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Development of a bicycle geometry database to facilitate cycle parking convenience.

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Abstract

In many developed countries such as Australia, cycling for transport has a low mode share compared to the private car. There are a range of contributing factors to this culture of motorised trips, and this research focuses on the notion of convenience. If cycle trips are made more convenient then we can expect to see impact in the choices people make between modes, in particular shifting some journeys, especially short ones less than 10km, from the private car to the bicycle.

In the development of a new bicycle parking device (BPD) it was discovered that a knowledge gap may be holding back the development of new convenient interventions in the field. A comparison of two related standards - *AS2890.1 Parking facilities. Part 1: Off-street car parking* (Standards Australia 2004) and *AS2890.3 Parking Facilities Part 3: Bicycle Parking* (Standards Australia 2015), reveals that there is a detailed knowledge base around motor vehicle geometry and dynamics that serves to inform the development of convenient, easy to use, efficient, car parking. Although the standard for cycle parking makes reference to some of the varied cycle geometries found in the field, no detailed study has been undertaken to determine the functional geometry of bicycles and how this may relate to similarly convenient parking for bikes.

This paper describes a field study which directly targeted this knowledge gap. A field study was conducted where 54 bicycles were measured with key geometry recorded in a database. Analysis of the data found that while the types of cycles are indeed diverse in geometry, the diversity is within a narrow enough band which can make the development of BPDs and convenient cycle infrastructure a simpler task. A geometric "package" is presented to communicate the results and policy recommendations are made.

1.Introduction

Cycling for transport in Australia has a very low mode share, especially when compared to the private car. In Melbourne, for example, active transport has a 5% mode share of journey to work mobility in Australia, whereas vehicles are used for 68% (Australian Bureau of Statistics

2016) This is in spite of many journeys being over short distances and relatively forgiving terrain, for example suburban trips of less than 5km. When we look at motivations and attitudes towards cycling as a mode of transport, a person's propensity to cycle can generally be used to categorise such an individual into one of four user groups, those being "no way no how", "interested but concerned", "enthused and confident" and "strong and fearless" (Dill and McNeil 2013). Of these groups, the "interested and concerned" are estimated to make up 60% of people in Victoria (Transport for Victoria 2017), and are therefore often targeted in policy as those most likely to shift more journeys from car to bike, with the scale of the group meaning that such efforts are likely to have a proportionally greater impact in mode share. One of the barriers to cycling for such people is the convenience of the mode - a catch all term usually describing how much trouble a user might have to go to, when compared to alternatives. While cycling offers some unique modal conveniences, it suffers in some regards, with one of those being the focus of this research - cycle parking.

Strategic approaches to cycling include aspirations towards building a more connected cycling network, and this includes an ability to provide adequate parking at destinations. Adequate, meaning both the quantity and quality of cycle parking made available, and also the location of such parking, for example at railway stations or other high-use nodes.

In the development of Bicycle Parking Devices (BPDs) some understanding of bicycle geometry is required in order to provide mechanically sound, usable designs. At present such data is unavailable from relevant standards as explored in the literature review. This paper is organised in the following way: following a statement of the aim and methods, a brief literature review presents the current state of knowledge and identifies the gap. Data collection and results are presented, followed by analysis and a discussion of the impact of the data and proposals for further work.

2. Aim

To facilitate the development of convenient cycling infrastructure by building a publicly available database of bicycle geometry.

3. Method

This research is carried out in two main stages. The first, a literature review, looks at the current parking standards in the Australian context to determine what is currently available. The second stage of research carries out a field exercise gathering a first pass of data to build an initial database presented in this paper.

5. Data collection

Through the practical task of designing a BPD, a list of required geometry was drawn up. This is based on the observation that an AS2890.3 compliant BPD will need to have, to some extent, an ability to hold a bike stationary, afford locking, and provide a reasonably spatial allowance for users to place bikes in such a device. The list of requirements is connected to this function, and is not a complete description of all the geometry of a bicycle, but a shorter list of the dimensions that will need to be referred to in BPD design. The list is based on the hypothesis that most bicycles in the field will be of a traditional "double diamond" frame design which has been the obdurate form of the bicycle since 1885. While designs have evolved since then, and with them nuances such as wheel size and tyre geometry, the essential points have remained in proportion. In addition to geometry, it was decided that other information could be added for relatively little effort which may be useful when studying the population of bicycles as a whole. The geometry planned to be recorded in this study were:

1. Manufacturer (if available)
2. Model (if available)
3. Type (as per AS2890.3)
4. Size (as shown on frame if available)
5. Wheel type (as noted on tyre sidewall)
6. Wheel outside diameter
7. Wheel inside diameter
8. Wheelbase
9. Tyre width
10. Handlebar width
11. Handlebar height (from ground to highest point)
12. Overall length (wheelbase + wheel outside diameter)
13. Remarks (useful information for BPD development)
14. Location measured (where the bike was)

Owing to time and funding resources being very limited, an approach was taken to take a simple random sample of bicycles in Melbourne, Australia, to commence this research. In such a sample, the probability of any part of the population of bicycles being part of the sample is equal. A small sample of 54 bicycles were recorded for this study, with the intention of increasing this sample size and geography in future work. The collection was taken from bicycles parked in public, using several locations within suburban Melbourne and was inclusive of all bicycle types described in AS2890.3. The sample did not include bicycles locked in secure facilities such as Parkiteer or workplace cages as these could not be accessed. This sample is small owing to limited resources, however some inferences are already able to be drawn which are useful for the development of a BPD.

7. Analysis

In the sample, all but two bicycles were of an ordinary, double diamond design. The two exceptions were a folding bike and a cargo bike. This relatively small proportion was expected, however the sample size is not large enough to infer these numbers as part of the broader population. It is not expected that 1 in 54 bikes are of cargo or folding design as this proportion seems high when compared to anecdotal observations. One electric bike was observed, and while e-bikes are gaining popularity it was expected that this proportion would be low as e-bikes tend to have higher value and are therefore less likely to be locked in public by their owners.

For the development of a BPD, it is useful to know the population distribution of several important geometric attributes. Firstly, in order for wheels to be somewhat captive in a BPD the wheel outside diameter and type width are useful. As expected, wheels were found to fall in to the range of commonly available market sizes, with the study revealing a distribution of sizes as shown in table 2. The overwhelming majority of wheels were in the range of 651-700mm with one folding bike having smaller wheels at 490mm.

Table 2. Wheel outside diameter distribution.

Range (mm):		Count
0	450	0
451	500	2
501	550	0
551	600	0
601	650	7
651	700	42
701	750	3
751	plus	0

Also of use to the designer will be the tyre width, as many designs exploit an interference "tight" fit between BPD and tyre in order to capture the bike. The tyre is also a convenient contact point between BPD and bike, as they can be tightly held without damaging the bike. Tyre width distribution is shown in table 3. The range is quite broad, with the majority of the sample falling between 20mm and 50mm, a seemingly narrow band but when considered against the task of holding the bike captive this will pose a challenge to design for.

One of the most cumbersome elements of the bike is the handlebars. By their nature, handlebars are protuberant to afford steering however they are generally an interference when parking, and to a large extent govern how closely bicycles may be parked. They are the widest point of all the bicycles studied with the distribution varied significantly as shown in table 4. More than half of the sample have handlebars between 450 and 550mm wide, however any efforts to standardise parking around this width will likely be frustrated by the small number of bicycles with handlebars of 750-800mm wide.

Table 3. Tyre width distribution.

Range (mm)		Count
0	20	1
21	30	16
31	40	16
41	50	12
51	60	9
61	plus	0

Table 4. Handlebar width distribution.

Range (mm)		Count
0	400	0
401	550	9
551	600	16

601	650	18
651	700	8
701	750	1
751	800	2
801	plus	0

Overall length will affect how much space is required within and around BPDs, and is the other main determinant of a reasonable spatial allowance for bikes. Length distribution is fairly small with nearly all bikes being between 1600 and 1900mm long as shown in table 5. If the sample is representative this means that the spatial demands of most bicycles are quite similar, such that a broadly standardised approach may be followed. However provision needs to be made for the occasional long bicycle with the cargo bike in this sample being 2200mm long, with a subsequent lengthening of turning circle and overall manoeuvrability.

Table 5. Bicycle overall length distribution.

Range (mm)		Count
0	1400	0
1401	1500	1
1501	1600	1
1601	1700	17
1701	1800	29
1801	1900	5
1901	2000	0
2001	2100	0
2101	2200	1
2201	plus	0

When 95% confidence intervals are examined against the data, the small sample size used in this research appears to be reasonably representative. Table 6 shows descriptive statistics for each of the 7 measurements taken.

Table 6. Descriptive statistics of the sample and comparison against AS2890.3.

	Wheel OD	Wheel ID	W'base	Tyre Width	H'bar Width	H'bar Height	O'All Length
mean:	672	560	1075	39	600	1044	1733
lower conf. int	660	537	1055	36	579	1028	1708
higher conf. int	683	583	1094	42	622	1061	1758
Confidence Level(95.0%)	11	23	19	3	21	17	25
50th %ile	679	588	1065	38	610	1047	1733
95th %ile	716	611	1163	56	720	1167	1874
AS2890.3	n/a	n/a	n/a	n/a	600	1200	1800

When comparing AS2890.3 to this sample, it is evident that the bicycle width – measured by the widest point of the bike, the handlebars – of 600mm in the standard is not aligned with the population of bicycles. Much like the design of doorway apertures is typically taller than the vast majority of humans, it follows that in order to fit bicycles into a rack without handlebars clashing or tangling that this figure ought to be increased. Bicycle height compares more favourably, with the standard suggesting a height of 1200mm being comfortably above the 95th percentile in this sample. Bicycle length in the standard does not compare very well to the sample, with the 95th percentile bike being longer than the standard's 1800mm. This is an important practical consideration given the space needed to place bicycles and also for users to access a BPD.

9. Conclusion

This research set out to fill a knowledge gap concerning relevant bicycle geometry for the development of Bike Parking Devices. Through a field survey of 54 bicycles in Melbourne a dataset was produced which showed a majority of bicycles in narrow enough ranges to enable a standardised approach to bicycle parking. Comparing the sample population against the relevant Australian standard shows that the standard underestimates the length and width of bicycles. The sample also showed that there are some outlier bicycles which require accommodation in parking. It is recommended that such data are included as a guide to designers in revisions of AS2890.3. Further research was proposed to increase the dataset to be global, have a larger sample, and to consider behavioural aspects such as to enable the development of convenient bicycle infrastructure.

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