Use of regression analysis to calculate the required number of stalls for disabled people in the trade objects construction

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Abstract. The article addresses the unified methodology lack problem for calculating the required number of stalls for people with disabilities in parking lots near various infrastructure facilities. To solve this problem, one of the possible algorithms for calculating this indicator is presented. This algorithm application is shown for the trade objects in St. Petersburg and the equation of the pair regression is found.

Introduction
The road transport development has become one of the last century outstanding events. At the same time, it gave rise to a lot of new serious problems, including the uncomfortable environments appearance in the human habitat zone. As the sanitary and hygienic conditions analysis shows, the most acute ecological situation arises in the parking boxes [1]. However, along with the transport infrastructure development, along with environmental problems, a number of social problems, one of which is to create the most comfortable conditions for people with limited mobility, taking into account the interests of other road users need to be solved [2, 3].

To date, measures to ensure equal access for persons with disabilities to facilities and services in various spheres of people with limited mobility life activities are carried out in accordance with the state program “Accessible Environment”, approved by the Government of the Russian Federation Decree dated December 1, 2012.

According to the Federal State Statistics Service, as of January 1, 2017, there were 12259 disabled people in the Russian Federation, with a total population of 146.9 million people (as of April 2, 2018). The transport service data shows that 16.6% of disabled people use a car (or motorcycle) as a driver, 29.0% as a passenger for 2016 [4].

Regulatory documentation regulates the number of places for disabled people. For example, in individual car stalls near the buildings of service establishments, it is necessary to provide 10% (but not less than one place) for the disabled people’s vehicles [5]. An indicator of 10% for calculating the required number of stalls is set in accordance with the total percentage of persons with disabilities in the Russian Federation. So, in 2010 the number of people with disabilities in the Russian Federation was about 10% of the country’s population (according to the Ministry of Health and Social Development). At the beginning of 2018, this figure is about 8%. The stalls for people with disabilities required number standard indicator is valid throughout the country and is mandatory in design. However, the number of persons with disabilities varies in the regions. The top five, where the
The largest number of people with disabilities are registered, include the Belgorod Region (16.2% of the total population), St. Petersburg (15.9%), Ryazan Region (13.5%), Moscow (12.9%) and the Chechen Republic (12.8%).

**Algorithm for calculating the required number of stalls for people with disabilities**

According to the authors, the main problem of calculating the number of required stalls at various infrastructure facilities is the lack of an individual approach, which considers such factors as: type of object, location, transport accessibility, number of people with disabilities in the region, etc. One of the proposed problem solutions is the development of a unified model for calculating a specific number of stalls for people with limited mobility, considering various factors.

The algorithm for calculating the required number of stalls for people with limited mobility may look like this:

1) Selection of experts (specialists in the field of design and construction) who will carry out the assessment of factors, by their pair-wise comparison;
2) Determination of the list of factors that influence the stalls total number;
3) Building a regression model, i.e. finding the equation of the stalls number on the factors;
4) Calculating the required number of stalls based on the model obtained.

The result of the study is the construction of a regression equation, which in full will quantitatively display the actual connections between the factors and the required number of stalls.

According to the authors, the most significant factors in calculating the number of stalls for people with disabilities at trade objects are: the object area, the distance to the city community center, the total number of stalls and the number of people with disabilities in the region.

**Construction of a regression model for calculating the required number of stalls for people with disabilities during the shopping centers construction in St. Petersburg**

The initial data for building a regression model are the indicators of the previously mentioned factors for 50 shopping facilities (Table 1) located in St. Petersburg. We should also separately justify the decision to build a regression model for St. Petersburg separately from other cities of the Russian Federation. This decision is explained by the fact that in large cities (St. Petersburg and Moscow) the number of disabled people is several times higher than this number in other regions. These cities are not included in the ratings of million-plus cities in terms of the shopping centers availability degree for the reason that the population in St. Petersburg and Moscow is very different from other cities, which in turn does not allow an objective comparison.

**Table 1. Source data for building a regression model**

| Item No. | Shopping centers       | Total stalls | Stalls for disabled | Trading area, [m²] | Distance to the city community center, [m] |
|----------|------------------------|--------------|---------------------|--------------------|------------------------------------------|
| 1        | Putilovsky             | 300          | 50                  | 9500               | 12000                                    |
| 2        | Academichesky          | 400          | 35                  | 22956              | 11000                                    |
| 3        | Atmosphere             | 340          | 44                  | 21500              | 10000                                    |
| 4        | Balkansky              | 1500         | 200                 | 59500              | 15000                                    |
| 5        | Varshavskiy ekspress   | 1000         | 200                 | 25500              | 4300                                     |
| 6        | Vladimirskiy passazh   | 500          | 75                  | 18000              | 2900                                     |
| 7        | Gallery 1814           | 40           | 10                  | 7800               | 6000                                     |
| 8        | Garden City            | 1500         | 150                 | 42000              | 14000                                    |
| 9        | Grand Canyon           | 2100         | 200                 | 53000              | 15000                                    |
As the initial data, a matrix of correlation indicators was compiled, in which the following conventions are used: Y is the number of stalls for people with disabilities; X₁ is the total number of stalls; X₂ – object’s trading area; X₃ - distance to the city community center.

**Table 2. Correlation matrix**

|      | Y   | X₁  | X₂   | X₃  |
|------|-----|-----|------|-----|
| 10   | Grand Palace | 300 | 50   | 7500 | 1600 |
| 11   | Gulliver     | 1500| 120 | 61000| 8100 |
| 12   | Interio      | 500 | 100 | 18000| 8900 |
| 13   | Iyun`        | 1100| 250 | 30500| 1100 |
| 14   | Galereya     | 1200| 150 | 97000| 3600 |
| 15   | Leto         | 3200| 350 | 80000| 1500 |
| 16   | Masshtab     | 1200| 100 | 20000| 1600 |
| 17   | MEGA Dybenko | 7700| 800 | 14040| 1500 |
| 18   | MEGA Parnas  | 6500| 700 | 10219| 2100 |
| 19   | Merkuriy     | 1300| 100 | 77000| 1000 |
| 20   | Nevskiy      | 402 | 35  | 44700| 1200 |
| 21   | Nord         | 400 | 40  | 36500| 1400 |
| 22   | Ozerki       | 200 | 45  | 15000| 1200 |
| 23   | Piter        | 400 | 35  | 28500| 1100 |
| 24   | Piter-Raduga | 3500| 400 | 10300| 9600 |
| 25   | Rodeo Drive  | 1100| 150 | 32982| 1300 |
| 26   | City Moll    | 1200| 250 | 68511| 8700 |
| 27   | Ulyanka      | 200 | 30  | 15000| 1500 |
| 28   | London Moll  | 1500| 220 | 62831| 9500 |
| 29   | Frantsuzskiy Boulevard | 200 | 20 | 11299| 1200 |
| 30   | Evrika       | 640 | 50  | 35000| 8400 |
| 31   | Shkiperskiy moll | 100 | 20 | 7076 | 5800 |
| 32   | Yuzhnvy polyus | 500 | 70 | 26352| 1200 |
| 33   | Raketa       | 350 | 32  | 17000| 3300 |
| 34   | Piterland    | 1302| 220 | 83445| 9100 |
| 35   | Radius       | 80  | 15  | 6000 | 6800 |
| 36   | Rio          | 1700| 200 | 45581| 9100 |
| 37   | Monpanse     | 600 | 55  | 26000| 1300 |
| 38   | Atlantic City | 1200| 130 | 33000| 1000 |
| 39   | Zvezdnny     | 500 | 50  | 8000 | 1400 |
| 40   | Mezhdnarodnny| 270 | 35  | 45000| 1000 |
| 41   | Kitay gordon | 700 | 80  | 12000| 2100 |
| 42   | Kosmos       | 800 | 75  | 27000| 1200 |
| 43   | Nevsk Centre | 550 | 60  | 45000| 3100 |
| 44   | Zhemchuzhnaya plaza | 1390| 150 | 48000| 1700 |
| 45   | Europolis    | 1300| 200 | 60000| 7200 |
| 46   | Parad        | 150 | 17  | 10000| 1800 |
| 47   | Okhta moll   | 1900| 240 | 78000| 7400 |
| 48   | Sampsoniyevskiy | 175 | 20 | 15600| 4500 |
| 49   | Outlet Village Pulkovo | 1600| 190 | 24758| 1800 |
| 50   | Svetlanovskiy | 200 | 35 | 14000| 9300 |
The matrix analysis revealed a strong mutual correlation between the factors X1 and X2, and the low closeness of the relationship of the factor X3 with the result Y. For this reason, the X3 factor is excluded from the model, as well as the X2 factor, which is less closely related to the result Y than the X1 factor. In this way, only one factor is included in the regression equation.

Using the Microsoft Excel Program capabilities, the tables 3-5 were obtained. Table 3 presents the multiple correlation coefficient values, the corrected coefficient of multiple determination, etc.

**Table 3. Regression statistics**

| Indicator                  | Value       |
|----------------------------|-------------|
| Multiple R                 | 0.974320245|
| R-squared                  | 0.94929994  |
| Normalized R-squared       | 0.948243689|
| Standard error             | 35,52219121 |
| Number of observations     | 50          |

Table 4 presents the analysis of variance (the residual variance value for the freedom degree, the Fisher criterion value).

**Table 4. Variance Analysis**

|                         | df (freedom degree number) | SS (dispersion) | MS (dispersion on 1 degree of freedom) | F (Fisher statistics) | significance F  |
|-------------------------|-----------------------------|-----------------|---------------------------------------|-----------------------|-----------------|
| Regression              | 1                           | 1134059         | 1134059,169                           | 898,7444              | 9.77E-33        |
| Residue                 | 48                          | 60567,65        | 1261,826069                           |                       |                 |
| In total                | 49                          | 1194627         |                                        |                       |                 |

Table 5 contains the regression equation coefficients values, the standard errors of determining the coefficients, as well as the actual values of the Student’s t-criterion.

**Table 5. Regression statistics**

|                         | Coefficients | Standard Error | t Stat | P-value | Lower 95% | Upper 95% | Lower 95.0% | Upper 95.0% |
|-------------------------|--------------|----------------|--------|---------|-----------|-----------|-------------|-------------|
| Intercept               | 16.015       | 6.445          | 2.485  | 0.016497259 | 3.057     | 28.974    | 3.057       | 28.974      |
| X 1                     | 0.106        | 0.004          | 29.979 | 9.77454E-33 | 0.099     | 0.113     | 0.099       | 0.113       |

In this way, the pair regression equation for the objects located in St. Petersburg has the form (1):

\[ y = 16.015 + 0.106X_1 \]  

The correlation coefficient is 0.9743 and the coefficient of determination is 0.9493 (66). The correlation coefficient indicates extremely strong links. The value of the coefficient of determination
for this linear model suggests that 94.93% of the variation of the result $y$ is explained by the variation of the factor $x_1$. In other words, the strength of the linear connection between $y$ and $x_1$ is high.

The verification of the significance of the equation as a whole, that is, the hypothesis of the presence of a linear relationship between $x_1$ and $y$, is carried out using Fisher's test. The actual value of the Fisher $F$-test is 898.7444.

The critical value of the $F$-criterion at a significance level of 0.05, the number of degrees of freedom for the regression sum equal to 1 and for the residual sum equal to 48 is 4.0427.

Thus, $F_{\text{factual}} > F_{\text{critical}}$, from which follows the adoption of the hypothesis about the significance of the coefficient of determination and the whole linear regression equation.

Standard errors for determining the parameters $a$ and $b$ are respectively 6.445 and 0.004. To assess the statistical significance of the regression coefficients used student's criterion. For the coefficient $b$, the value of Student's $t$ test is 26.6.

For the coefficient $a$, the value of Student's $t$ test is 2.5. The critical value of the criterion at a significance level of 0.05 and the number of degrees of freedom 48 is 2.01.

For both criteria, the actual values are greater than critical values, i.e. $a$ and $b$ are significantly different from 0.

The parameters $a$ and $b$, as well as the coefficient $R^2$, differ from 0 in a non-random manner, the resulting equation of the pair regression is significant with a probability of 95%. In other words, this equation can be used for analysis and prediction.

Summary

The main problem faced in the study course is the problem of selecting experts for assessing the factors significance. In other words, due to the fact that the procedure for the selection of experts is a time-consuming process that requires a lot of time and money to find specialists and then agree with them the conditions of work, it was decided to present the proposed calculation algorithm essence considering the opinion of only two experts.

Attracting a sufficient number of specialists from different fields of science (construction, architecture, etc.) can improve the quality of the constructed model. In other words, with a considerable investment of time and finances, it is possible to obtain an equation that includes the influence of various factors on the total number of stalls for people with disabilities.

Changing the approach to the calculation of the previously mentioned indicator can have a positive effect on the state program “Accessible Environment” implementation by increasing the accuracy of calculations and the requirements for developers.

As a result of testing the resulting model for a shopping center located in St. Petersburg, the car parking of which is designed for 7,699 spaces, the required value of specialized stalls for disabled people was 833. This value exceeds the design value (770 spaces) by 63 units.

Although regulatory documents state that at least 10% of stalls must be adapted for people with disabilities, in practice few people exceed this minimum value. The new calculation algorithm introduction assumes an individual approach to the indicator under consideration calculation at various sites, which in turn will allow rationally distributing the area when arranging the territory of the object under construction.

References

[1] Cyplakova E G 2014 The ecological Situation analysis of the stalls in St. Petersburg (Bulletin of Saint Petersburg Mining University) 209 144-147.
[2] Petrov A, Svistunova V 2019 Program of integrated development of transport infrastructure of Tyumen (E3S Web of Conferences) 91 05031.
[3] Alagappan V, Hefferan A, Parivallal A 2018 Exploring accessibility issues of a public building for the mobility impaired. Case study: interstate bus terminal (ISBT) (Vijayawada, India, Disability and Rehabilitation: Assistive Technology) 13 (3) 271-279.
[4] Gur'eva O S, Skachkova M E 2018 The development of the methods for calculation the needed quantity of stalls for people with limited mobility (Saint Petersburg Engineering University. POLITEH-PRESS) 307-309.

[5] Goverdovskaya L G 2018 The problems of stalls for the people with limited mobility (Traditions and innovations in construction and architecture, Samara, Samara State Technical University) 177-182.