SEMARAK ILMU PUBLISHING

Journal of Advanced Research in Applied Mechanics

Journal homepage:
https://semarakilmu.com.my/journals/index.php/appl_mech/index
ISSN: 2289-7895

Factor that Contributes to the Ramp Design and the Effective Gradient for Ramp at Entrance Carporch Area for Housing Sector in Double-Storey House to Accommodate Low-Clearance Vehicles

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ARTICLE INFO

Article history:
Received 10 June 2023
Received in revised form 13 August 2023
Accepted 27 August 2023
Available online 6 October 2023

Keywords:
Ramp, safety, housing, Low-Clearances Vehicle

ABSTRACT

The main aim of this study is to propose the effective gradient for different dimensions between ground clearances vehicles for ramp design in car porch areas for the housing sector. There are many guidelines and standards have been established, such as Building (Federal Territory of Kuala Lumpur) By-Laws 1985, Selangor Uniform Building By-Laws 1986, Guidelines for Car Parking ad Internal Traffic Circulation (Wilayah Persekutuan Kuala Lumpur 2018), Malaysian Standard 2426 1 2011, and Neufert Architect's Data (Fourth Edition) as references to the consultants. However, each guideline shows only minimum guidelines and is not specific for each type of vehicle, especially vehicles which have lowered skirtings, such as sports cars or hummer vehicles. Hence, the aim of this research is to propose the effective gradient for different dimensions between ground clearances vehicles for ramp design in car porch areas for the housing sector and to determine the issues of ramp design at car porch in housing and residential area. To propose the effective gradient, the research will focus on the factor that contributes to the ramp design for accommodating low-ground clearances vehicles on high profile at the car porch area. In other words, to achieve this aim, an interview session has been held with the professional parties with architects, engineers in the engineering department at Majlis Bandaraya Seremban, DBKL, Majlis Bandaraya Melaka, Majlis Bandaraya Johor Bahru, Jabatan Kerja Raya (JKR) and consultant firms. The data that been collected during the interview session is based on the four aspects that are background of interview, existing guidelines and standards of ramp design, impact of improper design to residents and proposed the specific high ramp design criteria in a different situation to accommodate low-clearance vehicles. The researcher analyzed the data by grounded theory and color coding based on the respondents' feedback. In short, after the researcher completes all the data collection, the researcher makes a conclusion and summary to propose the maximum gradient for different dimensions between the different dimensions of ground clearances. These data can be used to estimate the suitable degree and percent for different categories of ground clearances which is useful for current development and current technology circulation.

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https://doi.org/10.37934/aram.110.1.2236

1. Introduction

The ramps are sloping walkways that can be used inside or outside of a building to allow access to various levels. In fact, there are five types of ramps which are ramp for heavy vehicles, ramp for home accessibility, ramp for driveways, ramp for auto parking facilities, and ramp for metering at highway. For this research, the type of ramp that will be explored is a ramp at the car porch area that involves two types of ramps. In short, the two ramps that include in the residential and housing sector are ramp at driveways and ramp at entrances.

There are a lot of low–clearance vehicles that have been created according to current technology. Every version of every vehicle from import or local vehicles has a different dimension of car clearance, and the design of ramps needs to follow according to the dimension to avoid any issues. Besides, the owners modified their vehicles and lowered the skirting. The dimension of ground clearances is one of the factors which need to be consider when designing the ramp. The dimension of ground clearances is one of the factors which need to be considered when designing the ramp. Hence, if the dimension of ground clearances becomes decreases, the most serious possible accident will happen. In other words, the accident will happen due to the lowered skirting, and the dimension of ground clearances is decreased.

There are many guidelines and standards have been established, such as Building (Federal Territory of Kuala Lumpur) By-Laws 1985, Selangor Uniform Building By-Laws 1986, Guidelines for Car Parking ad Internal Traffic Circulation (Wilayah Persekutuan Kuala Lumpur 2018), Malaysian Standard 2426 l 2011, and Neufert Architect's Data (Fourth Edition) as references to the consultants. Then, each of these guidelines has different standards depending on different situations, conditions, and states. Thus, referring to all guidelines related to the ramp at the car porch for housing at the landed area, the gradient has been decided and published. For instance, in Building (Federal Territory of Kuala Lumpur) By-Laws 1985, the maximum gradient for the straight ramp is 10%, and as stated in Selangor Uniform Building By-Laws-1986, the gradient for the straight ramp is not exceeding is 12%. Highlighted by Dewan Bandaraya Kuala Lumpur (2018), in Guidelines for Carpark &Internal Traffic Circulation, there are two gradients for straights ramps for the parking area and straights ramps for the non-parking area. Each of these situations has two different preferred gradients, which are for straights ramps in the parking area between 4% to 5% and preferred non-parking area between 10% to 14.3%. Hence, the three guidelines show that the gradient is the main component in designing the ramps.

Referring to the professional architect in the building department in Majlis Bandaraya Seremban, the developers that have ramp issues in their development are located at Taman Lavender Height, Seremban, and Taman Bukit Kepayang Seremban. As discussed, the main factor contributing to the problem mentioned previously is the weakness of the guidelines and standards for ramp design on car porches for residential areas. Besides, the specific design of the ramp needs to be according to the different dimensions of car clearances at the car porch area. In other words, the design and the guidelines or ramp at the car porch area need to comply with the current vehicles to avoid any issues and accidents to the consumer.

As a conclusion, after interview session with professional parties, the researcher will used grounded theory as the main analytic method. Then, after identifying the main factor when designing the ramp especially in gradient factor, the researcher proposed effective gradient for different type of vehicles. In addition, the input of discussion in interview session acts as a research instrument in evaluating and investigating the existing guidelines and proposing the most suitable gradient for different dimensions between ground clearances vehicles. The result of this study will be valuable to

the construction industry and tools for future design as a reference for professional parties, especially for authority.

A lot of guidelines and standard for geometric ramp design in car porch area is proposed by the other countries. However, the limitation of accurate geometric design of ramps with different specific dimensions of vehicles, including wheelbase, ground clearances and different situations, is not published and clarified. Based on previous studies which have been mentioned in the literature, the general per cent and degree of sloping have been clarified. Therefore, in this research, a comprehensive study will be conducted to investigate and propose new guidelines and standards of ramp design in the different situations, which are high ramps in driveways, the high gradient of the ramp and low ramps in driveways, and high gradient of ramp depending on a different specific dimension of vehicles including wheelbase and ground clearances will be implemented.

2. Issues of Ramp

There are a lot of low–clearance vehicles that have been created according to current technology. Every version of every vehicle from import or local vehicles has a different dimension of car clearance, and the design of ramps needs to follow according to the dimension to avoid any issues. Besides, some of the owners will modify their vehicles and lowered the skirting. Hence, when a low clearance vehicle negotiates a high-profile ramp, especially at driveway entrances, the vehicle may become lodged or stuck on the 'hump'Header level three (1.1.1) and above will follow header level three style.

In fact, ramp entrances have two gradients, i.e., single gradient and double gradient. However, single gradient and double gradient have different gradients to avoid any issues in future.

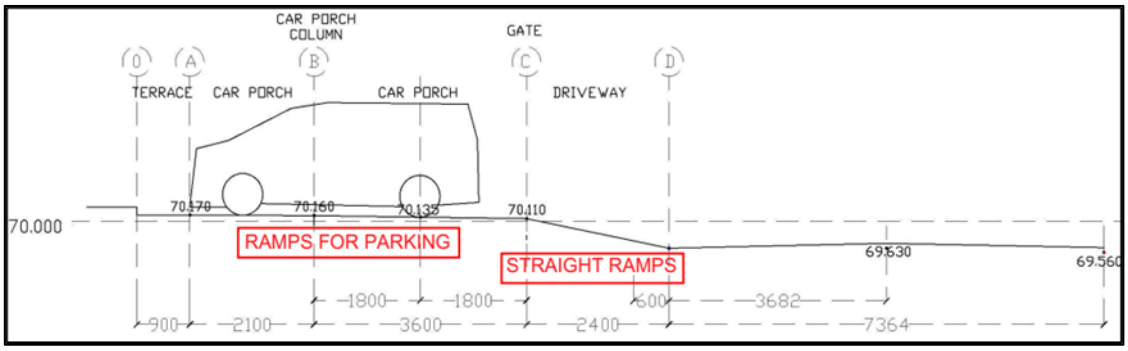

Fig. 1. Typical Design for Car porch Area for Double Gradient

For the double gradient, it has two ramps, i.e., straight ramps and parking ramps, that need to be considered and explored. Thus, based on the existing guidelines which have been used by consultants in the design stage, there is a maximum gradient for the parking ramp and straight ramp to avoid any issues in future.

Referring to Table 1, For the double gradient, Malaysian Standard 2426: 2011 and Neufert Architect's Data (Fourth Edition) highlighted the gradient should not exceed 15%. Meanwhile, based on the Guidelines for Car Parking and Internal Traffic Circulation (Wilayah Persekutuan Kuala Lumpur, 2018), the maximum gradient is 14.3%. Besides, some of the guidelines stated the most preferred gradient is 10% which is from Building (Federal Territory of Kuala Lumpur) By-Laws 1985 and Guidelines for Car Parking and Internal Traffic Circulation (Wilayah Persekutuan Kuala Lumpur, 2018). However, based on Guidelines for Car Parking and Internal Traffic Circulation (Wilayah Persekutuan Kuala Lumpur, 2018) and Malaysian Standard 2426: 2011 for parking ramps, the maximum gradient

should be not more than 5%, and the most suitable gradient is 4%. Meanwhile, referring to the Neufert Architect's Data (Fourth Edition), the gradient should not exceed 6%.

Table 1
Existing Guidelines for Double Gradient

Guidelines	Straight Ramps	Parking Ramps
Building (Federal Territory of Kuala Lumpur) By-Laws 1985	1: 10 – 10%	Not stated
Selangor Uniform Building By-Laws-1986	Not exceeding 1: 8.3 (12%)	Not stated
Guidelines for Car Parking and Internal Traffic Circulation (Wilayah Persekutuan Kuala Lumpur 2018)	Suitable: 1:10 (10%) Maximum: 1:7 (14.3%)	Suitable: 1:25 (4%) Maximum: 1:20 (5%)
Malaysian Standard (MS – 1184) (similar gradient with OKU)	Not exceeding 1: 8.3 (12%)	Not stated
Malaysian Standard 2426 : 2011	Not exceeding 3:20 (15%)	Not exceeding 1 : 20 (5%)
Neufert Architect's Data (Fourth Edition)	Not exceeding 3:20 (15%)	Not exceeding 1:16.5 (6%)

Thus, in designing a double gradient, the straight ramp should not be more than 15%, and the preferred gradient is 10%; meanwhile, for the parking ramp, the maximum gradient is 5%, and the suitable gradient is 4%.

2.1 Factor that Contributes to the Ramp at Entrance House.

The profile of ramp is an important element because it affects potential damage to the vehicle and to the comfort of the vehicle. The minimum width, maximum gradient, ramp geometry design, and length of the ramp are profile ramp components that are taken into consideration while determining the ramp design influence factor.

Sze and Christensen [1] clarified that the slope, ramps, minimum, desirable clear width, dimension of landing, maximum gradient, and design protection, including curbs and barriers, were specified in the guidelines. Besides, as mentioned by Fitzpatrick *et al.,* [2], four factors that directly affect ramp are design consistency. To conclude, if all the factors weren't considered while designing the ramp, there's a chance that an accident could occur where the car gets trapped or lodged on the "hump." Figure 2 is all the factors that contribute to the failure of ramp at entrance house.

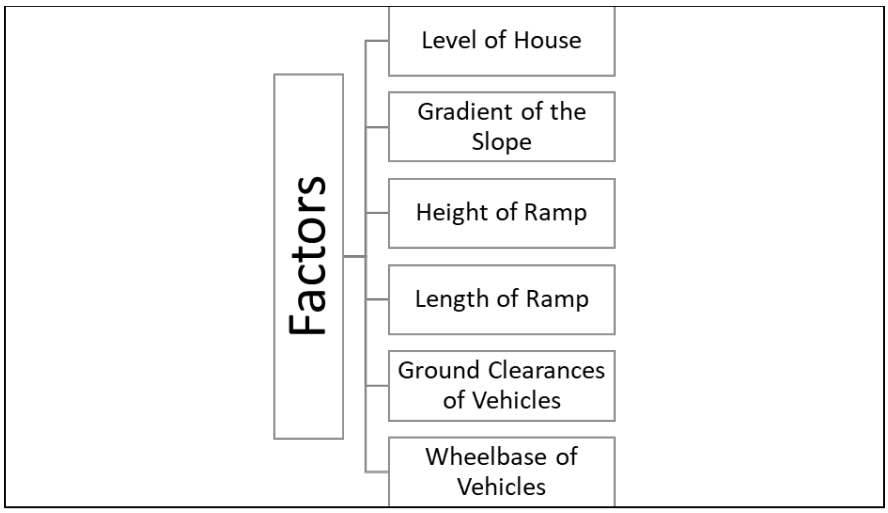

Fig. 2. Factors that contribute to the failure of ramp at entrance house

2.1.1 Ground clearances and wheelbase of vehicles

When designing the ramp, ground clearance should be the primary consideration. Each of the vehicles must study more depth pertaining to the ground clearance dimensions to accommodate the design. Basically, there are four categories of car that are hatchback, sedan, multi-purpose vehicle (MPV), sport utility vehicle (SUV) couple-convertible. Thus, each of these types has different clearances ground. Table 2 is the dimension of clearances ground based on different categories of car.

Table 2
Dimension of ground clearances for four categories

No	Categories	Dimension
1	Sedan	300mm [3]
2	SUV	200mm [3]
3	Sports Utility Vehicles	More than 50mm [4]
4	MPV	500mm [3]

To sum up, Table 2 demonstrates that different car kinds in this technological age have various ground clearances and wheelbases. The dimensions of vehicles, such as wheelbase and ground clearances, need to be taken into consideration and researched to construct a straight ramp and parking ramp.

The most critical condition was a rear overhang on short-wheelbase vehicles under conditions of rear jounce, which is a vehicle's downward action in a vertical sag curve or bump. The wheelbase, defined as the distance from the rear axle of the tractor to the front axle of the trailer, is even more variable. Data from weigh stations indicate that wheelbases of low-ground clearances vehicles can range from 21 to more than 40ft. Thus, the most critical condition of rear overhang on short-wheelbase vehicles under conditions of rear jounce, which is a vehicle's curve or bump. In short, the dimension of the wheelbase is the main component, which needs more focus because it will affect the vehicles.

2.1.2 Level of the house and level of the road

In the preliminary stage of design, the level of the house and the level of the road are the main items which need to be considered and explored before proceeding to the site works. After the level of the road and level of the platform the level had been made by a professional consultant, the architect will estimate the gradient for the parking ramp and straight ramp. Besides, some of the researchers recommended that there be no more than 5 % for the parking ramp; meanwhile, for the straight ramp, it is below 15%. Hence, the per cent of the gradient for both slopes, which are straight ramps and parking ramps, will affect the effective ramp in the housing sector.

2.1.3 Gradient of the slope including height and length of ramp

The gradient of a surface is its slope. In order to decide the quantity of gradient, the length of the ramp and height of the ramp are included in the calculations. Figure 3 shows the example of the ramp at the car porch that involves the gradient of the ramp.

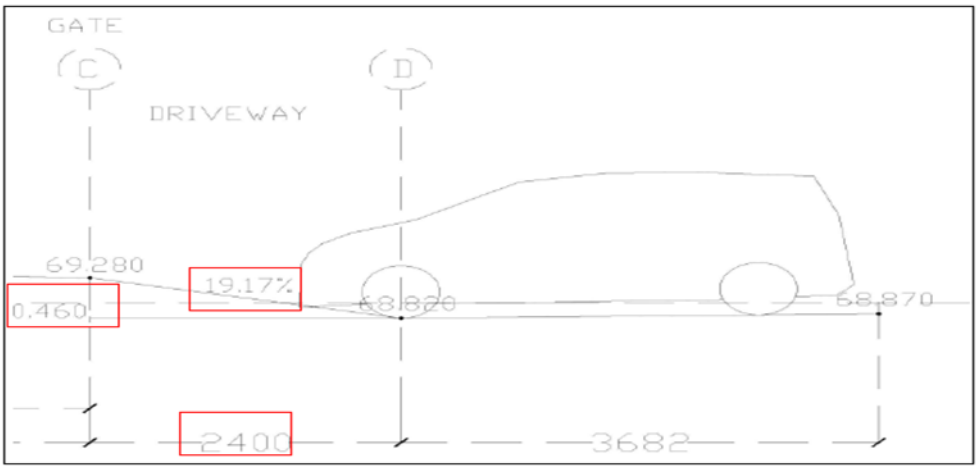

Fig. 3. Typical Sketch for Ramp at Car porch Area

Referring to Figure 3, the sketch shows to get the quantity of gradient, the length of the ramp and the height of the ramp need to be decided and explored in the design stage. Hence, to get a gradient at a straight ramp, i.e., 19.17 %, the designer needs to divide between the length of the ramp, i.e., 2,400 mm and the high ramp, i.e., 0.460 mm.

2.1.4 Impact of gradient on the consumer

The lowered the skirting or ground clearance vehicles, the higher the negative impact of vehicles touching and scratching the ramps. Hence, the Figure 4 below is an example case, i.e., 19.17% gradient at the straight ramps.

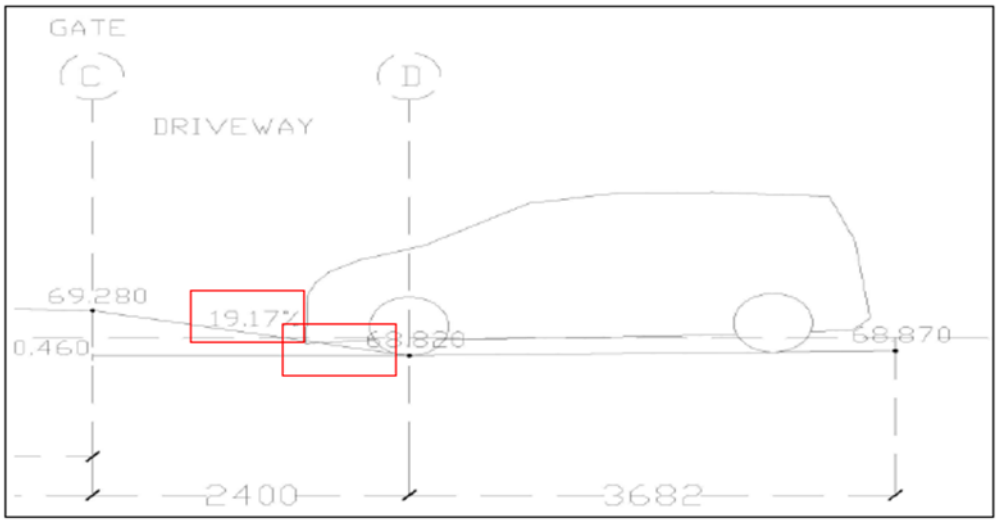

Fig. 4. Typical Sketch for Ramp at Car porch Area

As highlighted in Figure 4, the vehicle of Perodua Alza touched and scratched the straight ramp that has the highest ramp. In other words, the quantity and total percent of the ramp at the car porch are the important items which need to focus on because they will affect all types of vehicles.

2.2 Existing Guidelines for the Gradient of the Ramp at Entrance House

For this study, eight guidelines and standards have been identified and related to the ramp at the car porch area that are Guidelines for Car Parking and Internal Traffic Circulation (Wilayah Persekutuan Kuala Lumpur 2018), Malaysian Standard (MS – 1184) (similar gradient with OKU), Malaysian Standard 2426: 2011, Selangor Uniform Building By-Laws 1986, Neufert Architect's Data (Fourth Edition), Guidelines for The Design of Off-Street Car Parking Facilities By Kingdom of Bahrain Ministry of Municipalities &Agriculture Urban Planning Affairs, Building (Federal Territory of Kuala Lumpur) By-Laws 1985 and Selangor Uniform Building By-Laws 1986. Each of the guidelines and standards has different requirements to achieve a good design for the ramp in the housing sector. Table 3 show the summary for each guideline during the design phase for ramp at carporch area.

Table 3
Existing Guidelines for the Gradient of the Ramp at Entrance House

No	Guidelines	Descriptions
1	Guidelines for Car Parking and Internal Traffic Circulation (Wilayah Persekutuan Kuala Lumpur 2018) [7]	Part II Section 2.4 (Ramps): A) Parking Ramps i)Preferred Gradient: 1:25 (4%) ii)Maximum Gradient: 1:20 (5%) B) Straight Ramps i)Preferred Gradient: 1 :10 (10%) ii)Maximum Gradient: 1:7 (14.3%)
2	Malaysian Standard (MS – 1184) (similar gradient with OKU) [8]	Part Ramp – Section 2: Ramp slope no more than 1:12 (8.3%)
3	Malaysian Standard 2426: 2011[9]	Part 4 – Section 4.2.16 (a): -Parking Floor and Ramp Grades A) Parking Ramps: Not exceed 1: 20 (5%) B) Straight Ramps: Not more than 15%
4	Selangor Uniform Building By-Laws 1986[10]	A) Part III – Space, Light and Ventilation (35): The access shall be in accordance with a layout plan approved by the competent planning authority or the local authority. B) Part VII (Fire Requirements) Section 140 (d): Straight Ramps-Access Road not exceeding a gradient of 1: 8.3 (12%)
5	Neufert Architect's Data (Fourth Edition) [8]	Part Parking Facilities – Ramps: A) Parking Ramps: Not exceed 6% B) Straight Ramps: Not more than 15%
6	Building (Federal Territory of Kuala Lumpur) By-Laws 1985[12]	Part III Section 36(4): The gradient does not exceed one in ten (1: 10 – 10%) (Straight Ramps)

As mentioned in the existing guidelines (see Figure 5), there are two ramps which need consider that are ramps at driveways (Y3) and ramp entrances (Y5). Each of these two ramps has different gradients to prevent vehicle scratches at the skirting area. As highlighted in existing guidelines and standards, the ramp of driveways (Y3), the preferring gradient for the parking ramp, is 4%, and the maximum gradient will be 5%. Meanwhile, the maximum gradient for a straight slope is 14.3%, and the preferred gradient is 10%. Hence, 12% to 15% is the most accurate gradient for the maximum gradient of ramp entrances at the car porch.

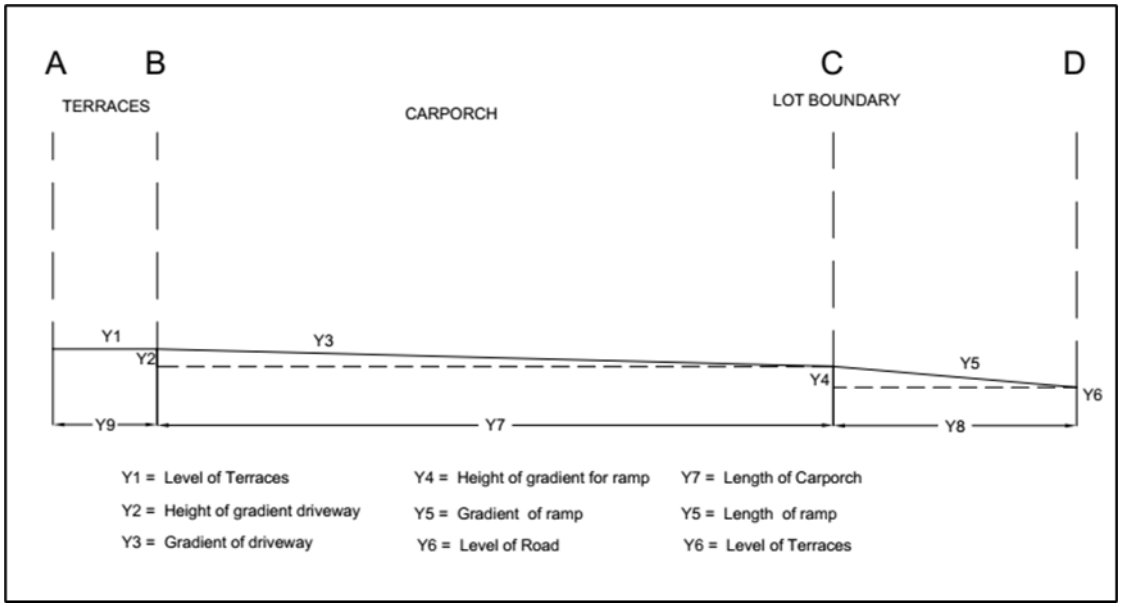

Fig. 5. Example of Typical Sketch for Ramp at Car porch
(Sources: Example Case Study at Taman Bukit Kepayang, Seremban Negeri Sembilan)

3. Methodology

This study focuses on a conceptual framework because it is the researcher's primary goal to provide a suitable gradient for variations in ground clearance vehicle size. In order to address the issue of stuck and lodged automobiles, the researcher will apply their own notion and create a new theory. The researcher will propose effective gradient to solve the problem of stuck and lodged for vehicles.

In the research methodology, it was attempted to discuss and explain the method carried out and the method of analysis in the research. Then, the research methodology chapter also covered qualitative research, research scope and design, data collection, analysis, sampling and population of the study. The structure of the questions that were asked during interview sessions and activities during the site observations and visual inspection.

The informal interview with semi-structured text is chosen because it acts as a tool to gain more additional information other than the scripted structure questions. The interview sessions were carried out with a person who has experience in ramp design. The people who were involved in the interview sessions were engineers, assistant director, architects from Majlis Bandaraya Seremban (MBS), Dewan Bandaraya Kuala Lumpur (DBKL), Jabatan Kerja Raya (JKR), architects, principal, project managers from consultant firms and developer company. All the questions during the interview session are related to the factors while designing the ramp, the existing guidelines, standards for profile ramp, impact of improper design to residents and proposal and advice for the specific high ramp design criteria in a different situation to accommodate low-clearance vehicles.

This research focuses on the situation of vehicles that could be stuck and lodged depending on the cars' clearance dimension, design of the ramp and guidelines in the ramp design. Hence, to study these elements, several methods have been used to achieve the objectives. The scope of study for this research is located at Taman Bukit Kepayang, Seremban, Negeri Sembilan. The case study strategy is used to achieve the research objectives in qualitative methods. A case study is a form of descriptive research in which the researcher conducts the study through observations and interviews session to collect data to get accurate data for this study. The selection of Taman Kepayang as the case study was carried out after an investigation of potential locations suited for this research, where the main objective is to evaluate and propose a new effective ramp design for the car porch area for the housing sector. As per records by GUH Properties Sdn. Bhd., which is the developer in Taman Bukit Kepayang, 74 purchasers had requested the developer to rectify these defects in their Defect Rectification Request

4. Result

The data collection for this research has been carried out by semi-structured interviews of parties who are responsible and involved in ramp design in car porch areas for the housing sector. In fact, no exact guidelines published in Malaysia indicate a state-specific gradient for a ramp on a car porch. Hence, the interview session was held to explore the existing guidelines for a ramp in the car porch area, which have been used by professional parties, especially architects, in the design and planning stage before starting construction and the issue of ramp design in their experiences. The qualification respondents are from an authority, architect firm and developer**.** The themes were prepared according to the research objectives, and the coding was defined based on the respondents' feedback, that are issue of ramp design at Taman Bukit Kepayang, existing and implementation of guidelines and standards for ramp design at car porch and recommendation gradient for future design.

4.1 Factor that Contributes to the Ramp Design

The factors that contribute to the ramp issue are the dimension and specifications of vehicle that are included wheelbase, angles of approach, angle of departure, minimum ground-clearances and ramp break-over angle [5]. Hence, to design the ramp, the specific dimension of each type of vehicle needs to be considered because each type of vehicle, which is SUV, sedan and MPV, has a different specific dimension [6].

Ground clearances are one of the main factors that need to be considered when designing the ramp. To make the design work, it is necessary to investigate the different vehicle kinds and vehicle dimensions. Basically, the consultant and developer need to explore the dimension for each type of vehicle to prevent this case from recurring.

In facts, designing the ramp in the housing sector is managed by the consultants who are the architect and engineer consultants. the consultants who have been appointed by the developer will make the submission for the new development to local authorities. the engineer will indicate the level of road and platform of the house at the Road and Drainage Drawing, and the architect will show the level of each house and platform level in the Building Plan and Drawing. To avoid any issue to residents, the most suitable difference between road level and car porch level is less than 200 mm. In other words, the road level and finished floor level need to be accurate and need to be suitable for all types of vehicles. Figure 6 shows the illusion for the different level between road level and car porch level is more than 300mm.

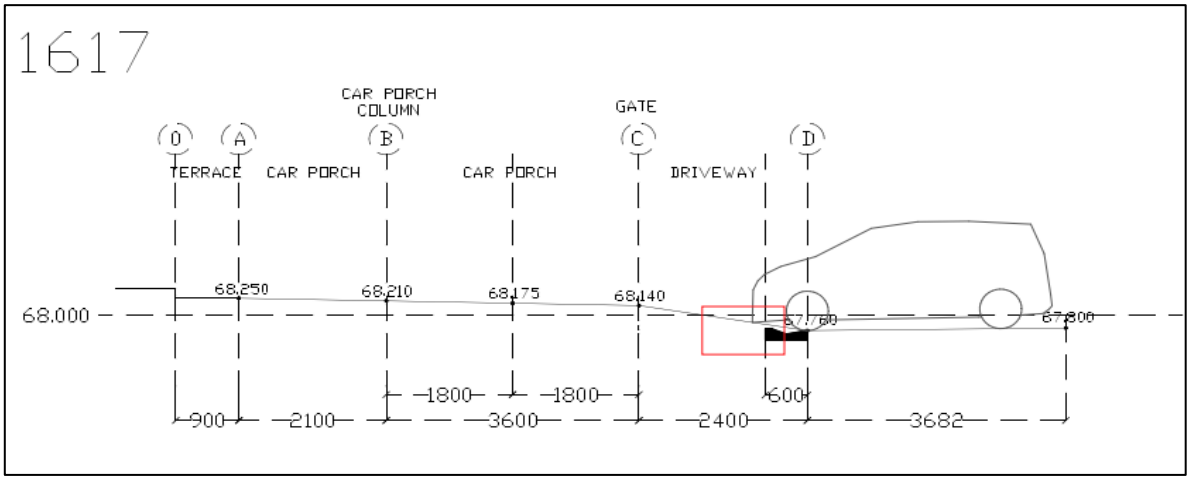

Fig. 6. Diagram for 300 mm to 400 mm level different between road level and car porch level

The road level at 1617 is 67.760, and for car porch level is 68.140. The levelling survey shows the different level is around 380 mm, which impacts the lower ground clearances. Referring to Figure 6, which involves typical vehicles dimension, i.e., Toyota Vellire and Perodua Alza scratches the ramp at the car porch when accessing the house area. In short, to avoid any accident, the most suitable difference between road level and car porch level is less than 200 mm.

Besides, the consultants who are engineers and architects should cooperate with each other and indicate the accurate platform level and the accurate road level to design the suitable gradient at car porch for a different type of vehicles.

Other factor the contributes to the ramp design is the vehicles load. From the illusion from Figure 7, it shows the vehicles can access the car porch area without any issue due to the road level at the unit and the car porch level is 70.110 so the difference between both levels is around 210 mm, but the car clearance vehicles from ramp is around 70 mm. In other words, if the vehicle load increases, the vehicles will touch the ramp when entering the car porch area.

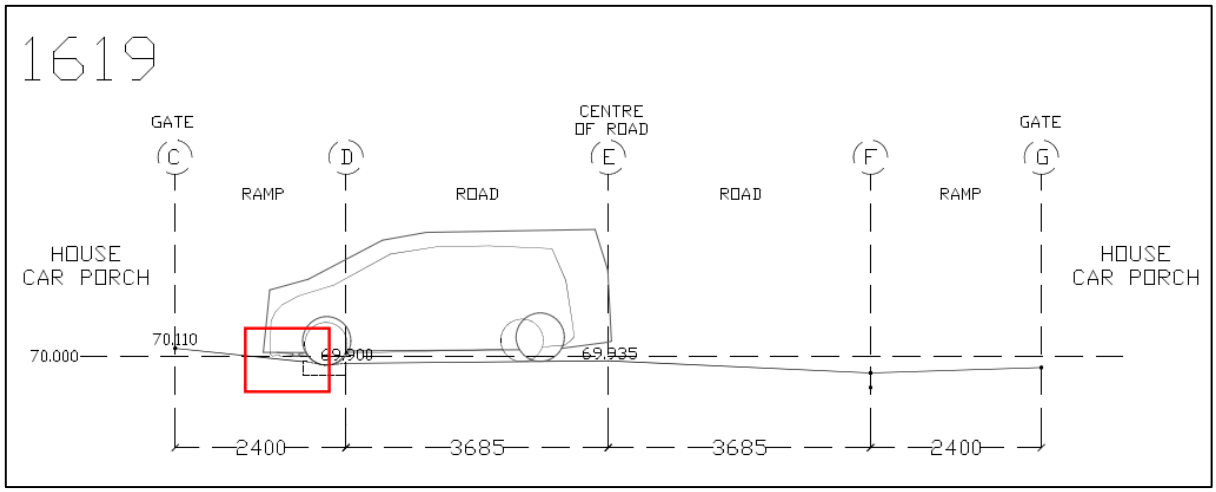

Fig. 7. Diagram for 200 mm to 300 mm level difference between road level and car porch level

Many types of materials have been used at parking ramps, such as concrete imprints, tiles, pavement or cement render. Each of the materials has a different thickness that will affect the finish floor level (FFL) at the parking area. Therefore, if the material change, it will affect the current level of the platform. In other words, the architect consultant should choose the material wisely, and if

the material changes because of site conditions, the architect needs to focus on the FFL again to avoid discrepancies at the site.

Lastly, the attitude is another element that contributes to an increase in customer complaints. Additionally, a picky or meticulous buyer will protest to the developer about the design. In other words, attitudes have a significant impact on behavior and are frequently the outcome of experiences or upbringing.

4.2 Suitable Gradient for Ramps

In fact, when designing the ramp in the car porch area, there are two ramps which need to be considered that are straight ramps and parking ramps. Each of the ramps has a different gradient depending on its function. Thus, for straight ramps, the gradient needs to be considered to access the area, but for the parking ramps, the gradient needs to be suitable to place vehicles. Based on the findings, there are several recommendations for both gradients to implement for all types of vehicles.

As mentioned by an architect from local authority and a principal from an architect firm, the maximum gradient for straight ramps is 1:10 (10%). It also is supported by the Head of Department (Developer Firm) statement, "The gradient of the straight ramp should be not exceeding 1:10 (10%)". However, as mentioned by the senior project manager from the developer firm, the difference for both ramps should be less than 180 mm, and the gradient at the parking ramp should not be more than 5%. It was also agreed by the architect from JKR that the parking ramp should not exceed 6%, as stated in Neufert Architect's Data (Fourth Edition).

Besides, from the interview session with the project executive from the developer firm, she advises that straight ramps (sag grade) should not exceed 15% and for parking ramps (summit grade) not more than 12.5%. Based on data findings, there are several existing guidelines which has been used by consultants as a reference in their design for parking ramps and straight ramps.

Although some states and countries stated and published the specific gradient for parking and straight ramps, some of the development design depends on on-site conditions. A few consultants and developers will design both ramps with a gentle gradient and ensure the slope is suitable for water discharge. Besides, they will avoid steeper gradients, which the level between the car porch and the level of the road is more than 180 mm because it is not practical and dangerous for consumers.

Ramps at the car porch consist of straight ramps and parking ramps, and the drawing at Figure 8 and Figure 9 are the typical sketch and illusions for ramps at the car porch area for the landed area.

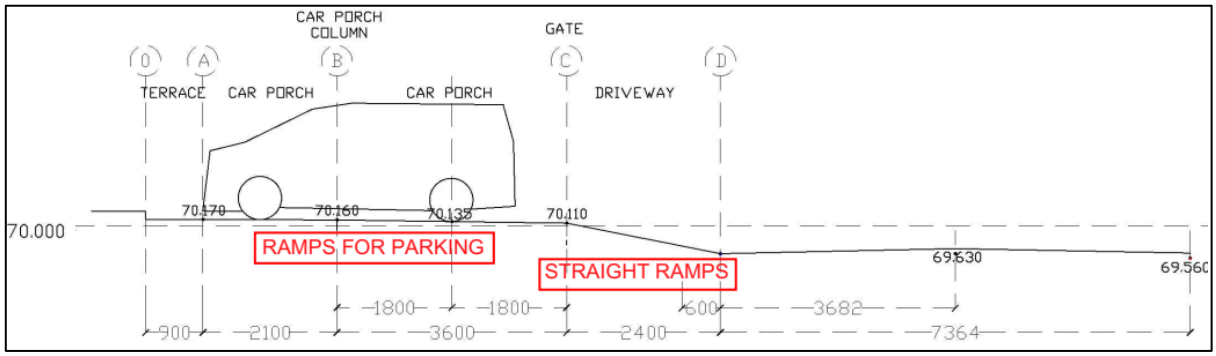

Fig. 8. Typical Design for Car porch Area (Double Gradient)

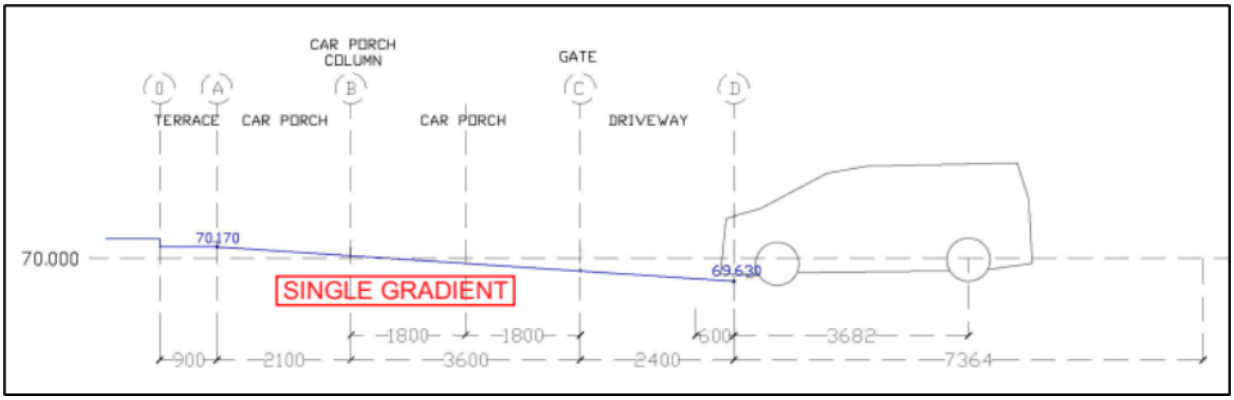

Fig. 9. Typical Design for Car porch Area (Single Gradient)

To be conclude, the Table 4 below is the recommendation and proposes a maximum gradient for straight ramp and parking ramp for double gradient and single gradient, which is acceptable with the current vehicles be placed at the center.

Table 4
Recommendation Gradient for Single, Straights and Parking Ramps

Single Gradient (Figure 7)	Double Gradient Straight Ramps (Figure 6)	Double Gradient Parking Ramps (Figure 7)
Maximum: 1:12 (8.3%)	1. Preferred: 1:10 (10%) 2. Maximum: 1:7 (14.3%) 3.Grade changes (sag grade): <15%	1. Preferred: 1:25 (4%) 2. Maximum: 1:20 (5%) 3.Grade changes (summit grade): <12.5%

Referring to the findings, there are four factors that contribute to the issue of the ramp, i.e., the types of vehicles, responsible parties, existing guidelines and attitude of purchasers related to the ramp in the housing sector.

The research has successfully developed the existing guidelines and standards of ramps based on the responses, opinions and suggestions of the professional parties involved in the design and implementation of the parking ramp and straight ramp. Hence, after exploring the existing guidelines in detail, the researcher finds an alternative way and proposal to improve one of the factors of guidelines and standards, which is the gradient at the ramp. Thus, the table below is the summary of the proposal from the researcher to propose the maximum gradient for different dimensions between the different dimensions of ground clearances.

From the input in the interview session, and based on the Table 5, the researcher makes a summary to propose the maximum gradient for different dimensions of ground clearances and wheelbase. Table 5 shows that for the lower ground clearances, i.e., between 140 mm to 160 mm ground clearances, the maximum gradient should be 4%, and between 165 mm to 280 mm ground clearances, the maximum gradient should be 5%. Hence, based on the Table 5.1, the most suitable gradient for typical vehicles that have ground clearances more than 160mm, is 1% to 3%.

After the researcher completes all the data collection, the researcher makes a conclusion to propose the maximum gradient for different dimensions of ground clearances and wheelbase for the straight ramp. Table 6 shows that for the lower ground clearances, i.e., between 140 mm to 160 mm ground clearances, the maximum gradient should be 12%, and between 165 mm to 280 mm ground clearances, the maximum gradient should be 14.3%. Hence, based on the Table 5, the most suitable gradient for typical vehicles that have ground clearances more than 160mm, is 1% to 14.2%.

Table 5
The maximum gradient for different dimensions of ground clearances and wheelbase (Parking Ramp)

Wheelbase	**Ground Clearances**																												
(mm)	140	145	150	155	160	165	170	175	180	185	190	195	**200**	205	210	215	220	225	230	235	240	245	250	255	260	265	270	275	**280**
2000	4%	4%	4%	4%	4%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
2050	4%	4%	4%	4%	4%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
2100	4%	4%	4%	4%	4%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
2150	4%	4%	4%	4%	4%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
2200	4%	4%	4%	4%	4%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
2250	4%	**4%**	4%	4%	4%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
2300	4%	4%	4%	4%	4%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
2350	4%	4%	4%	4%	4%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
2400	4%	4%	4%	4%	4%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
2450	4%	4%	4%	4%	4%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
2500	4%	4%	4%	4%	4%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
2550	4%	4%	4%	4%	4%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
2600	4%	4%	4%	4%	4%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
2650	4%	**4%**	4%	4%	4%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
2700	4%	**4%**	4%	4%	4%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
2750	4%	4%	4%	4%	4%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
2800	4%	4%	4%	4%	4%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
2850	4%	4%	4%	4%	4%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
2900	4%	4%	4%	4%	4%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
2950	4%	4%	4%	4%	4%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
3000	4%	4%	4%	4%	4%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%

Table 6
The maximum gradient for different dimensions of ground clearances and wheelbase (Straight Ramp)

Wheel base	Ground claearances																											
(mm)	140	145	150	155	160	165	170	175	180	185	190	195	200	205	210	215	220	225	230	235	240	245	250	255	260	265	270	275	280
2000	12%	12%	12%	12%	12%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%
2050	12%	12%	12%	12%	12%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%
2100	12%	12%	12%	12%	12%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%
2150	12%	12%	12%	12%	12%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%
2200	12%	12%	12%	12%	12%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%
2250	12%	12%	12%	12%	12%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%
2300	12%	12%	12%	12%	12%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%
2350	12%	12%	12%	12%	12%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%
2400	12%	12%	12%	12%	12%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%
2450	12%	12%	12%	12%	12%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%
2500	12%	12%	12%	12%	12%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%
2550	12%	12%	12%	12%	12%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%
2600	12%	12%	12%	12%	12%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%
2650	12%	12%	12%	12%	12%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%
2700	12%	12%	12%	12%	12%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%
2750	12%	12%	12%	12%	12%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%
2800	12%	12%	12%	12%	12%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%
2850	12%	12%	12%	12%	12%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%
2900	12%	12%	12%	12%	12%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%
2950	12%	12%	12%	12%	12%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%
3000	12%	12%	12%	12%	12%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%

5. Conclusion

Referring to the findings, there are four factors that contribute to the issue of the ramp, i.e., the types of vehicles, responsible parties, existing guidelines and attitude of purchasers related to the ramp in the housing sector. For a first factor of the types of vehicles, it includes the dimension and specifications of vehicles, i.e., wheelbase, angle of approach, angle of departure, minimum ground – clearances and ramp break-over angle. Some people also modified their vehicles by adding the skirting, so the ground clearance becomes increases, and then their vehicles with scratch the ramp when accessing the car porch. In short, the lower the ground clearances, the highest the possibilities to scratch the ramp.

he second factor is responsible parties that are the consultants and authority are the parties who are involved in the design stage of ramp design. After consultants complete all the drawings, whether the building plan or the infrastructure plan, the drawings need approval from the authority before starting work at the site. Hence, the professional consultants need to ensure and study the design of the ramp, and the design should not have a bad impact on purchasers, although the purchaser used vehicles which are low ground clearances. Besides, authorities in each local state need to verify all the designs by professional consultants and ensure they are following all the related guidelines.

However, for this study, as highlighted by Majlis Bandaraya Seremban (MBS), the guidelines that refer to the ramp design in the housing sector is minimum design. Thus, the consultants have an issue with the guidelines due to the guidelines being the minimum guidelines, and they need to explore more to avoid any issues in the future. The attitude is also the third factor which increases the complaint from purchasers. In addition, the purchaser who is too fussy and a perfectionist will complain about the design to the developer. In other words, attitudes are often the result of experiences or upbringing, and they have a powerful influence over their behaviour.

In conclusion, the research has identified the four factors which contribute to the problem of the ramp at the car porch. The overview of the factors in straight ramp and parking ramp has been determined at this stage. In addition, the relevant parties involved in this matter are the architect, civil engineer, developer, and authorities. Based on the findings, each organisation involved in thedesign stage should carry out their responsibilities to ensure the design does not have a bad impact on consumers.

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