PARKING STANDARDS THAT CAN WORK IN SOUTH AFRICA

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ABSTRACT

The current South African manual for parking standards, as issued by the South African Department of Transport, was last updated in 1985. Since the dimensions of parking bays are based on data that has changed over time it is in South Africa's best interests that the entire document be updated to meet current parking needs. The dimensions of the bays should be based on the dimensions of the vehicle population in South Africa. In response to this need, the purpose of this paper was to establish a new vehicle sales and dimension database based on data for the period 2006 - 2010. This was then used to determine a new set of parking bay dimensions, which can accommodate current vehicle sizes in South Africa.

Another change since 1985 was the large increase in the use of light commercial vehicles (LCV's) that are not only used for commercial purposes, but also as passenger cars and it was clear that provision should be made to cater for these vehicles in parking areas.

The paper will show the results of the analyses of the values for the length, width and wheelbase of the representative (95th percentile) South African vehicle in parking bays.

1 INTRODUCTION

The current Parking Standards is based on research that was performed during 1985 using the sales data for passenger cars for the period 1971 – 1976 as well as the sales data for 1984 (van Zyl et al, 1985). Due to the age of the data on which the current Parking Standards are based, the impact on the design of parking lots in South Africa today can be significant. The dimensions prescribed in the codes are essentially 26 years old and may no longer apply today due to the size of vehicles being sold today having changed. Therefore, a new analysis had to be performed based on recent car sales data to determine new parking standards that meet the current vehicle sales and their dimensions. The purpose of this paper is to describe a study (Da Silva, 2011) in which new vehicle sales and dimensions were used to determine new parking stall sizes.

The research aim was the gathering of South African vehicle sales data as well as the compilation of a vehicle model dimension database. These data sets were used to perform an analysis so as to determine the new design vehicle dimensions. The design vehicle can be defined as a template that the parking stalls are designed to accommodate. Using the new design vehicle dimensions, a proposal can be made for the update of current parking bay dimensions to meet current vehicle size needs.

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The specific objectives of the research were as follows:

- Compile Light Commercial Vehicle (LCV) and passenger car sales database for the years 2006 -2010.
- Compile a dimension database for all LCV and passenger cars sold in South Africa.
- Determine the new design vehicle dimensions by performing an individual analysis for LCV and passenger cars as well as a combined analysis using both LCV and passenger cars.
- Calculate new parking bay dimensions for 90°, 60° and 45° parking bay orientations using the determined design vehicle.
- Calculate aisle width between parking bay rows.
- Determine a vehicle dimension trend, which can be used to track the change in dimensions of vehicles from year to year. This analysis may be used to ascertain whether the newly proposed parking bay dimensions will continue to satisfy future motorist's vehicles.
- Perform a parking lot survey of various shopping centres around the Western Cape to ascertain whether the parking lot designs adhere to the South African Parking Standards' prescribed parking bay dimensions.

The paper deals with the subject under the following headings: Literature Review, Methodology, Results, Discussion of Results, Conclusions and Recommendation.

2 LITERATURE REVIEW

During the course of the research for the project it became apparent early on that very little research has been published on determining the 'design vehicle' dimensions specifically as regards to parking requirements. It was noted that in many countries there is no fixed national set of parking standards. The United States of America is a good example of this as each state has their own standards regarding parking dimensions and in some cases the counties within the states have their own parking standards. The Canadian parking standards document obtained was published with the expressed purpose of unifying the parking standards of Toronto to ensure the different municipalities within the city zone used the same set of parking standards (City of Toronto, 2005).

In a number of countries (e.g. USA, Britain, Canada and Australia) parking standards are based on a system of Levels of Service (LOS) for parking lots. Essentially, the required LOS for a parking lot determines the parking stall dimensions and aisle widths. The LOS for parking lots is defined based on the length of time a vehicle would be parked in a bay. The longer the time a vehicle would be parked the smaller would be the dimensions of the parking bays. This is done because cars that spend long hours in a bay do not need the extra room required to manoeuvre in and out. Bays that have high turnover rates, such as those at shopping centres typically require larger dimensions for easier access (ACT Planning & Land Authority, 2005). The minimum parking standards, or lowest LOS (lowest turnover rate) obtained from the various codes for general 90° parking bay dimensions can be found in Table 1, where they are compared to the 1985 South African standards. The latter are, however, not related to a LOS, but the single value prescribed for all stalls. The size of the American vehicles is clearly illustrated in this table with the South African standards (van Zyl et al., 1985) somewhere between the USA and the rest. The USA guidelines (ITE, 1994) do, however, make provision for small cars (compacts) where stalls of 2.3m wide and 4.6m long are suggested.

Table 1: Parking bay dimensions around the World

Country	Stall width (m)	Stall length (m)	Aisle width (m)
USA	2.7	5.3	7.9
Canada	2.4	5.5	6.0
Britain	2.4	4.8	N/A
Australia	2.4	5.2	6.2
South Africa	2.5	5.0	7.5

A method with which the dimensions of the design vehicle for parking can be calculated is described by Chrest et al (2002). It is based on the dimensions of vehicles sold in the country where the analysis is taking place. This is achieved by obtaining the vehicle sales figures for the preceding years and these figures are then broken down into the sales of small, medium and large cars. The vehicle size categories are classified according to the area or footprint (m^2) of a vehicle. The design vehicle dimensions are then based on the 85th percentile of each category of vehicle.

The method for the calculation of the design vehicle in the South African Parking Standards (van Zyl, et al. 1985) is similar to that which Chrest proposed. There are, however, some differences. The South African Parking Standards method does not break down the car sales figures into small, medium and large cars. Instead the sales figures of all vehicles for preceding years are used in conjunction with the vehicle dimension data of the sold cars to plot several graphs relating to vehicle geometrics i.e. length, width, height and turning circle. A cumulative percentage graph is plotted and the 95th percentile value is obtained for each of the vehicle dimensions which are then used to define the proposed design vehicle. Using these dimensions of the design vehicle the 90°, 60° and 45° parking stalls can be designed to accommodate the design vehicle (van Zyl et al., 1985).

3 METHODOLOGY

In order the re-evaluate the South African Parking Standards the dimensions of the new design vehicle must be obtained. The design vehicle dimensions were based on vehicles sold between 2006 and 2010 and does not include the previously registered vehicles. The new design vehicle will be used as the basis for new parking bay dimensions. South Africa has a large LCV market (32% of light vehicle sales over five years) where pickups (bakkies) are used not only for commercial purposes but also for private purposes. It is, therefore, required that the new design vehicle dimensions must also take into account the LCV market to ensure that the new proposed parking dimensions will satisfy the greatest number of vehicles on South African roads today.

3.1 <u>Sales database</u>

To ensure the vehicle sales data is sufficient for the analysis purpose (sample size) and that is it represents recent vehicle sales trends, a period of 5 years was selected - from 2006 to 2010. This period ensures that the data is up to date and allows for the possible future predictions of vehicle sizes trends in South Africa. These trends may give an indication of whether the new parking stall dimensions, that will be calculated, will be applicable for the foreseeable future. The National Association of Automobile Manufactures of South Africa (NAAMSA) was consulted in order to acquire passenger vehicle and LCV sales data for the 2006 - 2010 period. NAAMSA members consist of most of the vehicle manufacturers in South Africa. Another company namely, Response Group

Trendline was also consulted during the compilation of the sales database. During the compilation of the sales database there were several vehicle manufactures whose sales data was not available. They were the following: Aston Martin, Bentley, Lotus, Geely, GWM, JMC, Zotye, Rolls Royce and Lotus. The luxury vehicle brands such as Aston Martin, Bentley, Royce and Lotus will have low yearly sales figures in comparison to the other vehicle manufacturers. Their impact on the final analysis will be very small and, therefore, all results obtained are accurate enough to make definite proposals for parking bay dimensions. Although the NAAMSA sales data base is extensive, there were a few manufacturers whose sales data was incomplete. The incomplete data was an indication that the manufacturer has ceased being a NAAMSA member. Attempts to contact each manufacturer whose data was incomplete were made. However, many of the requests were ignored. The manufacturers whose sale data was incomplete are Ferrari, Cherry and Meiya.

In the database all vehicle manufactures were listed with their respective models and the sales figures for each model over the five year period. This database, however, only lists the sales data for each vehicle model and not the individual sales of the various derivatives of each vehicle model. This is important, as the same vehicle model may have various derivatives which have different dimensions associated with each derivative. An example of this would be a vehicle model having a combination of saloon, estate or cabriolet derivatives. It was decided that for each vehicle model in the dimension database which had multiple derivatives, the vehicle model derivative which has the largest dimensions (length, width, height and wheelbase) would be used as the dimensions of that model. A total of 399 vehicle models and 2.588 million vehicles were included in the database.

3.2 Dimensions database

The vehicle dimension database was compiled from the dimensions of all the manufactures' models. The length, width, height and wheelbase dimension for each model was listed in millimetres. For clarification the width dimension is the distance taken between the outer edges of the sides of the vehicle and does not include the door mirrors. The dimensions were converted to a meter unit, which allows easier analysis of the data. The meter dimensions were rounded up to one decimal place. This was done to ensure that the results are slightly conservative.

3.3 Sales and dimension analyses

Using both the dimensions and sales history of all vehicle models, cumulative percentage graphs were plotted to determine the 95^{th} percentile value for the dimension categories namely length, width, height and wheelbase. Three graphs were plotted for each dimension category, one for passenger cars, the second for LCV's and the last being a combination of both LCV and passenger car data.

The design vehicle dimensions were based on the 95^{th} percentile values of the combined data of LCV and passenger cars. The results for the design vehicle length (D_{VL}) and the design vehicle width (D_{VW}), were then used to determine the new parking bay dimensions.

3.4 90° Parking bay orientation

3.4.1 Width

The 90° parking bay width is composed of the design vehicle width (D_{VW}) plus a vehicle side clearance value and these dimensions can be seen in Figure 1. The summation of these values will be termed the Design Parking Bay Width (D_{PW}). The vehicle side clearance is defined as the distance between vehicles in adjacent parking bays. This side clearance value is important as it allows the vehicle doors to swing open to a point where people are able to get into the vehicles.

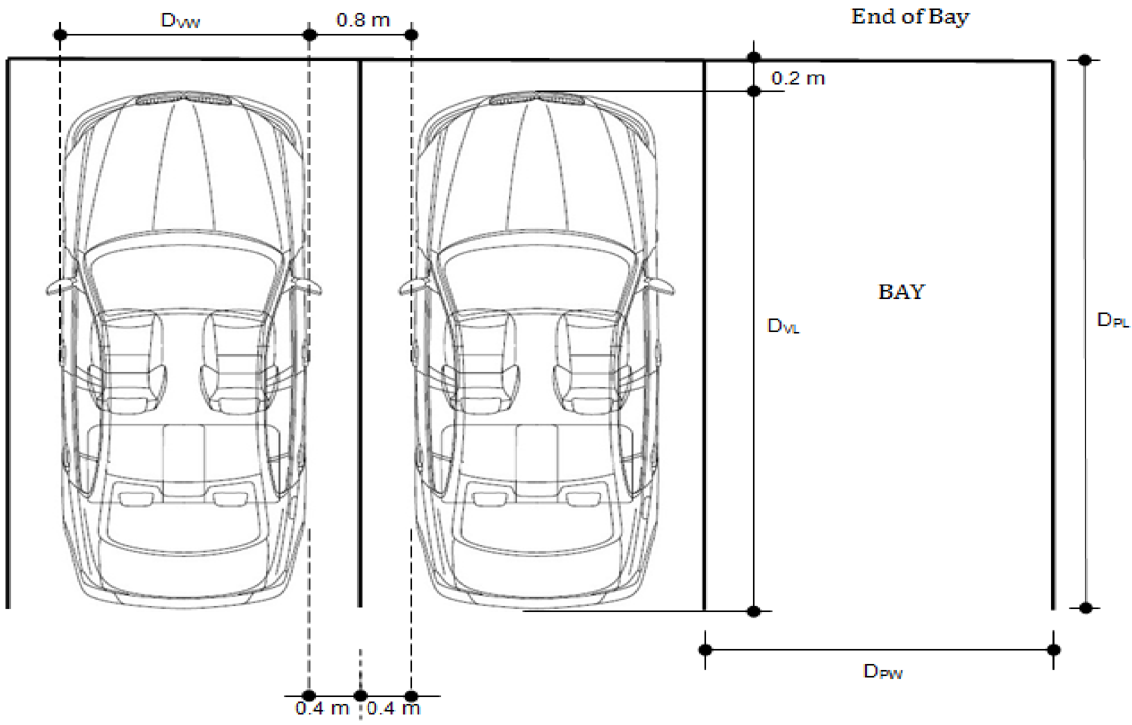

Figure 1: 90° Parking bay dimensions

In research by Radwan and Moradi (1983) in the USA, the average vehicle side clearance that was determined in a field investigation was 0.85 m. This research was performed in 1983 which is close to the time when the South African Parking Standards proposed a vehicle side clearance value of 0.7 m in 1985 (van Zyl et al., 1985). The difference in side clearance values can be attributed to the difference of the size of vehicles sold at the time in America as compared to those sold in South Africa.

When the previous South African Parking Standards were compiled the LCV market was included in the analysis. However, the LCV market today represents a much more significant portion of vehicles sold in South Africa. Therefore it was decided that the vehicle side clearance value should be increased to 0.8 m.

3.4.2 Length

The 90° parking bay length is composed of the design vehicle length (D_{VL}) plus an added accommodation distance (AD) and these dimensions can be seen in Figure 1. The summation of these values will be termed the design parking bay length (D_{PL}). It has been found that, on average, people do not pull their vehicles all the way into parking bays, which necessitates the additional length to parking bays. This is done to ensure that the parking bay lines will "protect" the vehicles from moving traffic within the parking lot.

Radwan and Moradi (1983) found the distance that American drivers stopped short of lane markings to be an average of 0.23 m. The current South African Parking Standards prescribes an additional length of 0.2 m to the parking bays (van Zyl et al., 1985). It was decided that the 0.2 m prescribed by the South African Parking Standards would not be adjusted in this study.

3.5 60° and 45° Parking Bay orientation

Parking bays orientated at 60° and 45° consist of two cases, the first being where the parking bays are allowed to interlock and the second where no interlocking of parking bays takes place. For the design of the layout of these bays the dimensions can be calculated by means of trigonometry (van Zyl et al., 1985) by using the design width and length as determined above and will not be repeated in this paper.

3.6 Aisle width determination

The aisle width of a parking lot is the distance between a row of parked cars and a wall or obstruction or another row of parked cars. The main variable that affects the calculation of the aisle width for a parking lot is the turning circle of the vehicles that must get into the parking bays. Another variable is the orientation - 60° and 45° parking bays will tend to have smaller aisle widths as vehicles don't need as much room to manoeuvre into them as for 90°parking bays. Another aspect, which affects the aisle width is whether the parking lot road is a one-way or a two-way road. The aisle width will have a minimum value in the case of a two-way road as there need to be enough room between the parking rows for two cars to pass each other.

The method which was used by the South African Parking Standards to determine the aisle width was a graphical method. The turning path of the design vehicle is drawn on a transparency; this template is then placed over a parking lot design drawing which is using the same scale as the transparency. The aisle width is then determined by moving the transparency over the drawing in such a manner that it minimizes the aisle width (van Zyl et al., 1985). For this method the turning circle of the design vehicle would be necessary. As the turning circles of all the vehicles have not been recorded in the dimension database, a cumulative 95th percentile value for turning circles of all the LCV and passenger cars in the database cannot be calculated. To determine the approximate turning circle of vehicles today it was decided that the turning circles of the top ten selling LCV and passenger car models will be obtained. As the top ten selling LCV and passenger car models will represent a significant portion (33.75%) of the total LCV and passenger car sales, it will provide a good approximation of the true total combined turning circle value. The combined top ten sales figures for LCV and passenger cars are shown in Table 2.

The first step in determining the representative turning circle of the vehicles will be the calculation of the cumulative 95th percentile value of the wheelbase for the combined top ten selling vehicles. The wheelbase is one of the important factors that affect the turning circle of the vehicle. This will be done so the top ten combined selling vehicles' wheelbase can be compared to the design vehicle's wheelbase which has already been established. If the values do not differ significantly, it will give an indication that the calculated 95th percentile of the turning circles of the top ten selling vehicles will be a good approximation of the 95th percentile of turning circles of the entire LCV and passenger car market.

Table 2: Top ten selling vehicles (2006 – 2010)

Position	Make - model	Number Sold	Turning Circle (m)	Wheelbase (m)
1	Toyota - Hilux	149638	12.4	3.1
2	Volkswagen - Polo	107570	10.6	2.5
3	Toyota - Corolla	104026	11	2.6
4	Opel - Corsa Utility	88002	11.64	2.8
5	Isuzu - KB	79496	12.4	3.1
6	Toyota - Yaris	78347	9.4	2.5
7	Volkswagen - Citigolf	72385	10.3	2.4
8	Mercedes - C Class	68646	10.8	2.8
9	Ford - Bantam	63099	10.4	2.7
10	BMW - 3 Series	62608	11	2.8

3.7 Vehicle Dimension Trend Analysis

A vehicle dimension trend analysis is useful to determine changes that take place on an annual basis. The dimension trends for the length, width, height and wheelbase of the combined vehicle sales were evaluated. This was done by finding the cumulative 95th percentile value for each dimension, for each year during the 2006 – 2010 period.

3.8 Parking Lot Design Survey

Several surveys were carried out at major shopping centres in the Western Cape with the intention of measuring the parking lot dimensions that are used at the shopping centres. The purpose of this survey was to ascertain whether the dimensions used in the parking lot design at these shopping centres are according to the standards and if not, by how much they differ.

4 RESULTS

4.1 Design vehicle dimensions

The results obtained for the various dimensions of the different vehicles can be found in Table 3. The results for the LCV and passenger cars have been calculated separately. This was done to illustrate the difference between sizes of each vehicle market. The combined dimension data will be selected as the new design vehicle dimensions.

The 1985 South African design vehicle dimensions (van Zyl et al., 1985) can be found in Table 4.

Table 3: New design vehicle dimensions (m)

Dimension	Passenger car	LCV	Combined
Length	4.83	5.37	5.28
Width	1.90	2.05	1.97
Height	1.79	2.25	1.99
Wheelbase	2.86	3.17	3.11

Table 4: 1985 design vehicle dimensions (m)

Dimension	Design vehicle
Length	4.75
Width	1.79
Height	1.94
Wheelbase	2.85

4.2 Parking bay dimensions

In Table 5 the new parking bay dimensions are compared to the 1985 values.

Table 5: Parking bay dimensions (m)

Dimension	1985	New
Length	5.0	5.48
Width	2.5	2.77

4.3 Aisle width dimensions

The wheelbase and turning circle dimensions necessary to determine the aisle width dimensions (see Section 3.6) are given in Table 6.

Table 6: Wheelbase and turning circle dimensions (m)

Dimension	All vehicles	Top 10
Wheel base	3.11	3.08
Turning circle	N/A	12.38

From the similarity of the wheel base dimensions it can be assumed that the turning circle dimension of the top ten selling models will be a good estimation of the turning circle dimension of all the models. When this value (12.38 m) is compared to the 12.4 m turning circle used in the 1985 document, it is clear that no major adjustments to the aisle width are necessary. The effect of overhangs will, however, have to be taken into account.

4.4 Vehicle Dimension Trend Analysis

In all dimensions there was an increase in the 95th percentile up to 2008 after which they decreased towards 2010. This is shown in Figure 2 for vehicle length. This is an indication that vehicle dimensions are unlikely to increase significantly in the near future.

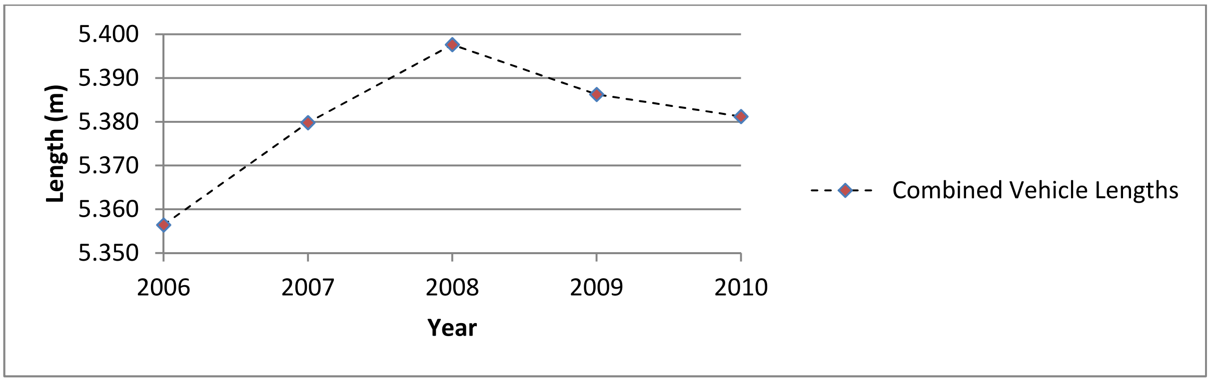

Figure 2: Change in combined vehicle lengths (m)

4.5 Parking lot survey results

The results of the surveys in terms of the minimum and maximum dimensions at the different parking lots at shopping centres are shown in Table 7. In all cases 90° stalls with two-way aisles were surveyed.

Table 7: Range of dimensions observed at parking lots (m)

Dimension	Minimum	Maximum
Width	2.3	2.9
Length	4.3	5.6
Aisle width	6.8	8.5

5 DISCUSSION, CONCLUSIONS AND RECOMMENDATION

From Tables 3 and 4 it is clear that the light vehicle dimensions have increased significantly since 1985. The length and width have both shown an increase of 10%. Even the current 85th percentile lengths (5.10 m) and widths (1.87) are greater than the 1985 values. The result is that the parking bay dimensions will have to be increased (Table 5). The seriousness of the situation is illustrated by the fact that the top selling light vehicle model (5.8% of all sales over five years) with a length of 5.255 m will not even fit into the current standard parking bay. From Table 6 it can be concluded that no major adjustment to the aisle width would be necessary, because the turning circle of vehicles have not increased since 1985. The effect of overhangs will, however, have to be taken into account.

From the sales figures and associated 95th percentile dimensions during the period from 2006 to 2010 it was shown (Figure 2) that light vehicle dimensions have peaked in 2008 and were showing a decreasing trend towards 2010.

In a survey of the dimensions of existing parking lots at shopping centres it was clear that a large range (Table 7) of dimensions is currently being used.

Taking all the above into account it is clear that the time has come to revise parking standards (guidelines?) in South Africa. This would then be the main recommendation of this paper. As part of the study leading to such standards, the actual use of parking areas by different sized vehicles should be included.

6 ACKNOWLEDGEMENTS

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