The Analysis of Toilet Use Efficiency in Expressway Service Area Based on Anylogic

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Abstract: As the facility with the highest utilization rate in the expressway service area, the toilet has the greatest influence on the crowd gathering degree in the expressway service area. In order to study the scale and location of toilets in the Meicun service area, this paper conducts a field survey on the service area of Meicun by means of video recording and crowd tracking questionnaire survey. Through the investigation, the key data such as the probability of customers using toilet and toilet turnover rate were obtained. Based on this, the flow model of the crowd in the high-speed service area is established by using the simulation software of Anylogic. In the simulation, the scale and location of the toilet facilities in the high-speed service area are analyzed and evaluated according to the number of people using the toilet at the same time. The results show the influence of different toilet layout on the efficiency of toilet use and the degree of crowd gathering, and prove that double toilets are more efficient than single toilets, disperse the flow of people, reduce the degree of crowd gathering and avoid crowd crowding.

1. Introduction

The service area serves as a key node connecting the expressway and the surrounding scenic spots. Reasonable geometric layout of internal facilities is the basis to ensure the efficient and orderly operation of the service area, among which the toilet is the most frequently used and the most important facility in the service area, playing a pivotal role in the service area. How to accurately evaluate the toilet in the design stage of the new service area is of great significance for predicting the traffic state in the operation stage of the new service area, adjusting the design scheme in advance and improving the traffic organization means, which is the necessary premise to ensure the smooth traffic inside the new service area. However, there are few relevant studies at home and abroad, so it is difficult to provide necessary theoretical support for the construction of service area. During the operation of the existing service area, there are some problems such as chaotic traffic flow and low efficiency of the toilet. In developed countries such as Europe, America and Japan, the development of expressways started earlier, and the corresponding research on service areas is relatively perfect. There are even amusement parks, tourism product exhibitions and special rescue facilities set up inside. These countries pay attention to the environmental design when constructing the expressway service area, and regard it as an artificial landscape. The functional setting is more in line with the actual needs of users. Britain's "the location and layout of lay-bys and rest areas", Japan's "highway design manual", and the rest area's guide to the safety of the United States is the more complete technical guidance of service area planning and construction[1][2]. They define the service area as a kind of facility built on both sides of high-grade highway, and its function is to provide drivers and passengers with rest, dining, shopping, refueling / charging activities without leaving the road[3]. Its interior is
generally equipped with gas stations, public toilets, restaurants, parking lots, recreation squares and other areas, with a full function to meet the basic driving needs of drivers and passengers. Since the 21st century, on the basis of in-depth discussion of existing theories, foreign studies have begun to pay attention to the economic benefits of service areas and tried to apply new technologies to service areas to improve their operational efficiency. Zhou Tong [4] discussed the shortcomings of traffic organization in service areas based on technical indicators and regional traffic background of service areas. He Jiangjing [5] analyzed the activity pattern, activity path and travel proportion of the passengers in the traditional service area under different demands. Qin Huarong [6] and Chen Guomei [7] investigated the needs of vehicles and drivers in traditional and open service areas. Although this part of research does not directly apply the results to the new service area road geometric layout and traffic organization methods, but it provides a certain research basis for this paper.

However, the above studies did not consider the arrangement of facilities from the perspective of pedestrians, and the mature theories of pedestrian traffic characteristics were not applied, which also led to the situation that some areas in the service area were crowded and some areas were idle and unused. Because of this, this article refer to a lot of application in the subway station, airport facilities layout pedestrian simulation method of the research, using computer simulation software and Anylogic on high-speed service area inside the pedestrian flow field investigation and modeling and simulation analysis, simulate the crowd flow between the various facilities, from the crowd density figure and toilet use Numbers, in order to find out the current expressway service area location and size of toilet design flaws, and some optimization measures are put forward.

2. Survey data and parameter setting

2.1. Parameter Analysis

Through video recording, crowd tracking, big data analysis and other methods, field research was conducted in Meicun service area. As a representative of the comprehensive service area, Meicun service area concentrates all the facilities in a comprehensive building. The advantage of this method is that people will gather in the center of the service building to form a secondary traffic space. Compared with the traditional service area where the facilities are arranged separately outdoors, its advantage lies in that the flow of people is controlled through the location of the entrance and exit, but the convenience of the functional facilities is reduced. The facilities in Meicun service area are arranged around the building. Pedestrians gather in the center (toilets in the center). The layout of the facilities in the comprehensive service building is shown in the figure.

[Figure 1. Structure of Meicun Service Area]

Through crowd tracking, it was found that:

1. As the facilities in the service area are relatively monotonous, the staff are mostly limited to 1 to 3 facilities. The use time of the toilet is generally 2 to 3 minutes, the use time of the supermarket is generally 3 to 5 minutes, and the stay time of the restaurant is relatively scattered, generally more than 20 minutes.
2. The number of people tracked in Meicun is 56, among which 38 people enter the restroom, 10 people enter the restaurant and 6 people enter the supermarket. In the second choice, 28 people went to the restaurant for dinner, 12 went to the supermarket for shopping, and four went to the bathroom.

2.2. Data
Anylogic software, as a software based on system dynamics, is widely used in the simulation of subway station, airport and other facilities. Its reliability and technical maturity are trustworthy. To simulate with Anylogic, you need to enter a series of parameters to ensure the reliability of the experiment. The required parameters are as follows:
1. Pedestrian flow: Total number of pedestrians entering the service area
2. Probability of pedestrians entering various facilities
3. Turnover rate: time spent by pedestrians using various facilities
4. Facility scale: How many people can the facility serve at the same time

In addition, data such as pedestrian pace are also required, which adopts default data within the software. According to the survey data, the simulation parameters used are in the table 1.

| Table 1. The probability of population access to facilities |
|----------------------------------------------------------|
| Preferred toilet | Preferred shops | Preferred shoprestauran | Secondary toilet | Secondary shops | Secondary restaurant |
| Probability      |                |                           |                   |                |                          |
| 0.67857          | 0.01786        | 0.17857                   | 0.07143           | 0.16071        | 0.50000                  |

Through the field survey, the size of the toilet in Meicun is 266 people, and the turnover rate of the service area is table 2.

| Table 2. Facility turnover rate |
|--------------------------------|
| visitors flowrate | restaurant turnover rate | shops turnover rate | toilet turnover rate |
| 2615p/h            | Uniform (20,40) min      | Uniform (3,5) min   | Uniform (2,3) min   |

3. Influence of facility location on crowd aggregation
The number of functions and facilities in the new service area is large, and the pedestrian needs are complex. The cross conflict of the flow lines in the new service area will easily lead to the low efficiency of the traffic flow inside the service area. If the pedestrian traffic organization optimization design is not targeted, it will affect the use of internal facilities in the service area. Assuming that under the traffic level set above, all facilities in the service area can serve all the people with relevant needs, that is, no queuing will occur, the facilities in the service area of Meicun will be simulated. Its simulation parameters are shown above.

3.1. The influence of the central single toilet in the comprehensive service area on the degree of crowd gathering
Simulation modeling is carried out based on the data and assumptions in the tables listed in this paper. At the same time, as there are many shops in the service area, in order to simplify the model, various small shops are combined to carry out simulation modeling in the form of business district and catering area. The simplified model is shown in Figure 1.

The resulting crowd density diagram is shown in Figure 2:
Figure 2. Density diagram of human flow of single toilet in Meicun Service Area

The route of crowd gathering degree is the route from the entrance to the toilet, among which the most crowded area arranged in the center of the opposite toilet is the left and right sides of the toilet door. For the key paths from both sides of the entrance to the toilet, the flow of people through the paths is, the number of toilet users changes with time, as shown in Figure 3, and the abscissa time is the model running time, that is, the peak time of the service area.

![Figure 3](image)

**Number of toilet users**

Figure 3. Figure of the number of single-toilet users in Meicun service area

The average number of people using the toilet at the same time during peak hours is 132, and the maximum number is 176. The utilization rate was 49.718% and the maximum utilization rate was 66.165%. The simulation results are similar to the field survey results, the average use efficiency is less than 50%, most of the time the toilet resources are idle, causing serious waste.

3.2. The influence of two toilets on the degree of crowd gathering in the Meicun service area

Figure 4. Double toilet structure of Meicun Service Area
Figure 5. Flow density diagram of double toilets in Meicun Service Area

Two toilets are set on both sides. In order to facilitate the flow of people to the restaurant after using the toilet, two exits are set in the toilet. Meanwhile, the total number of people served by the toilet remains unchanged, while the number of people served by other facilities remains the largest (i.e., no queuing phenomenon), as shown in Figure 4.

Figure 6 Figure of the number of double toilet users

Queuing phenomenon occurs in both toilets, and the flow density decreases greatly after changing to double toilets. There is no area with flow density higher than 1.5 people/m² in the whole figure. The average number of people using the left and right toilets at the same time is 63 and 100, and the maximum value is 80 and 121, respectively. The use efficiency increased from 49.178% to 61.549%, and the maximum use efficiency was 75.564%. The specific number of users is shown in Figure 6, and the abscissa is the start time of the peak period, just like figure 3.

4. conclusion

1) Through investigation and simulation verification, it is found that the existing toilet facilities have low use efficiency, and the use efficiency in daily peak hours is less than 50%, which causes a large waste of resources.

2) The two-bathroom structure in the service area can make more rational use of resources than the single-bathroom structure. The simulation results show that the efficiency of double toilets is more than 15% higher than that of single toilets.

3) The route from the entrance to the toilet is the one with the largest crowd density. In the service area of Meicun, the two flow paths from the entrance to the toilet divide the entire internal space, which is not conducive to the internal flow of people and is prone to congestion, collision and other accidents on the two flow paths. It can be clearly seen in the figure that the high-density crowd path from the toilet to the restaurant and the crowd path from the supermarket have formed a cross, which has hidden security risks.
4) The structure of double toilets can disperse the flow of people and reduce the degree of crowd gathering. In the simulation, it is found that after the reconstruction of the dual toilets, there is no area with a population density of more than 1.5 people/m² in the crowd flow path. It is suggested to set up the dual toilets in the service area with conditions.

5) The differences of facilities used by women, children and special people were not taken into account in the simulation in this paper. Only the general facilities were simulated without considering the use of drinking water, gardens and other rest areas. At the same time, the data in this paper were only obtained in several service areas in China, so the sample data was insufficient and the results lacked further verification. Although the data in this paper could reflect the general situation, the service areas in different regions had different focuses, which might not accurately reflect the real situation of the facility layout plan.

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