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**Comparison Turkish Standard-TCRP-Rationality Criteria IETT and Public Private Bus (PPB) Lines**

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ABSTRACT

Today, it is seen that public transportation has moved from being an important to more advanced dimensions, and serious solutions have not been taken in this context.However, considering the interaction of vehicles and pedestrians,which are the main inputs of the transportation system,especially pedestrains are referred to public transportation,while at the same time reducing the use of private cars. Of course, when it comes to public transportation, the scarcity of existing buses within the scope of municipalities is taken into consideration and it receives assistance from the type of transportation we call private public bus (PPB). In this road transport analysis, the stop in Istanbul Kücükcekmece district Besyol neighbourhood, which includes the university, especially during the peak hours of the day, in the morning,noon and evening, and which has frequent passenger mobility,has been examined.

The interaction between the lines operating within the body of Istanbul Electric Tramvay AND Tunnel Enterpriess(IETT) and the PPB, the current location and routes of the lines were handled, and the route line study was created using the Geographic Information Systems (GIS) program. In this context, TCRP100-TCRP165 reports within the Transit Cooperative Research Program (TCRP) were compared and evaluated by comparing the Rationality Analysis and TS compliance percentages. These three criteria are aimed at us , the distances between two stops,the length of the routes, whether the lines are sufficient,the need for additional flights,and wherher new regulations on the line will be required, especially considering the peak hours.

Keywords- *Percent Conformity, TCRP, Rationality, Public Transportation, Route, GI*

I. INTRODUCTION

The most important factor of the service level improvement works is carried out by making new arrangements, especially in cities and regions with heavy traffic. Today, when the causes of most traffic problems are listed, many items such as the increase in the use of private vehicles, insufficient routes, and inappropriate public transportation system can be listed. In metropolitans and metropolitan areas, during the traffic service level, public transportation during rush hour, morning, noon and evening, is examined within the framework of the determined criteria, and if there are problems in the existing system, they should be detected and fixed.In order to ensure that traffic is not considered as a problem today, it is necessary to balance the routes at an appropriate rate, to arrange the number of trips on the existing route, to make public transport attractive, and to increase the usability of public transport in all aspects.

In GIS, graphical information provides information about the geometry, location, shape and size of the geographical entity, while non-graphical data explains other structural features belonging to the same geographical entity [1].

In TS11783, it is stated that the distances between two stops on the roads of primary importance should be between 600 m and 700 m. If the current region has passenger density and demand for public transportation, the distances between these stops can be reduced by 100 m [2].In his studies, he explains that although there are many different situations to connect the starting point and the destination point, the most rational route should be chosen among the limited number of route alternatives during the route design [3].In the study, he states the Rationality analysis as an analysis method used to determine the most ideal route and to bring the public transportation routes in use to a suitable state [4].In his study, it was seen that there are many different satisfaction variables belonging to the public transportation system, and it is not possible to evaluate these variables only with surveys. For example, distance between stops, service interval, route length etc. It states that the factors affecting public transportation should be evaluated by making a detailed analysis [5].It states that there is no study to offer the transportation, which has been made more attractive by increasing the transportation service quality for public transportation routes, to the users and to encourage them to use public transportation [6]. The urban transportation problem, which is evaluated on the basis of the current and very urgent peak hours that arise due to inter-regional journeys, explains that it is related to this transportation system [7]. Especially in the majority of the society, in order to choose one of the transportation systems, it is the condition that it should be safe. It is explained that all vehicles used within the scope of public transportation should be able to transport people and goods in the shortest time and at the most affordable price and to be comfortable during transportation [8]. TCRP is an applied-based research program that examines and observes the transportation system in public transportation and develops short-term, practical, solutions to problems [9]. There are six different service levels in TCRP 100. Here, the existing line is considered to be at the service level according to the criteria and classes are made with lettering such as A, B, C, D, E and F. There is no letter classification in TCRP 165. It is evaluated and categorized according to the perspectives of passengers and operators. TCRP 100 is used as a standard that measures the compliance of criteria in public transportation in the USA. Public transportation capacities in Tcrp 100; It is explained as a concept that includes human and vehicle movements [10]. The difference between TCRP 165 and TCRP 100 is that it can evaluate its criteria from the perspective of passengers and the views of the transportation system operator, and make comparisons between the two groups [11].

II. MATERIAL AND METHOD

It has choosen the sefaköy Beşyol stop area, which is used extensively by the students of Istanbul Aydın University, was selected, and in this context, the routes of the lines passing through the Beşyol stop belonging to Küçükçekmece District on Istanbul province basis were examined, especially in the east and west directions of the city, and IETT, which serves for all passengers who need public transportation, especially passing through the Beşyol stop. and ÖHO buses were examined. Another reason for choosing Küçükçekmece district is that it ranks 2nd among all districts in Istanbul according to the 2020 population ranking. It was evaluated in the morning, noon and evening peak hours on four lines passing through Beşyol stop. It is aimed to compare the tse, tcrp and rationality values ​​of the four existing lines, firstly within its own body and then to the mutually obtained data, and to improve the service levels by determining the appropriate lines as a result.

A. TSE Compliance Percentages for Public Transport Lines

In the calculations of TSE compliance percentage, the existing stop intervals were made with three different colors and it was accepted to be taken between 301 m - 600 m in the distances between the stops according to TS 11783. Colorings were made between the routes and the stop intervals made on the GIS, and in Table 1, the distance between the stops according to TS 11783 is given in coloring.

Table 1. Coloring the Distance Between Stops According to TS 11783 [2]

|  |  |  |
| --- | --- | --- |
| Color | Stop Distance (m) | TSE Compliance |
| Blue | 0 - 300 | Not Available |
| White | 301 - 600 | Suitable |
| Red | 601 – 20.000 | Not Available |

The following formulas are used in the percentage of compliance calculations.

The calculation of the total number of stop intervals was obtained by using equation (3.1.).

T.S.R: Total Stop Range (pieces)

T.NS: Total Number of Stops (units)

T.S.R = T.N.S. – 1 (3.1.)

The percentage of fit ratio calculation was obtained using equation (3.2.).

P.E. : Percentage of Eligibility (%)

ASD: Available Stop Distance (pcs)

 $Percentage of Eligibility : \frac{A.S.N )}{T.S.N)}\*100$ (3.2.)

Table 2. Percentage of Compliance with TS 11783

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Line number** | **Stop Distance (m)** | **Turkish Standart 11783** | **Total Stop Number** | **Percentage of Eligibility****PE(%)** |
|  | **0-300 Blue** | **301-600 White** | **601-20.000 Red** | **Available Stop Number** | **Not Available Stop number** |
| 73B Departure | 9 | 11 | 9 | 11 | 18 | 30 | 37,93 |
| 73B Arrival | 9 | 15 | 8 | 15 | 17 | 33 | 46,87 |
| 73H Dep | 0 | 2 | 6 | 2 | 6 | 9 | 25,00 |
| 73H Arr. | 0 | 3 | 6 | 3 | 6 | 10 | 33,33 |
| 76 Dep | 16 | 21 | 17 | 21 | 33 | 55 | 38,88 |
| 76 Arr. | 18 | 27 | 14 | 27 | 32 | 60 | 45,76 |
| 76D Dep.  | 15 | 35 | 20 | 35 | 35 | 71 | 50,00 |
| 76D Arr. | 13 | 41 | 15 | 41 | 28 | 70 | 59,42 |
| Total Number | 80 | 155 | 95 | 155 | 175 | 330 | 46,96 |

When Table 2 is examined, in terms of TS compliance, the number of blue-colored stop intervals in the 0m-300m range for four lines is determined as 80, the number of white-stop intervals in the 301m-600m range is 155 and the number of red-colored stop gaps in the 601m-20.000m range is determined as 95. On these four routes, which have a total of 330 stops, the number of suitable stops was determined in white with 155 stop intervals as appropriate, and 175 stop intervals as unsuitable.

According to the TS stop intervals eligibility criteria, the most suitable bus line was the 76D line with a rate of 50.00% on the departure route, while the 73H line was the unsuitable line with a rate of 25%. While the most suitable bus line was the 76D line with a rate of 59.42% on the return route, the 73H line was the unsuitable line with a rate of 33.33%.

B. Rationality Criteria for Public Transport Lines

When rationality is mentioned, the first thing that comes to mind is the bird's flight distance criterion, and it is obtained as a result of the ratio of the bird's flight distance (BFD), which gives the shortest path between two existing points, and the route length. The ideal situation is evaluated as 1.0 for BFD, and it is understood that the service level of the line whose SUM criterion rate is close to 1.0 is good. Secondly, it is the Average Speed ​​(AS) criterion, where the speed evaluation of the bus line traveling on the route at the time of departure and return is determined. It is stated that the line with a high speed during public transportation is rational.

Calculation of rationality; The BFD criterion was obtained using equation (3.3.) [4]

 $BFD=$ (Line Real Distance/Bird Flight Distance) (3.3.)

Calculation of rationality; The OH criterion was obtained using equation (3.4.) [4]

 (3.4.) Average speed Criteria=( Line Real Distance/Travel Time)

Table 1 was obtained by determining the bird flight distances of the lines via the GIS QGIS program application. It has been observed that the longest line actual distance value on the outgoing route is line 76D with 39.782 km, and line 76D with the longest line actual distance value 39.883 km on the return route. Stall and sand investigations of the lines are given in the supplementary tables.

As it can be seen from Table 3., it is seen that the most suitable line on the outgoing route in the Sand criterion is 76D with 1.545 values, and the most unsuitable line is line 73B with a value of 2.313. Also, the most suitable line on the return route is 76D with a value of 1.549, and the most suitable line is 76D. It is seen that the line that does not exist is the line 73B with a value of 2.483.

Table 3. Bird Flight Criteria Round-Trip Values of IETT Bus Lines.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Line Number** | **Departure** | **Arrival** | **Departure** | **Arrival** |
|  | **Real distance(km)** | **Bird Flight Distance(km)** | **Real distance(km)** | **Bird Flight Distance(km)** | **BFD** | **BFD** |
| 73B  | 14.984 | 6.478 | 16.088 | 6.478 | 2.313 | 2.483 |
| 73H  | 7.944 | 4.113 | 9.786 | 4.113 | 1.931 | 2.379 |
| 76  | 28.788 | 18.519 | 29.653 | 18.519 | 1.554 | 1.601 |
| 76D  | 39.782 | 25.747 | 39.883 | 25.747 | 1.545 | 1.549 |

As can be seen from Table 4., it is seen that the most suitable line is 73B with a speed of 24.973km/h and the most suitable line is line numbered 73H with a speed value of 22,189km/h in the Oh criterion. It is seen that it is 73H with a speed value of 27.335 km/h, and the most unsuitable line is line 76D with a value of 24.423.

Table 4. Avarage Speed Criterion Values of IETT Bus Lines.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Line Number** | **Travel time (Min)** | **Departure real Distance (km)** | **Arrival Real distance (km)** | **Avarage Speed Criteria (km/h** |
| **Dep.** | **Arr.** |
| 73B  | 36 | 14.984 | 16.088 | 24.973 | 26.813 |
| 73H  | 21.5 | 7.944 | 9.786 | 22.189 | 27.335 |
| 76  | 72 | 28.788 | 29.653 | 23.990 | 24.710 |
| 76D  | 98 | 39.782 | 39.883 | 24.361 | 24.423 |

C. Evaluation of TCRP100-TCRP165 Criteria for Public Transport Lines

In the Tcrp 100 report, capacities in public transportation are specified as a criterion that includes vehicle and user movements [10]. Difference of TCRP 165 from TCRP 100; Satisfaction evaluation is made by evaluating the criteria from the user's point of view and taking into account the views of the operator, and making comparisons between the user and the operator [11].

1) Evaluation of Hourly Expeditions:

The obtained results were measured by the number of travels every weekday morning, noon and evening peak hours, hourly travel frequency. In the service level tables, the lettering system in TCRP 100 and the category classification in TCRP 165 are determined in seven categories. Evaluation of criteria for hourly trips is shown in Table 3. [12].

In determining the conformity status of the lines, A-B-C levels in TCRP100 and D-E-F levels were evaluated as unsuitable criteria are included. When the number of hourly travels on the four lines is examined, during the peak hours between 06:00-08:00 in the morning, 12:00-14:00 in the afternoon and 17:00-19:00 in the evening; According to TCRP 100; In the morning peak hours, all lines with A, B and C service levels in the direction of the most ideal line are suitable, there are no unsuitable lines, and on the return route 73H, 76D are suitable and other lines are not suitable. According to TCRP 100; At noon peak hours, lines 73H, 76, and 76D, which have A, B and C service levels in the outbound direction of the most ideal line, are suitable, 73B is not suitable, and 76D is suitable on the return route, and other lines are not suitable. According to TCRP 100; At the peak hours of the evening, it is understood that lines 73B, 73H, 76D, which have A, B and C service levels in the direction of the most ideal line, are suitable, while line 76 is not suitable, and not all lines are suitable on the return route. It has been stated that improvements should be made on the lines that do not meet the compliance criteria and that they should be brought to A, B, C service levels.

When the number of hourly voyages on the four lines is examined, during the peak hours between 06:00-08:00 in the morning, 12:00-14:00 in the afternoon and 17:00-19:00 in the evening; According to TCRP 165, in the morning peak hours, the lines belonging to Category 1 (C1), C2 and C3 service levels in the direction of the most ideal line, 73H, 76D are suitable, other lines are not suitable, on the return route, 76D is suitable and 73B, 73H, Line 76 is not suitable According to TCRP 165, at noon peak hours, lines 73H, 76D from the lines belonging to C1, C2 and C3 service levels in the direction of the most ideal line are suitable, other lines are not suitable, while 76D is suitable on the return route and all other lines are suitable. According to TCRP 165, at peak hours in the evening, it is understood that lines 73H, 76D from the lines belonging to C1, C2 and C3 service levels in the direction of the most ideal line are suitable, other lines are not suitable, and the lines are not suitable on the return route. It has been stated that improvements should be made on the lines that do not meet the compliance criteria and that they should be brought to C1, C2 and C3 service levels.

Table 5. Evaluation of Tcrp 100-Tcrp165 Hourly Number of Trips for IETT Bus Lines (06:00-08:00 in the morning hours)

|  |
| --- |
|  |
| **Line Number** | **Travel Number****Departure** | **TCRP 100****Dep.** | **TCRP 165****Dep** | **Travel Number****Arrival** | **TCRP 100 Arr.** | **TCRP 165 Arr.** |
| 73B  | 5 | B | C4 | 0 | F | C7 |
| 73H  | 6 | A | C2 | 5 | B | C4 |
| 76  | 1(+2) | C | C4 | 0 | F | C7 |
| 76D  | +16 | A | C1 | +6 | A | C2 |

Table 6. Evaluation of Tcrp 100-Tcrp165 Hourly Number of Trips for IETT Bus Lines Afternoon 12:00-14:00)

|  |
| --- |
|  |
| **Line Number** | **Travel Number****Departure** | **TCRP 100****Dep.** | **TCRP 165****Dep** | **Travel Number****Arrival** | **TCRP 100 Arr.** | **TCRP 165 Arr.** |
| 73B  | 2 | D | C5 | 0 | F | C7 |
| 73H  | 5 | B | C3 | 0 | F | C7 |
| 76  | 1(+2) | C | C4 | 0 | F | C7 |
| 76D  | +11 | A | C1 | +11 | A | C1 |

Table 7. Evaluation of Tcrp 100-Tcrp165 Hourly Number of Trips for IETT Bus Lines 17:00-19:00 in the evening

|  |
| --- |
|  |
| **Line Number** | **Travel Number****Departure** | **TCRP 100****Dep.** | **TCRP 165****Dep** | **Travel Number****Arrival** | **TCRP 100 Arr.** | **TCRP 165 Arr.** |
| 73B  | 3 | C | C4 | 0 | F | C7 |
| 73H  | 9 | A | C2 | 0 | F | C7 |
| 76  | +2 | D | C5 | 0 | F | C7 |
| 76D  | +10 | A | C2 | 0 | F | C7 |

2) Evaluation of Daily Working Hours: The working hours of the IETT and PPB providing service were measured every day for the week, and the lettering system was used in TCRP 100 and categorized classifications (C) in TCRP 165 at service levels in the tables. The evaluations of the daily working hours criteria for the four existing lines are shown in Table 8. [13]. When the daily working hours criteria are examined on four lines between 00:00-24:00, according to TCRP 100, all lines with A, B and C service levels in the outbound direction of the most ideal line are suitable, and there is no unsuitable line on the return route. It has been observed that other lines where . In order to bring unsuitable lines to A, B and C levels, their routes and the number of trips during the day should be rearranged. When the daily operating hours criteria are examined in the peak hours between 00:00-24:00 on four lines, according to TCRP 165, it is seen that there is no unsuitable line where all lines are suitable in the outbound direction of the most ideal line, and other lines where line 76D is suitable on the return route. found to be unsuitable. Routes and working hours during the day should be rearranged in order to bring unsuitable lines to C1, C2 and C3 levels. According to the TSE stop intervals, the most suitable bus line was the 76D line with a rate of 50.00% on the departure route, while the 76D line was the most suitable bus line with a rate of 59.42% on the return route. In the sand criterion, it is seen that the most suitable line on the outgoing route is 76D, and the most unsuitable line is line 73B. It is also stated that on the return route, the most suitable line is again 76D, and the most unsuitable line is line 73B. In the Oh criterion, it is seen that the most suitable line on the departure route is 73B, and the most unsuitable line is line 73H. It is also seen that the most suitable line on the return route is 73H, and the most unsuitable line is line 76D. Considering the number of hourly trips in the morning, noon and evening, it is seen that the most ideal line on the TCRP100 round-trip route is line 76D. It is seen that the most ideal line on the TCRP165 round-trip route is line 76D. Considering the number of daily working hours in the morning, noon and evening, it is seen that all lines are suitable on the TCRP100 departure route, and line 76D is the most ideal line on the return route. All lines are suitable on the return route, and line 76D is the most ideal line on the return route. appears to be. The most important data that emerges in the comparison of the results is the absence of the line that meets all the criteria at once. Also, in the hourly criterion, it means only the private public bus expressed with + 10, and there is no IETT service on this line, and the line expressed as "1 ( +2 )" has a total value. There are 3 trips, 1 of which is İETT and 2 of which means private public bus. In the daily criterion, it is the 76D Private Public Bus (PPB), and this line is not IETT. there is none. Line 76, on the other hand, works halfway as PPB and IETT. Within the scope of the study, the comparison of İETT and PPB was made at the same time, and it is understood that they are indispensable in public transportation in PPB. If there is a need to make an arrangement in service levels, it is necessary to evaluate PPB and İETT together, especially in cities such as metropolitan Istanbul. the other can work on the route and it is clearly seen that it ensures the elimination of service congestion. All regional İETT and PPB lines' expedition times, routes, distances between stops, number of passengers using public transportation at peak hours, etc. It is beneficial to create a more attractive public transportation network compared to private cars with a high service level by observing critical values ​​such as these at certain periods.

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