Analysis of the quality of bicycle facilities and urban resilience in the city of Rio de Janeiro

Análise da qualidade de instalações de bicicleta e resiliência urbana na cidade do Rio de Janeiro

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ABSTRACT
COVID-19 has generated great debates about the future of urban mobility, in a scenario of economic recession without the possibility of major planning or investment. Cities become experiment laboratories that can bring benefits during the crisis and with a focus on sustainable urban mobility when the worst is over. Cities on all continents have announced contingency measures to offer more security in displacement during the pandemic and as they begin to relax social isolation, the world health organization recommends those who need to move during the crisis - such as essential service workers use a bicycle when possible. The city of Rio de Janeiro has developed a great infrastructure for bicycles among the mega events of 2014 (World Cup) and the 2016 (Olympic Games). This article aims to apply bicycle model analysis criteria and to promote the discussion about quality of bicycle facilities in the west of Rio de Janeiro and its structure. The bicycle lanes and cycle paths of the Santa Eugênia Road in Paciência neighborhood and the Padre Guilherme Decaminada avenue in Santa Cruz neighborhood were measured in order to highlight the real problems that are currently being faced in the specific spaces for bicycle use. For the analysis of local conditions and the cycle paths, field trips were made by bicycle. The methodology used has ten benchmarking criteria. The collected results point to good operating conditions but a lack of compliance with some minimum requirements for signaling, lighting and maintenance of bicycle ways pavement. Thus, this study contributes to the analysis of the quality of cycle routes in the city by encouraging sustainable urban mobility and for the adoption of resilient measures to face the pandemic.

Keywords: Urban Planning, Bicycle Facilities, Mobility, resilience

RESUMO
O COVID-19 gerou grandes debates sobre o futuro da mobilidade urbana, em um cenário de recessão econômica sem a possibilidade de grandes planejamentos ou investimentos. As cidades se tornam laboratórios de experimentos que podem trazer benefícios durante a crise e com foco na mobilidade urbana sustentável quando o pior já passou. Cidades de todos os continentes anunciaram medidas de contingência para oferecer mais segurança no deslocamento durante a pandemia e, quando começam a relaxar o isolamento social, a organização mundial de saúde recomenda aqueles que precisam se...
mudar durante a crise - como trabalhadores de serviços essenciais usam bicicleta sempre que possível. A cidade do Rio de Janeiro desenvolveu uma ótima infraestrutura para bicicletas entre os megaeventos de 2014 (Copa do Mundo) e 2016 (Jogos Olímpicos). Este artigo tem como objetivo aplicar critérios de análise de modelos de bicicletas e promover a discussão sobre a qualidade das instalações de bicicletas no oeste do Rio de Janeiro e sua estrutura. As ciclovias e ciclovias da estrada Santa Eugênia, no bairro Paciência, e da avenida Padre Guilherme Decaminada, no bairro Santa Cruz, foram medidas para destacar os problemas reais que estão sendo enfrentados atualmente nos espaços específicos para o uso da bicicleta. Para a análise das condições locais e das ciclovias, foram realizadas excursões de bicicleta. A metodologia utilizada possui dez critérios de benchmarking. Os resultados coletados apontam para boas condições operacionais, mas a falta de conformidade com alguns requisitos mínimos para sinalização, iluminação e manutenção do pavimento de ciclovias. Dessa forma, este estudo contribui para a análise da qualidade das ciclovias na cidade, incentivando a mobilidade urbana sustentável e adotando medidas resilientes para enfrentar a pandemia.

**Palavras chave:** Planejamento Urbano, Instalações para Bicicletas, Mobilidade, resiliência

1 INTRODUCTION

A resilient way that cities can adopt to cope with the COVID 19 pandemic is to offer more space so that people can maintain a safe distance from each other when traveling on foot or by bicycle. The bicycle has been recognized as a transport capable of stopping contagion. But it is also important that the infrastructure dedicated to the circulation of bicycles has adequate conditions.

In the last decades, the use of urban mobility policies by bicycles has gained prominence in the Brazilian scenario, especially in Rio de Janeiro. The history of the Rio de Janeiro cycle routes began in 1991, when the first cycle routes were built from a program to redevelop the seafront known as “Rio Orla” (Rio Seaboard). The program has built 23 km of bicycle lanes designed mainly for leisure. Since 1993, and with the influence of ECO92 (United Nations Conference on Environment and Development), which the city of Rio de Janeiro has hosted, the Municipal Environment Secretariat was created. The city government has incorporated the program "Rio, urban mobility capital by bicycle" into the urban mobility plan of the city as an alternative transportation and as a modal element of transport for short distances with the ability to integrate BRT systems (Bus Rapid Transport), trains and subway. The bicycle plan of the city of Rio de Janeiro had the goal of expanding its extension from 150 km in the year 2009 to 450 km by the end of 2016, a period in which the city received the Mega events such as World Cup 2014 and the 2016 Rio Olympic Games. However, a cycling programme is not only sustained by its extension, and a set of socio-spatial criteria is necessary for its effectiveness. Em termos de extenção de infra estrutura para bicicletas os objetivos não foram atingidos, After the Covid-19 crisis is over, it will be an opportunity to reevaluate urban infrastructure and adopt different strategies in the construction of more sustainable and resilient cities, combating air pollution, carbon emissions and other negative externalities of mobility based on individual motorized transport.
As a sample of existing bicycle infrastructure, the Santa Eugênia Road cycle paths were chosen in the Paciência neighbourhood and Padre Guilherme Decaminada Avenue in the Santa Cruz neighbourhood, both in the western zone of Rio de Janeiro. The west zone of Rio de Janeiro is represented as AP-5 (planning area 5) and comprises five administrative regions with 21 districts distributed in an area of 609.50 km² occupying about 42% of the city's territorial area (IPP, 2013). It is an area of great real estate expansion of the city, where the land use and occupancy patterns are predominantly horizontal and the use of the bicycle is frequent between residents and merchants.

1.1 PADRE GUILHERME DECAMINADA AVENUE

The bicycle system of Av. Padre Guilherme Decaminada is 3.60 km long (Mobility and Culture, 2016), composed of a shared bicycle path in the sidewalk of the neighbourhood functioning as an axis between the train station of Santa Cruz and Avenida Brasil, lighting and signage. It has an intense flow of people due to the services and schools in the surroundings. The flow of cyclists and pedestrians is intense in the cycle path as well as the flow of private vehicles in the neighbourhood.

1.2 SANTA EUGENIA ROAD

The cycle path of the Santa Eugenia Road has similar characteristics, with a 6.00 km extension (Mobility and Culture, 2016) divided between a shared cycle path on the sidewalk and the cycle path. It is located along the intense chain of services, schools and hospitals and goes to the train station of Patience and the station of BRT Santa Eugenia.
2 METHODOLOGY

The present article makes a qualitative analysis of the bicycle paths and bicycle lanes of two important routes for the displacement of the local population. Based on this diagnosis, a critical analysis is carried out in these two routes and their connections with the public transport, focusing on the compliance with the criteria of the bicycle book (nonconformities and suggestions for improvements.

To do this, maps and photos of the research scope were compiled. After this survey of documentation, a search was made for bibliographic references that indicated temporal results of the goals and actions proposed.

From the observed references, the total route of bicycle route was divided into 2 distinct sections with the objective of a specific evaluation for each cycleway analysed. (figure 01 and figure 02)

2.1 STUDY OF THE ROUTE AND SECTION MARKINGS

In possession of the aforementioned maps of the two avenues, the bicycle paths and their facilities were marked with a purple and light blue line. Each extension of the bicycle paths was evaluated as well as small sections due to different conditions along the two avenues.

2.2 METHOD AND MEASUREMENT CRITERIA’S

Based on the research carried out in the theoretical references, it was defined that the "Brazilian Bicycle Mobility Program" and its "Reference Notebook for the elaboration of: Mobility Plan by Bicycle in Cities" indicates the criteria for the elaboration of the collection table for Data and metrics
appropriate to a bicycle system. The main purpose of such table is to raise the situation of these cycle routes following minimum criteria and suggest improvements to expand the connectivity and meet the criteria required in the Brazilian Bicycle Mobility Program.

The table was divided into two topics. The first topic relates the Basic Elements for Projects with the purpose of detailing the criteria for evaluating the quality of the cycle paths of this research. This topic was divided into 10 questions with the objective of evaluating the following criteria: 1 - Geometric Project; 2 - Cyclist Useful Space; 3 - Traffic Moderation - measures for the humanization of the city; 4 - Runs and Tracks of Cyclists; 5 - Intersections and Crossings; 6 - Paving; 7 - Drainage; 8 - Lighting; 9 - Parking for Bicycles; 10 - Bicicletário. The second topic aimed to analyze the integration of the bicycle with the collective modalities in the following points: 1 - bicycle and bus; 2 - bicycle and train; 3 - bicycle in BRT; To measure, the following criteria were adopte

a) The criteria receive a score for each Section The possible punctuation are: Not Conformity (zero point up to 0.59 points), In Conformity, need improvements (0.60 points up to 0.79 points) e In Conformity (0.80 points up to 1.00 point);

b) If the sum of the points attributed to a certain section of cycling route is <0.60 it is considered Non-Conforming the use of bicycles in this place because it does not contemplate 60% of the analyzed criteria; If the sum of the points attributed to a particular section of cycle path is ≥ 0.60 and <0.80, it is considered Partially According to the use of bicycles in this section, since it presents more than 60% of the analyzed criteria, and in this way, there is The need for improvements in order to have the perfect state of use and its connections with the public transport systems evaluated; And if the sum of the points assigned to a given section of cycling track is > 0.8 and ≤ 1.00, the use of bicycles as In Conformity is adopted, since it can reach 80% to 100% of the criteria assessed.

These evaluation criteria were applied during the month of February 2017 in 2 field visits during the morning, afternoon and evening periods. At each start and end point, the bicycles were parked for the appropriate notes. With the notes, it was possible to calculate the ICC (Cycle-Rate Conformity Index) of each of the small sections and then add them using a simple average formula that we will see To follow, to reach the Conformity Index of Decaminada and Santa Eugenia. Thus we will have different notes for each short section evaluated and a general note for each scope of each cycle of the
survey, giving an overview of the conforming and nonconforming conditions of that urban space of the city of Rio de Janeiro.

2.3 ADOPTION OF A BICYCLE CONFORMITY INDEX – BCI

With possession of the notes of each section, by avenue and relating all evaluation criteria, we decided to adopt an Index of Compliance with the Brazilian Bicycle Mobility Program with the necessary adaptations for an adequate assessment. The adapted weighted average formula was chosen to facilitate readers' understanding and is also applied to large works contracts in Brazil and the city of Rio de Janeiro, and is accepted by fiscal audit courts.

$$BCI=\left(\sum\text{Basic Project Elements Criteria Applicable} \times 8 + \sum\text{Integration Criteria with collective modals Applicable} \times 2\right)/10$$

2.4 THE EVALUATION CRITERIA

The selected criteria were taken from the Brazilian Bicycle Mobility Program in chapters 3 and 4. The topic lists the Basic Elements for Projects has the following criteria:

**Geometric design** - the arrangements and dimensions of bicycle spaces will always depend on five factors, namely: the minimum dimensions required for the safe circulation of bicycles; The remnants of spaces or the rearrangements of parts or all of the existing roads, converting to the bicycles a slice of the road system; The creativity of designers by combining techniques with existing opportunities in urban spaces, adapting them to the needs of cyclists.

**Useful space of the cyclist** - the standard bicycle in Brazil has a longitudinal dimension of about 1.75 m. The width of 1.00 m results from the width of the handlebar (0.60 m), plus the space required for the movement of the arms and legs (0.20 m on each side). The template to be adopted, however, for safety measures, shall be higher by 0.25 m in height and on each side, in order to maintain the cyclists' balance. (Brazilian Bicycle Mobility Program, page 99.)

**Traffic moderation** - measures for humanization of the city As a measure of moderation of traffic directed to the circulation of bicycles, it is recommended to use cycle paths near the bed of the collecting ways. Corner radius reduction; • Change of texture and color of the lining of the cycle lane; • Adoption of central islands separating flows; • Demarcation of crosswalk;

**Cycle lanes and lanes** - Cycle lanes are dedicated to the exclusive circulation of bicycles, separated from the other runways by embankment, with a minimum of 0.20 m of unevenness, which is usually higher than the car lane Motorized. In the road system, it can be located along the central bed or on the sidewalks. Bicycle lanes is the space destined to the circulation of bicycles, contiguous
to the raceway of automotive vehicles, being separated of it by painting and / or devices limited
denominated of tacks by the Brazilian Transit Code.

*Intersections and crossings* - Will be evaluated in the crossings: the Circulation Channelized in
Crossings with Ample Side Space, Circulation with Little Side Space, Shared Circulation, Upper
Crossings. Rotary - Roundabouts are considered by many experts dangerous for pedestrians and
cyclists. However, this concept has to be relativized, according to their sizes and positions in the
territory of a city or region. Rotates with inclusion of special spaces for the bicycle In Brazil it is still
not common.

*Paving* - The basic requirements for a bicycle lane in relation to the pavement are as follows:
the rolling surface must be regular, waterproof, non-slip and, if possible, pleasant in appearance. Due
to the close proximity of the bicycle lane with the pedestrian walk, it is desirable that the surface of
the bicycle lane and that of the lane be visually differentiated so that there is no invasion of the bicycle
path by the pedestrian as well as the invasion of the ride by the cyclist. Cycle paths are not subjected
to great efforts, Requiring a larger structure than that used for pedestrian routes

*Drainage* - The drainage of the bicycle lanes should be as natural as possible, taking advantage
of the topography of the site, thus avoiding the installation of sophisticated networks for the drainage
of rainwater. When there is greater freedom of tracing (especially on leisure cycle routes), cuts and
embankments should be avoided, as soil movements always create some drainage problems that
imply erosion or need for clearing. The position of the lobes in the mouth of a wolf is an important
aspect regarding the safety of the cyclists, referring to the drainage in cycle paths, cycle paths or
routes where there is bicycle traffic. Considering that the size of adult bicycle wheels is greater than
0.60m, the space between the closing transverse bars being less than 0.50m will prevent their falling
into the drainage area.

*Illumination* - When using poles of the existing electrical network, it is recommended to place
metal rods in a lower position than is normally used for illumination of the entire track. The height
should be between 2.60m and 3.20m, making access to the luminaire difficult for anyone without the
use of stairs or other elements that raise their height.

### 3 EVALUATION OF RESULTS

Cycle routes and cycle routes of the Santa Eugênia Road in the Paciência neighbourhood, BCI
= 0.61 STATUS = In Conformity, with suggestions for improvements.
Table 1 - BCI Santa Eugenia Road

| Santa Eugênia Road divided into sections | BCI = 0.61 |
|----------------------------------------|-----------|
| Section 2.1                             | 0.63      |
| Section 2.3-2.5                         | 0.67      |
| Section 2.6-2.13                        | 0.66      |
| Section 2.14                            | 0.67      |
| Section 2.15                            | 0.59      |

Source: Own authorship

Comments and results of the criteria

Geometric Design

Average = 1.0 - Conformed
Technical comment: Safe circuits and allow the visualization of the section to be covered.

Useful space of the cyclist
Average = 0.75 - Conformity, needs improvement.
Technical comment: The minimum dimensions of 1.20 required for circulation are respected, but in some cases the pedestrian walkway suffers bottlenecks

Traffic moderation
Average = 0.60 - Conformity, needs improvement.
Technical comment: There is a lack of elements for the reduction of the turning radius of corners and signalling on the bicycle lane. As well as a more objective demarcation in relation to the pedestrian range

Cycle tracks and tracks
Average = 0.60 - Conformity, needs improvement.
Technical comment: There are excerpts where the boundary between cyclist and sidewalk lanes are not well delimited.

Intersections and crossings
Average = 0.60 - Conformity, needs improvement.
Technical comment: In Brazil it is still not common crossings with satisfactory safety conditions for the rider. In the evaluated sections they are restricted to the end of the pivot radius.

Paving
Average = 0.65 - Conformity, needs improvement.
Technical Comment: Paving is either precast concrete or concrete block, both suitable. But the conservation is irregular. Leveling for crossing is the most critical point

. Drainage
Average = 0.62 - Conformity, needs improvement.
Due to the irregular state of conservation of the pavement, imperfections and unevenness, the water flow is compromised creating areas and allowing the growth of unwanted vegetation.

. Lighting
Average = 0.60 - Conformity, needs improvement.
Technical comment: illumination is interrupted or compromised by existing vegetation

. Bicycle parking
Average = 0.61 Conformity requires improvement.
Technical comment: Bicycle stands are public and can be found mainly near public buildings or near corners. Along the stretches there is no presence of bicycle lifts

. Connectivity to public transport
Average = 0.38 - Not in conformity

| Padre Guilherme Decaminada Avenue divided into sections | BCI = 0.67 |
|--------------------------------------------------------|------------|
| Section 1.1                                            | 0.74       |
| Section 1.2                                            | 0.82       |
| Section 1.3                                            | 0.77       |
| Section 1.4                                            | 0.78       |
| Section 1.5-1.6                                        | 0.76       |
| Section 1.7                                            | 0.84       |
| Section 1.8                                            | 0.77       |
| Section 1.9                                            | 0.75       |
| Section 1.10                                           | 0.60       |

Source: Own authorship

Comments and results of the criteria

. Geometric Design
Average = 1.0 - Conformed
Technical comment: Safe circuits and allow the visualization of the section to be covered.

- Useful space of the cyclist
  Average = 0.78 - Conformity, needs improvement.

Technical comment: The minimum dimensions of 1.20 required for circulation are respected, but in some cases the pedestrian walkway suffers bottlenecks

- Traffic moderation
  Average = 0.67 - Conformity, needs improvement.

Technical comment: There is a lack of elements for the reduction of the turning radius of corners and signalling in the sections in bicycle-band

- Cycle tracks and tracks
  Average = 0.65 - Conformity, needs improvement.

- Intersections and crossings
  Average = 0.64 - Conformity, needs improvement.

Technical comment: In Brazil it is still not common crossings with satisfactory safety conditions To the cyclist. In the sections evaluated, they are limited to the distance at the end of the turning radius of the pavement

- Paving
  Average = 0.80 - Conformity.

Technical Comment: Paving is either precast concrete or concrete block, both suitable. But conservation is irregular.

- Drainage
  Average = 1.0 - Conformity.

The blocking paving in some sections works with a drainage element.

- Lighting
  Average = 0.75 - Conformity, needs improvement.

Technical comment: Crossings have irregular lighting

### 4 CONCLUSION

By the methodology applied, the bicycle system of the Estrada Santa Eugenia reached an BCI = 0.61 and the Padre Guilherme Decaminada Avenue an BCI = 0.67. Both are compliant with the applicables criterias, but need improvements mainly in connectivity with modal systems and safety of crossings. It is necessary to adapt the train stations for the handling of bicycles, and to create bicycle stands with an infrastructure that can attend to the cyclist needs and secure the bicycle. The parameters established for analysis are physical and infrastructure and establish direct influence on
the choice of the bicycle as an element of mobility. The results presented in this article highlight the need to expand research on public policies adopted in the city of Rio de Janeiro to transform the bicycle into a resilient form of urban mobility that helps fight pandemics such as COVID 19.

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