Establishing Criteria and Thresholds for Bicycle Facility Selection on NCDOT Roadways

NCDOT Technical Assistance 2024-05
FHWA/NC/2024-05
December 2023

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STATE OF NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

RESEARCH & DEVELOPMENT

Technical Report Documentation Page

1. Report No. Technical Assistance FHWA/NC/2024-05	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle Establishing Criteria and Thresholds for Bicycle Facility Selection on NCDOT Roadways		5. Report Date December, 2023
		6. Performing Organization Code
7. Author(s) Seth LaJeunesse Dan Gelinne		8. Performing Organization Report No.
9. Performing Organization Name and Address Highway Safety Research Center University of North Carolina at Chapel Hill 730 MLK Blvd. #300 Chapel Hill, NC 27514		10. Work Unit No. (TRAIS)
		11. Contract or Grant No.
12. Sponsoring Agency Name and Address North Carolina Department of Transportation Research and Development Unit 1549 Mail Service Center Raleigh, North Carolina 276699-1549		13. Type of Report and Period Covered Final Report October 1, 2023 – December 31, 2023
		14. Sponsoring Agency Code FHWA/NC/TA2024-05

Supplementary Notes:

16. Abstract

This memo was developed in response to a request for technical assistance from District Engineer on determining thresholds for the types of bicycle facilities permissible on NCDOT-owned corridors. Given the evidently growing desires of municipalities to provide bicycle facilities in coordination with NCDOT's maintenance resurfacing schedule, it seems wise to establish a more standardized, uniform approach to bike facility provision across the state of North Carolina. However, NCDOT's resurfacing program does not provide funding beyond those obligated to resurfacing and restriping roadways; thus, funding for more substantive bicycle facilities becomes the responsibility of local agencies.

This memo provides a targeted literature review on the safety performance of various vertical bike elements, a summary of interviews with key informants from municipalities, MPOs, and NCDOT Divisions, and guidance on selecting context-appropriate vertical elements, and entering into arrangements with local agencies on the type of facility to provide and the agreed upon timeline to provide it.

17. Key Words Bicycle, Planning	18. Distribution Statement		
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 8	22. Price

Form DOT F 1700.7 (8-72) **Reproduction of completed page authorized**

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THE UNIVERSITY OF NORTH CAROLINA
HIGHWAY SAFETY RESEARCH CENTER

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Date: December 19, 2023

To: John Sandor, NCDOT District Engineer

From: Seth LaJeunesse and Dan Gelinne, Senior Research Associates at the UNC Highway Safety Research Center

Subject: NCDOT Division 5 Technical Assistance Request

This memo was developed in response to a request for technical assistance from District Engineer, John Sandor on determining thresholds for the types of bicycle facilities permissible on NCDOT-owned corridors. Given the evidently growing desires of municipalities to provide bicycle facilities in coordination with NCDOT's maintenance resurfacing schedule, it seems wise to establish a more standardized, uniform approach to bike facility provision across the state of North Carolina. However, NCDOT's resurfacing program does not provide funding beyond those obligated to resurfacing and restriping roadways; thus, funding for more substantive bicycle facilities becomes the responsibility of local agencies.

This memo provides a targeted literature review on the safety performance of various vertical bike elements, a summary of interviews with key informants from municipalities, MPOs, and NCDOT Divisions, and guidance on selecting context-appropriate vertical elements, and entering into arrangements with local agencies on the type of facility to provide and the agreed upon timeline to provide it.

1. Summary of Literature

The first task involved carrying out a targeted literature review of empirical studies that have examined the safety effects of various classes of bicycle facilities (e.g., shared lane markings, striped bike lanes, flexible and inflexible posts, barriers, and on-street parking, and multi-use paths).

Developing Crash Modification Factors for Separated Bicycle Lanes

Dixon, Avelar-Moran, and Seyedeh (2023) established crash modification factors for separated bike lanes, demonstrating that these facilities (with a variety of vertical element types) can reduce bicyclist crashes by **44 to 60 percent**.[i] A table of the CMFs developed is

presented below (Table 66 in the research report), demonstrating the effectiveness of transforming traditional or buffered bicycle lanes into different types of separated bike lanes.

Significance Level	Before Condition	After Condition	CMF	Standard Error
.01	Traditional Bicycle Lane	SBL with Flexible Posts	0.498	0.173
.01	Flush Buffered Bicycle Lane	SBL with Flexible Posts	0.441	0.297
.01	Traditional or Flush Buffered Bicycle Lane	SBL with Flexible Posts	0.468	0.267
.05	Traditional Bicycle Lane	SBL with Blend of Flexible Posts and Other Vertical Elements	0.640	0.203
.05	Flush Buffered Bicycle Lane	SBL with Blend of Flexible Posts and Other Vertical Elements	0.567	0.253
.05	Traditional or Flush Buffered Bicycle Lane	SBL with Blend of Flexible Posts and Other Vertical Elements	0.602	0.212

The study did not develop CMFs or present other findings about safety performance based on other factors like speed limit, traffic volume, or functional classification.

Among the CMF results that were presented, but not significant:

“results indicate that flexible posts separation is linked with a lower risk of bicycle crashes compared to the three base conditions without SBLs. Similarly, either flexible posts or blended separation is linked with a lower risk for bicycle crashes compared to the three base conditions without SBL” (p. 97).

Guidance for Separated/Buffered Bike Lanes with Delineators

Hourdos, Duhn, Dirks, and Lindsey (2021) examined separated bike lanes through interviews with practitioners and advocates, and survey responses from the broader bicycling community in Minnesota.[ii] Each set of interview/survey findings details practitioner, advocate, and bicyclist preferences and perspectives about different vertical element types. These most often focused on were flexposts (flexible delineators), sidewalk-level separated bike lanes, curb separated bike lanes, and concrete barriers. At the end of the report, Table 9-1 presents “considerations and tradeoffs for four buffer designs,” which include (1) solid barrier, (2) intermittent barrier, (3) curb and intermittent barrier, and (4) grade separation. They are presented in terms of their relative feasibility, safety performance, interactions with other road users, costs, maintenance considerations, and other factors (e.g., accessibility).

Not All Protected Bike Lanes Are the Same: Infrastructure and Risk of Cyclist Collisions and Falls Leading to Emergency Department Visits in Three U.S. Cities

Cicchino and colleagues (2020) examined safety performance of different types of bicycle facilities and looked specifically at separated bike lanes with various configurations and vertical elements.[iii] Vertical elements were categorized as

- "light separation" (transient [parked cars], noncontinuous [posts, parking stops], short [continuous low curb], and/or did not provide horizontal separation [raised lane immediately adjacent to the road]); or
- "heavy separation" (tall, continuous barriers [bridge rails, tall concrete barriers or walls], or lanes at sidewalk-level that were also separated horizontally from the road).

The risk of crashing or falling, resulting in injury, was elevated in conditions with light separation, especially in a two-way configuration, compared to roadways with no bicycle facilities.

2. Interviews

The second task involved conducting semi-structured interviews with North Carolina-based municipal, regional, and division transportation engineering and planning professionals. The purpose of these interviews was to discern how practitioners make bicycle facility provision decisions; any safety studies they have conducted before and after installing bicycle facilities; and their willingness and intentions to invest in more substantive, protective bicycle facilities in coordination with scheduled maintenance resurfacing projects.

The following individuals/agencies were contacted for interviews:

- City of Charlotte DOT
- City of Wilmington
- Wilmington MPO
- City of Asheville
- NCDOT Divisions 11 & 12
- Greensboro MPO
- Town of Chapel Hill

3. Guidance

The third and final task entailed developing research- and interview-supported guidance on ways to negotiate discussions around providing bicycle infrastructure in conjunction with resurfacing projects. One proposed goal of this guidance was to establish a "minimum facility threshold" given certain geometric (e.g., available space) and operational (e.g., operating speeds, speed differentials, conflict densities). Another goal of the guidance was to propose additional resurfacing agreement parameters, such as municipalities agreeing to upgrade current bicycle facilities (e.g., a buffered bike lane) to one with inflexible posts (e.g., bollards) within one or two years of the resurface completion.

Bicycle Facilities and Vertical Separation by Functional Classification, Speed, Volume

In the published guidance on the topic, professionals provide specific bicycle facility recommendations and design thresholds for collector, minor, and major arterial roadway

types. This follows general guidance provided by FHWA in their Bikeway Selection Guide[iv], which established general thresholds for moving from a shared lane to standard bike lanes, buffered bike lanes, and then separated bike lanes or shared use paths as speed and volume increase.

- **Collectors:**
  - Speeds </= 30 mph
  - 9 ft lanes
  - 5-6 ft painted bike lane
- **Minor Arterials:**
  - Speeds > 30 mph
  - Separated bike lane with flexible delineator and buffer (at minimum)
- **Major Arterials:**
  - Speeds > 35/40 mph?
  - Separated bike lane with "higher tier" vertical element

An organizing goal across functional classifications is to render the entire road network "self-explaining" or "self-enforcing." The "uniform approach" to installing context-appropriate bicycle facilities in North Carolina could align with the self-explaining roads design paradigm, whereby collector roads look and function similarly to all other collectors in the state, yet differently from minor and major arterials. Minor arterials, on the other hand, should look and function similarly to all other minor arterials in the state, yet differently from collectors and major arterials, and so forth. Establishing minimum bike provision design standards for the functional classes would bring North Carolina closer to creating self-explaining/enforcing road networks, which holds promise to significantly reduce operating mistakes and traffic injuries.[v]

Considerations for "higher tier" vertical elements:

There are numerous factors to consider when selecting a "higher tier" vertical element, beyond a flexible delineator or bollard. Much of this is drawn from the to-be-published FHWA resource, *Separated Bike Lanes on Higher Speed Roads: A Toolkit and Guide.*

- **Cost:**
  - Flexible delineators and parked vehicles tend to be the least expensive options.
  - Heavy planters can be placed in the buffer space for a more significant vertical element, albeit one that cannot be installed in a continuous manner.
  - Parking stops can be installed as a low, continuous barrier, and are relatively inexpensive.
  - Concrete barriers (e.g., jersey barriers) and raised medians/curbs are more costly but offer more substantial protection for cyclists. Agencies also need to factor in the cost of crash cushions/end treatments where the barrier is exposed to turning traffic.
  - Grade-separated (raised) bike lanes tend to be the most expensive option.
- **Maintenance:**
  - Maintenance of the vertical element itself should be less of an issue with a heavier form of separation than with flexible delineators.

    - Issues can arise with respect to stormwater and collection of debris in the bike lane.
- **Width Requirements:**
    - Raised curb, raised lanes, and parking stops are low-profile solutions that require only two feet (or less) of buffer width.
    - Flexible delineators, bollards and concrete barriers typically require 3 feet of buffer space.
    - Parking lanes require 7 to 8 feet.

Vertical element selection and transition period

In conversations with local agencies, it seems that most are choosing to implement flexible delineators within the buffer area to create separated bike lanes. Despite maintenance concerns, these are often the least expensive option compared to other vertical elements. In some cases, especially where operating speeds are 30 mph or lower, research suggests that flexible delineators can be a safe option.[i] As travel speeds increase, however, agencies may begin looking toward other types of vertical elements that offer more substantial, reliable protection for bicyclists.

A main challenge is how to handle situations where a separated bike lane can be implemented through regular resurfacing of a State-owned roadway. On minor and major arterial streets, the end goal should be to utilize a more substantial vertical element, beyond the protection provided by a flexible delineator. However, these are typically much more expensive and require a greater financial commitment from the local agency. It is recommended that NCDOT and the local agency develop an agreement to initially install flexible delineators on arterial roadways with the understanding that they will be replaced by a higher-tier vertical element within an agreed upon period of time, such as 18 months. This would allow local agencies time to include vertical element funds in their municipal budgets.

To address the issue of financing the higher-tier vertical elements, NCDOT could work with local agencies to determine whether the cost of these vertical elements could be supported by STIP or SPOT Safety funds. This could involve flagging these projects in a way that elevates their priority when projects are ranked and selected for funding.

Funding arrangements to secure “higher tier” separation

One last arrangement to explore is whether it would be possible for NCDOT to procure and deliver some of the higher tier forms of separated bike lane vertical elements for local communities, who could then reimburse NCDOT. For example, NCDOT can likely procure jersey barriers at a lower cost than what a public agency would pay for the same treatment.

In summary, and based on a focused literature review and interviews with key informants, we recommend that NCDOT Division and District engineers:

- Align approvals for the local provision of bicycle facilities based on resurfaced roadways’ a) functional classification, b) operating speeds, and c) traffic volumes, with minor and major arterials roadway receiving more substantial vertical elements.

- Develop agreements with local agencies to initially install flexible delineators on arterial roadways with the understanding that they will be replaced by a higher-tier vertical element within an agreed upon period of time, such as 18 months.

- Determine whether the cost of higher tier vertical elements could be supported by STIP or SPOT Safety funds and consider privileging these projects' priority in project rankings.

- NCDOT could consider establishing and operating a reimbursement procedure, whereby NCDOT procures and delivers higher tier forms of separated bike lane vertical elements for local communities, who then reimburse NCDOT.

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[i] Dixon, K., Avelar-Moran, R., & Seyedeh, M. M. (2023). *Developing crash modification factors for separated bicycle lanes (No. FHWA-HRT-23-078)*. United States. Federal Highway Administration. Office of Safety Research and Development. Retrieved from https://rosap.ntl.bts.gov/view/dot/71847.

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