td>
<td>526</td>
<td>526</td>
<td>2.4%</td>
<td></td>
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<tr>
<td>VT1+AT1</td>
<td>45.8</td>
<td>45.8</td>
<td>0.2%</td>
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<tr>
<td>VT1+AT3</td>
<td>170.5</td>
<td>170.5</td>
<td>0.8%</td>
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<tr>
<td>AT1+AT2</td>
<td>504.5</td>
<td>504.5</td>
<td>2.3%</td>
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<tr>
<td>AT1+AT3</td>
<td>105.2</td>
<td>105.2</td>
<td>0.5%</td>
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<tr>
<td>AT2+AT3</td>
<td>1,273.6</td>
<td>117</td>
<td>6.4%</td>
<td></td>
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<tr>
<td>AT4 (2012)</td>
<td>1151</td>
<td>1151</td>
<td>5.3%</td>
<td></td>
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<tr>
<td>AT1+AT4</td>
<td>540.8</td>
<td>540.8</td>
<td>2.5%</td>
<td></td>
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<td>21715.2</td>
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5. Street Use based on Spatial Configuration Patterns

5.1 Analysis of Street Uses

Based on our field investigation, we can clearly see that real-world street use differs from intended use. These differences occur because of several reasons, such as: 1) some design standards do not fit with the reality; 2) some design standards do not adequately match the
residents’ lifestyle; and 3) some standards were not applied well because of a shortage in application, and post-design management and inspections (Fig. 5a and 5b).

5.1.1 Villa Type 1
The common aspects of villa neighborhoods are: 1) instead of parking within the property, residents use the street in front of their villa as a parallel-parking area and use the 4-m setback for their private use; 2) although the sidewalks are a public space because they are part of the street, they are used by villa owners as a place for private plantation, benches, or a spot for socializing, which means that pedestrians cannot walk on the sidewalks; and 3) pedestrians are forced to walk on the road close to the parked cars (see VT1 in Fig. 5a).

5.1.2 Apartment Type 1 and Apartment Type 2
The real-world uses of AT1 and AT2 have similarities in spatial configuration. The real-world spatial configurations differed from the design standards because of several factors: 1) Although the average length of cars is approximately 5 m, the AT1 and AT2 design standards place the parking lot area in the 4-m setback area, which led the residents to use the sidewalk as a part of their car parking space (see AT1 and AT2 in Fig. 5a and 5b). 2) Because of a lack of penalty for those who change the original sidewalk pavement, apartment owners change the public pavement to match the pavement on their private setback area. 3) Owing to a) a lack of regulation regarding a height limitation for the car park area level from the street level, or b) a lack of rainwater drainage network and sewage water drainage network systems, some owners level up the ground level of their building from the street level to prevent water from going inside their building. Therefore, there are differentiations in sidewalk height as well as building height.

5.1.3 Apartment Type 3 and Apartment Type 4
As the number of floors increased in the type of AT3 and AT4 comparing to AT1, and AT2 (see AT3 and AT4 in Fig.5a), which has led to increase the number of units in these types of apartments. The car park floor became not enough, so the setback areas are also used as parking areas in response to the shortage of car park. Therefore, the sidewalk was used as part of parking area. This caused pedestrians to walk on the street close to the cars.

5.1.4 Combination Designs
As shown in Fig. 5a and 5b, the real-world uses of various design types are becoming more complicated. The neighborhoods with combinations of different designs were characterized by a mixture of the previously mentioned real-world uses: using the sidewalks in villa neighborhood for semiprivate purposes, parking on the street in front of one’s villa, using the sidewalk as part of the parking area in AT1 and AT2 designs, and parking on sidewalks outside AT3 and AT4 apartment designs.

5.2 Future Issues Based on the Real-World Spatial Configurations
Creating a spatial configuration that matches with the design standard, and maintaining it for a long period depends on several factors, such as matching the design to the existing physical dimensions of the location; e.g., the dimensions available for car parking spaces to the cars’ actual dimensions. Post-implementation management and inspection are also essential. However, based on the AT1 and AT2 design standards, car parking spaces are located in the 4-m setback area, despite the average car length being approximately 5 m. since the sidewalks are located beside the parking space, sidewalks have become a part of the parking area. This forces pedestrians to walk on the street despite the danger. In AT3 and AT4 apartment neighborhoods,
the ground floor space for car parking does not correspond to the existing number of cars; therefore, this results in permanent parallel parking along the inner streets of planned neighborhoods and cars illegally park in the setback area. In villa neighborhoods, some sidewalks are in poor condition because of a lack of post-implementation management and are unsuitable places to walk. In addition, the regulated minimum number of parking spaces is one space per unit and, on average, Saudi Arabians own more than one car per household.

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Fig. 5a Combination of patterns of spatial configuration designs and real-world street uses
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<th>Section</th>
<th>Actual Condition</th>
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<td>![Plan Image]</td>
<td>![Section Image]</td>
<td>![Actual Image]</td>
</tr>
</tbody>
</table>

Legend:
- ▲ Perpendicular Parking
- ◦ Sidewalk
- ● Car-way
- ◆ Open space/Entrance for Service Floor
- ▲ Private use e.g. Play Space for Children
- ◦ Villas’ Owner Plantation / Bench
- ● Parking Floor
- ▲ Parallel Parking Villa Owner / Guest
- ◆ Parallel Parking in case of no parking lot available

Fig. 5b Combination of patterns of spatial configuration designs and real-world street uses
As a result, these two factors have meant that the pedestrian environment has moved from sidewalks to the street in villa neighborhoods because of the absence of a law forbidding parking permanently along the street or using the sidewalk for private purposes. However, the mismatch of the dimension of cars and the parking spaces is the main reason for the unavailability of sidewalks in AT1 and AT2 neighborhoods. In contrast, two factors changed the pedestrian route from being on the sidewalk to sharing the street with cars in AT3 and AT4 neighborhoods: the lack of a law forbidding parking in the 4-m setback area and along the street and a mismatch of the minimum area requirements of car parking spaces with the existing average cars per household.

6. Conclusion
Section 2 and 3 discussed and analyzed the changes in design standards, their related factors, and the factors that made the design standards difficult to apply in the real world. We conclude that it is necessary to evaluate the design standards regularly in the future to clarify the efficiency of the design standards in response to the housing shortage. It is important to consider the real-world environment in creating design standards.

Section 4 analyzed the chronological growth of planned neighborhoods with the application of spatial configuration patterns. For neighborhoods with both villas and apartments, it is necessary to revise the both design standards by considering the potential invasion of privacy by building apartments next to villas.

Section 5 analyzed the actual combination patterns of different spatial configuration designs with the real-world street uses in planned neighborhoods, and pointed out that several factors must be considered in the revision of design standards, including 1) the applicability and efficiency of sidewalks, and 2) ensuring that the average car ownership per household to match the minimum requirement for car parks per unit.

Finally, the Jeddah City pedestrian environment is influenced by three main factors: 1) the mismatch of design standard dimensions with the reality, 2) motor vehicle-oriented neighborhood planning, and 3) using sidewalks for semiprivate purposes, which originate from the historical and cultural background of the city. It is necessary to consider these three factors in planning future pedestrian-oriented neighborhoods in Jeddah City.

Acknowledgments
This work was supported by JSPS KAKENHI Grant Number 26249085.

Reference


