Green Stripe Pavement Markings Adjacent to Edgeline

Requested by
Rachel Carpenter, Division of Traffic Operations

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The Caltrans Division of Research, Innovation and System Information (DRISI) receives and evaluates numerous research problem statements for funding every year. DRISI conducts Preliminary Investigations on these problem statements to better scope and prioritize the proposed research in light of existing credible work on the topics nationally and internationally. Online and print sources for Preliminary Investigations include the National Cooperative Highway Research Program (NCHRP) and other Transportation Research Board (TRB) programs, the American Association of State Highway and Transportation Officials (AASHTO), the research and practices of other transportation agencies, and related academic and industry research. The views and conclusions in cited works, while generally peer reviewed or published by authoritative sources, may not be accepted without qualification by all experts in the field. The contents of this document reflect the views of the authors, who are responsible for the facts and accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the California Department of Transportation, the State of California, or the Federal Highway Administration. This document does not constitute a standard, specification, or regulation. No part of this publication should be construed as an endorsement for a commercial product, manufacturer, contractor or consultant. Any trade names or photos of commercial products appearing in this publication are for clarity only.

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Executive Summary

Background

Caltrans is planning to seek experimental approval from the California Traffic Control Devices Committee (CTCDC) and the Federal Highway Administration (FHWA) to use green stripe pavement markings to guide bicyclists on approved bike routes where bicycle facilities may not have been implemented. These markings would be placed directly next to a white edgeline with no gaps, to guide bicyclists along bike routes without an exclusive bicycle lane. The green stripe is not a dedicated cycling facility, but a pavement marking that can have a variety of uses to support a complete bikeway network, acting to alert road users to the presence of bicycles on the roadway. It may also be configured to offer directional and wayfinding guidance for cyclists.

Prior to experimentation, Caltrans was interested in obtaining information on any comparable pavement markings that have either been studied through peer-reviewed processes, are under experimentation by other states or local agencies, or are used in other countries.

To assist with this information need, CTC & Associates:

- Conducted a literature review on the implementation of green stripe pavement markings (or similar pavement markings) nationally and internationally.
- Conducted a survey of state departments of transportation (DOTs) concerning their use of green stripe or similar pavement markings, using as a contact list the AASHTO Subcommittee on Traffic Engineering (http://scote.transportation.org/Pages/Members.aspx).
- Consulted with national experts at FHWA.

Summary of Findings

Consultation with National Experts

According to Dave Kirschner of the FHWA Manual on Uniform Traffic Control Devices (MUTCD) Team, his office has received only two informal requests to experiment with designs similar to Caltrans' proposed green stripe pavement markings, and those requests were denied. Interim Approval 14 under the MUTCD specifies that green-colored pavement shall be used only within bike lanes and bike lane extensions.

Traffic Engineer Kevin Korth noted that FHWA is accepting proposals for the use of green-colored pavement in conjunction with shared-lane markings, and he suggested that Caltrans submit a proposal for green stripe markings. Kirschner said such a request would not be automatically denied, since Caltrans' green stripe markings seem intended for wayfinding rather than to outline bike lanes as other agencies have requested. He said Caltrans' proposal would need to clearly explain how these markings would improve on a deficiency in the currently compliant devices.

Survey of Transportation Agencies

- Thirty-five transportation agencies responded to our survey. None had used green stripe or similar pavement markings.

- Several agencies noted that they use green pavement markings in accordance with MUTCD Interim Approval 14:
    - Colorado DOT has used green paint only to mark a bike lane passing through an intersection or to identify a conflict area for a bike lane.
    - The city of Chicago uses green-colored bike lanes.
    - Michigan DOT uses green boxes within designated bike lanes in advance of or within traffic crossing locations (see Appendix B for a picture).
    - The city of Minneapolis has been utilizing green pavement for a few years for bicycle lanes and bike boxes.
    - Asheville and Chapel Hill, North Carolina, are interested in using green pavement for bike lanes.
    - Oregon DOT and some Oregon cities have tended to use sharrows (shared-lane arrow pavement markings) or signs for the purpose of alerting motorists to the presence of bikes on the roadway, and in Oregon green-colored pavement has mostly been used to highlight bike-car conflict points.
    - Rhode Island DOT has plans to use green pavement in bicycle lanes.

Related Resources

We did not find any research or resources directly related to the use of green stripe pavement markings. This Preliminary Investigation contains a selection of the literature available on bicycle facility pavement markings, including FHWA and AASHTO guidance, international guidance, and research on shared-lane pavement markings.

Gaps in Findings

We did not identify any transportation agencies that had used green stripe pavement markings, and did not find any research or resources directly related to the use of green stripe pavement markings nationally or internationally. These results are consistent with FHWA's rejection of two informal requests to experiment with similar pavement markings, and it seems likely that such markings have not been used in the United States.

Next Steps

Moving forward, Caltrans could consider:

- Contacting Broward County, Florida, about its inquiry to the FHWA MUTCD Team about green stripe pavement markings.
- Surveying European transportation agencies concerning their use of green stripe pavement markings.

Detailed Findings

Consultation with National Experts

We asked the FHWA MUTCD Team about whether state departments of transportation had requested experimental use of green stripe or similar pavement markings.

FHWA

Contacts:

- Dave Kirschner, Transportation Specialist, MUTCD Team, Federal Highway Administration, 202-366-6054, david.kirschner@dot.gov.
- Kevin Korth, Traffic Operations Engineer, California Division, Federal Highway Administration, kevin.d.korth@dot.gov.

Kirschner is the member of the MUTCD Team responsible for Part 9 of the manual, which covers bicycle facilities.

Interim Approval 14 (issued under the 2009 MUTCD) specifies that green-colored pavement shall be used only within bike lanes and bike lane extensions. Any other use would require an approved experiment. (See http://mutcd.fhwa.dot.gov/resources/interim_approval/ia14/index.htm for MUTCD Interim Approval 14.)

Kirschner said the MUTCD Team has received two requests to experiment with designs similar to Caltrans' proposed green stripe, and those requests were denied. Because these requests were informal and didn't receive a formal denial letter, Kirschner was unable to recall which transportation agencies made these requests. Also, in response to an inquiry by a resident, Broward County, Florida, asked the MUTCD Team if any states or localities had implemented a similar design.

In a follow-up exchange, Korth noted that FHWA is again reviewing proposals for the use of green-colored pavement in conjunction with shared-lane markings (see http://www.fhwa.dot.gov/environment/bicycle_pedestrian/guidance/mutcd/gcp_slm.cfm) and suggested that Caltrans submit a proposal. Korth said there is no current experiment involving green stripe markings.

Kirschner noted that such a request to experiment would differ from previously requested uses of green line markings because Caltrans' proposed use seems intended as a wayfinding or route identification tool. In evaluating a request to experiment, Kirschner said one thing FHWA weighs heavily is the potential for a new device or modification of an existing device to improve on a deficiency of the currently compliant devices. He posed the question: How would this fill in gaps or make up for shortcomings of the currently compliant wayfinding signing scheme for bike routes? Because Caltrans' application would be for this specific purpose rather than using green line markings to outline a bike lane as was previously requested, Kirschner said the request would not necessarily be automatically denied based on earlier precedents. He said FHWA would need a clear explanation of why green stripe markings would be an improvement, how that improvement would be measured, and road users' understanding of the markings.

Survey of Transportation Agencies

We surveyed members of the AASHTO Subcommittee on Traffic Engineering (http://scote.transportation.org/Pages/Members.aspx) by email. Questions were as follows:

1. Does your agency use **green stripe pavement markings** placed directly next to a white edgeline with no gaps (**or similar pavement markings**) to guide bicyclists along bike routes without an exclusive bicycle lane? (The green stripe is not a dedicated cycling facility, but a pavement marking that can have a variety of uses to support a complete bikeway network, acting to alert road users to the presence of bicycles on the roadway. It may also be configured to offer directional and wayfinding guidance for cyclists.)

If yes to (1):

2. Where have these pavement markings been implemented?
3. Please provide, if available, relevant specifications, design guidance, or other documentation for these markings.
4. Can you provide information on the cost and effectiveness of these markings compared to shared lane markings?
5. Do you have any data (including before-and-after studies) on the effect of these markings on safety?

Summary of Survey Results

Thirty-five transportation agencies responded to our survey. None had used green stripe or similar pavement markings. Several agencies noted that they have used green pavement markings in accordance with MUTCD Interim Approval 14:

- Colorado DOT has used green paint only to mark a bike lane passing through an intersection or to identify a conflict area for a bike lane.
- The city of Chicago uses green-colored bike lanes.
- Michigan DOT uses green boxes within designated bike lanes in advance of or within traffic crossing locations (see Appendix B for a picture).
- The city of Minneapolis has been utilizing green pavement for a few years for bicycle lanes and bike boxes.
- Asheville and Chapel Hill, North Carolina, are interested in using green pavement for bike lanes.
- Oregon DOT and some Oregon cities have tended to use sharrows (shared-lane arrow pavement markings) or signs for the purpose of alerting motorists to the presence of bikes on the roadway. In Oregon, green-colored pavement has mostly been used to highlight a bike-car conflict point.
- Rhode Island DOT has plans to use green pavement in bicycle lanes.

Survey Results

The full text of each survey response is provided below. For reference, an abbreviated version of each question is included before the response. Responses have been edited for clarity.

Alabama Department of Transportation

Contact: Kerry C. NeSmith, Deputy Bureau Chief, Maintenance Bureau, 334-242-6777, nesmithk@dot.state.al.us.

1. **Green stripe pavement markings or similar:** No. To my knowledge, I am not aware of any use of a green stripe as described below in our state.
2. **Where implemented:** N/A.
3. **Specifications/guidance:** N/A.
4. **Cost/effectiveness:** N/A.
5. **Safety data:** N/A.

Alaska Department of Transportation and Public Facilities

Contact: Jeff C. Jeffers, Statewide Traffic & Safety, 907-465-8962, jeff.jeffers@alaska.gov.

1. **Green stripe pavement markings or similar:** No. Alaska has not used green pavement to denote bike lanes or for other uses, such as supplementary striping. With respect to the bike lane color, we have been concerned with durability of the colored pavement as well as maintaining skid resistance. We plow a lot of snow and have experienced these issues with durable white markings at crosswalks and symbols affecting motorcyclists.
2. **Where implemented:** N/A.
3. **Specifications/guidance:** N/A.
4. **Cost/effectiveness:** N/A.
5. **Safety data:** N/A.

Arizona Department of Transportation

Contact: Richard C. Moeur, Traffic Standards Engineer, 602-712-6661, RMoeur@azdot.gov.

1. **Green stripe pavement markings or similar:** No. This is the first I've heard of this marking. Arizona DOT's Bicycle Policy states that bicycle facility markings on a state highway should not be installed unless a local agency has agreed to assume the costs of maintaining all signs and markings for such a facility. To my knowledge, no local agency has asked for this treatment on a state highway, or installed it on their own facilities. This treatment does not also seem to be within the scope of approved uses for green markings under the current MUTCD Interim Approval, so FHWA experimental approval would be needed prior to installation.
2. **Where implemented:** N/A.
3. **Specifications/guidance:** N/A.
4. **Cost/effectiveness:** N/A.
5. **Safety data:** N/A.

Arkansas Department of Transportation

Contact: John Mathis, Maintenance, 501-569-2658, John.Mathis@ahtd.ar.gov.

1. **Green stripe pavement markings or similar:** No. We do not use green stripes in Arkansas, nor are there any plans do so at this time.
2. **Where implemented:** N/A.
3. **Specifications/guidance:** N/A.
4. **Cost/effectiveness:** N/A.
5. **Safety data:** N/A.

Colorado Department of Transportation

Contact: Ken Brubaker, Bicycle and Pedestrian Facility Engineer, 303-757-9804, kenneth.brubaker@state.co.us.

1. **Green stripe pavement markings or similar:** No. Although I won't guarantee there is not a situation similar to the one you describe above somewhere in Colorado, it is not CDOT policy to use green paint in the manner you describe. CDOT allows the use of green paint when it conforms to the interim approval issued by the FHWA (IA-14). This approval states that green paint can be used to delineate conflict areas or to extend a bicycle lane through an intersection and notes that the use of green paint should apply to marked bicycle lanes only. To my knowledge, we have not used green paint other than to mark a bike lane through an intersection or to identify a conflict area for a bike lane, an example being the conflict area which is created when a right-turn lane is developed where there is a through bicycle lane. CDOT would also allow green paint to be used for a bike box or a two-stage turn box. But again, these would be on marked bicycle facilities. We also do not encourage green paint to be used to provide way-finding assistance to bicyclists.
2. **Where implemented:** N/A.
3. **Specifications/guidance:** N/A.
4. **Cost/effectiveness:** N/A.
5. **Safety data:** N/A.

Delaware Department of Transportation

Contact: Mark Luszcz, Chief Traffic Engineer, 302-659-4062, mark.luszcz@state.de.us.

1. **Green stripe pavement markings or similar:** No.
2. **Where implemented:** N/A.
3. **Specifications/guidance:** N/A.
4. **Cost/effectiveness:** N/A.
5. **Safety data:** N/A.

Georgia Department of Transportation

Contact: Katelyn DiGioia, State Bicycle and Pedestrian Engineer, Office of Traffic Operations, 404-635-2834, kdigioia@dot.ga.gov.

1. **Green stripe pavement markings or similar:** No.
2. **Where implemented:** N/A.

3. **Specifications/guidance:** N/A.
4. **Cost/effectiveness:** N/A.
5. **Safety data:** N/A.

Illinois Department of Transportation

Contact: Kyle D. Armstrong, Acting Engineer of Traffic Operations, Bureau of Operations, 217-782-2076, Kyle.Armstrong@illinois.gov.

1. **Green stripe pavement markings or similar:** No. I am not aware of any installations in Illinois of green stripe pavement markings directly adjacent to standard pavement markings. The city of Chicago has utilized the interim-approved green-colored bike lanes, but not green pavement markings.
2. **Where implemented:** N/A.
3. **Specifications/guidance:** N/A.
4. **Cost/effectiveness:** N/A.
5. **Safety data:** N/A.

Iowa Department of Transportation

Contact: Timothy Crouch, State Traffic Engineer, Office of Traffic and Safety, 515-239-1513, Tim.Crouch@dot.iowa.gov.

1. **Green stripe pavement markings or similar:** No.
2. **Where implemented:** N/A.
3. **Specifications/guidance:** N/A.
4. **Cost/effectiveness:** N/A.
5. **Safety data:** N/A.

Kansas Department of Transportation

Contact: Mike Floberg, Bureau of Traffic Safety and Technology, 785-296-7431, floberg@ksdot.org.

1. **Green stripe pavement markings or similar:** No. We have not experimented with green pavement markings yet. I have attached a memo to Wyandotte County regarding green pavement but not green pavement markings. [See Appendix A.]
2. **Where implemented:** N/A.
3. **Specifications/guidance:** N/A.
4. **Cost/effectiveness:** N/A.
5. **Safety data:** N/A.

Kentucky Transportation Cabinet

Contact: Jeff Wolfe, Division of Traffic Operations, 502-564-3020, Jeff.Wolfe@ky.gov.

1. **Green stripe pavement markings or similar:** No.
2. **Where implemented:** N/A.
3. **Specifications/guidance:** N/A.
4. **Cost/effectiveness:** N/A.
5. **Safety data:** N/A.

Louisiana Department of Transportation and Development

Contact: Jody Colvin, Traffic Engineering Division Administrator, 225-242-4635, jody.colvin@la.gov.

1. **Green stripe pavement markings or similar:** No.
2. **Where implemented:** N/A.
3. **Specifications/guidance:** N/A.
4. **Cost/effectiveness:** N/A.
5. **Safety data:** N/A.

Manitoba Infrastructure

Contact: Glenn A. Cuthbertson, Director, Traffic Engineering, 204-945-0329, Glenn.Cuthbertson@gov.mb.ca.

1. **Green stripe pavement markings or similar:** No.
2. **Where implemented:** N/A.
3. **Specifications/guidance:** N/A.
4. **Cost/effectiveness:** N/A.
5. **Safety data:** N/A.

Maryland State Highway Administration

Contact: Cedric Ward, Director, Office of Traffic & Safety, 410-787-5814, CWard@sha.state.md.us.

1. **Green stripe pavement markings or similar:** No. The Maryland State Highway Administration has not yet started to use green pavement markings to denote bike facilities. We are still evaluating whether to move forward with this practice and developing warrants. Some of the local jurisdictions within Maryland have moved to this practice however.
2. **Where implemented:** N/A.
3. **Specifications/guidance:** N/A.
4. **Cost/effectiveness:** N/A.
5. **Safety data:** N/A.

Michigan Department of Transportation

Contact: Mary K. Bramble, Pavement Marking and Delineation Engineer, Design Division, Traffic and Safety Section, 517-335-2837, BrambleM1@michigan.gov.

1. **Green stripe pavement markings or similar:** No. In Michigan we do not use the type of green stripe markings you describe. The only green pavement markings we have installed are the green boxes within designated bike lanes in advance of and/or within traffic crossing locations, such as in the attached picture [see Appendix B].
2. **Where implemented:** N/A.
3. **Specifications/guidance:** N/A.
4. **Cost/effectiveness:** N/A.
5. **Safety data:** N/A.

Minnesota Department of Transportation

Contact: Melissa Barnes, Statewide Bicycle & Pedestrian Safety Engineer, Office of Traffic Safety and Technology, 651-234-7376, Melissa.Barnes@state.mn.us.

1. **Green stripe pavement markings or similar:** No. MnDOT has not installed any green pavement markings on our system. I know the City of Minneapolis has been utilizing green pavement for a few years now, but I believe they've only installed it within bicycle lanes or bike boxes: http://www.ci.minneapolis.mn.us/bicycles/WCMS1P-083248
2. **Where implemented:** N/A.
3. **Specifications/guidance:** N/A.
4. **Cost/effectiveness:** N/A.
5. **Safety data:** N/A.

Mississippi Department of Transportation

Contact: James S. Sullivan, State Traffic Engineer, Traffic Engineering Division, jssullivan@mdot.ms.gov.

1. **Green stripe pavement markings or similar:** No.
2. **Where implemented:** N/A.
3. **Specifications/guidance:** N/A.
4. **Cost/effectiveness:** N/A.
5. **Safety data:** N/A.

Missouri Department of Transportation

Contact: Tom Honich, Sign and Marking Engineer, Traffic and Highway Safety Division, 573-526-0122, thomas.honich@modot.mo.gov.

1. **Green stripe pavement markings or similar:** No. We do not use any green markings of any kind for bicycle markings. We have had one city utilize green bicycle lane pavement marking in a couple of test locations on our right of way, but the marking was not maintained and allowed to fade away. We do not have plans to incorporate green markings into our pavement marking program at this time.
2. **Where implemented:** N/A.
3. **Specifications/guidance:** N/A.
4. **Cost/effectiveness:** N/A.
5. **Safety data:** N/A.

Montana Department of Transportation

Contact: Danielle Bolan, State Traffic Engineer, 406-444-7295, dbolan@mt.gov.

1. **Green stripe pavement markings or similar:** No.
2. **Where implemented:** N/A.
3. **Specifications/guidance:** N/A.
4. **Cost/effectiveness:** N/A.
5. **Safety data:** N/A.

Nebraska Department of Roads

Contact: Daniel J. Waddle, Traffic Engineer, 402-479-4594, dan.waddle@nebraska.gov.

1. **Green stripe pavement markings or similar:** No.
2. **Where implemented:** N/A.
3. **Specifications/guidance:** N/A.
4. **Cost/effectiveness:** N/A.
5. **Safety data:** N/A.

Nevada Department of Transportation

Contact: Jeannie L. Drown, Principal Traffic Engineer, Traffic Operations Division, 775-888-7678, jdrown@dot.state.nv.us.

1. **Green stripe pavement markings or similar:** No.
2. **Where implemented:** N/A.
3. **Specifications/guidance:** N/A.
4. **Cost/effectiveness:** N/A.
5. **Safety data:** N/A.

New Hampshire Department of Transportation

Contact: William R. Lambert, Traffic Engineer/Administrator, 603-271-1679, wlambert@dot.state.nh.us.

1. **Green stripe pavement markings or similar:** No.
2. **Where implemented:** N/A.
3. **Specifications/guidance:** N/A.
4. **Cost/effectiveness:** N/A.
5. **Safety data:** N/A.

New York State Department of Transportation

Contact: David Woodin, Traffic Operations Bureau Director, Office of Traffic Safety & Mobility, 518-457-1793, David.Woodin@dot.ny.gov.

1. **Green stripe pavement markings or similar:** No.
2. **Where implemented:** N/A.
3. **Specifications/guidance:** N/A.
4. **Cost/effectiveness:** N/A.
5. **Safety data:** N/A.

North Carolina Department of Transportation

Contact: Ron King, State Signing and Delineation Engineer, 919-662-4335, ronking@ncdot.gov.

1. **Green stripe pavement markings or similar:** No. NCDOT has not installed green stripe pavement marking for bike routes; however, we have a couple of municipalities that are interested in colored pavement for bike routes (city of Asheville and town of Chapel Hill).

2. **Where implemented:** N/A.
3. **Specifications/guidance:** N/A.
4. **Cost/effectiveness:** N/A.
5. **Safety data:** N/A.

North Dakota Department of Transportation

Contact: Shawn Kuntz, Traffic Operations Engineer, 701-328-2673, skuntz@nd.gov.

1. **Green stripe pavement markings or similar:** No.
2. **Where implemented:** N/A.
3. **Specifications/guidance:** N/A.
4. **Cost/effectiveness:** N/A.
5. **Safety data:** N/A.

Oregon Department of Transportation

Contact: Gary R. Obery, Active Modes Traffic Engineer, 503-986-4062, gary.r.obery@odot.state.or.us.

1. **Green stripe pavement markings or similar:** No. The Oregon Department of Transportation has not used a green marking as a wayfinding tool. I am not aware of any jurisdictions in Oregon that have done that. ODOT and some other cities have tended to use sharrows or signs for the purpose of alerting motorists of the presence of bikes on the roadway. The city of Portland has limited their use of sharrows to primarily their neighborhood greenways (bike boulevards) as both a warning to drivers and as a wayfinding marker for the bike route. Many jurisdictions use bicycle destination signs for the route marking/wayfinding function. Other than a "bikes on roadway" sign and a few activated "bikes on roadway" beacons, we don't have a great tool for alerting motorists of the presence of bikes on higher speed roads. I would say that in Oregon, green colored pavement has mostly been used to highlight a bike-car conflict point. Here's a link to many of the places where ODOT or some other jurisdiction in Oregon has used green colored pavement markings: https://www.google.com/maps/@43.9822445,-123.3185036,8z/data=!3m1!4b1!4m2!6m1!1szY0tyDCxxAVM.k32azMHog1Oc?hl=en. We have generally strived to stay within the limits set by FHWA's *2011 Interim Approval for Optional Use of Green Colored Pavement for Bike Lanes* (http://mutcd.fhwa.dot.gov/resources/interim_approval/ia14/).
2. **Where implemented:** N/A.
3. **Specifications/guidance:** N/A.
4. **Cost/effectiveness:** N/A.
5. **Safety data:** N/A.

Pennsylvania Department of Transportation

Contact: Robert J. Pento, Manager, Traffic Engineering and Permits, Bureau of Maintenance and Operations, 717-783-6265, RPENTO@pa.gov.

1. **Green stripe pavement markings or similar:** No.
2. **Where implemented:** N/A.
3. **Specifications/guidance:** N/A.
4. **Cost/effectiveness:** N/A.
5. **Safety data:** N/A.

Rhode Island Department of Transportation

Contact: Sean Raymond, HSIP Program Manager, 401-222-2694, ext. 4204, Sean.Raymond@dot.ri.gov.

1. **Green stripe pavement markings or similar:** No. Rhode Island did recently request and was given approval from FHWA to use green-colored pavement in marked bicycle lanes statewide in Rhode Island, including state highways and all local roadways. As of now, we have not installed it at any locations but plan to install it along a roadway corridor later this year or next year. We have not developed a specification for the green-colored pavement at this time.
2. **Where implemented:** N/A.
3. **Specifications/guidance:** N/A.
4. **Cost/effectiveness:** N/A.
5. **Safety data:** N/A.

Saskatchewan Ministry of Highways & Infrastructure

Contact: Sukhy Kent, Director, Design & Traffic Engineering Standards, Design and Innovation Division, 306-787-4945, sukhy.kent@gov.sk.ca.

1. **Green stripe pavement markings or similar:** No. We are predominantly a rural highway agency and do not have a formal policy on accommodation of cyclists.
2. **Where implemented:** N/A.
3. **Specifications/guidance:** N/A.
4. **Cost/effectiveness:** N/A.
5. **Safety data:** N/A.

Tennessee Department of Transportation

Contact: Jason Oldham, State Traffic Engineer, Traffic Engineering Office, 615-741-0995, jason.oldham@tn.gov.

1. **Green stripe pavement markings or similar:** No.
2. **Where implemented:** N/A.
3. **Specifications/guidance:** N/A.
4. **Cost/effectiveness:** N/A.
5. **Safety data:** N/A.

Texas Department of Transportation

Contact: Michael Chacon, Traffic Operations Division, 512-416-3120, Michael.Chacon@txdot.gov.

1. **Green stripe pavement markings or similar:** No.
2. **Where implemented:** N/A.
3. **Specifications/guidance:** N/A.
4. **Cost/effectiveness:** N/A.
5. **Safety data:** N/A.

West Virginia Department of Transportation

Contact: Cindy Cramer, Traffic Engineering Director, 304-558-3063, Cindy.L.Cramer@wv.gov.

1. **Green stripe pavement markings or similar:** No.
2. **Where implemented:** N/A.
3. **Specifications/guidance:** N/A.
4. **Cost/effectiveness:** N/A.
5. **Safety data:** N/A.

Wisconsin Department of Transportation

Contact: William McNary, Engineering Section Chief, 608-266-1260, William.McNary@dot.wi.gov.

1. **Green stripe pavement markings or similar:** No.
2. **Where implemented:** N/A.
3. **Specifications/guidance:** N/A.
4. **Cost/effectiveness:** N/A.
5. **Safety data:** N/A.

Wyoming Department of Transportation

Contact: Joel Meena, Assistant State Traffic Engineer, 307-777-4374, joel.meena@wyo.gov.

1. **Green stripe pavement markings or similar:** No.
2. **Where implemented:** N/A.
3. **Specifications/guidance:** N/A.
4. **Cost/effectiveness:** N/A.
5. **Safety data:** N/A.

Related Resources

We did not find any literature or resources directly related to the use of green stripe pavement markings. Below is a selection of the literature available on bicycle facility pavement markings.

National Guidance

Manual on Uniform Traffic Control Devices for Streets and Highways, Federal Highway Administration, 2009.
http://mutcd.fhwa.dot.gov/kno_2009.htm
Abstract:

> The Manual on Uniform Traffic Control Devices, or MUTCD, defines the standards used by road managers in the United States to install and maintain traffic control devices on all streets and highways.

Related Resources:

> **MUTCD—Interim Approval for Optional Use of Green Colored Pavement for Bike Lanes (IA-14)**, Federal Highway Administration, April 2011.
> http://mutcd.fhwa.dot.gov/resources/interim_approval/ia14/index.htm
> This memorandum issues an "Interim Approval for the optional use of green colored pavement in marked bicycle lanes and in extensions of bicycle lanes through intersections and other traffic conflict areas." Several states contacted for this Preliminary Investigation are using green-colored pavement under this Interim Approval, but none are using green stripe pavement markings, and the FHWA MUTCD Team indicated that experimental use of similar markings had been informally rejected.
>
> **"Green-Colored Pavement with the Shared-Lane Marking,"** *Bicycle Facilities and the Manual on Uniform Traffic Control Devices,* Federal Highway Administration, September 2015.
> https://www.fhwa.dot.gov/environment/bicycle_pedestrian/guidance/mutcd/gcp_slm.cfm
> From the Background section:
>
> > The use of green-colored pavement with the shared-lane marking is noncompliant with the Conditions of the Interim Approval for the Optional Use of Green-Colored Pavement for Bike Lanes (IA-14). Therefore, this treatment is experimental.
> >
> > In July 2013, the FHWA discontinued the approval of new experiments using green-colored pavement with the shared-lane marking until the FHWA could analyze more information regarding preliminary feedback on this application. As of August 2014 the FHWA will accept requests to experiment using green-colored pavement with the shared-lane marking as a background conspicuity enhancement only.

Guide for the Development of Bicycle Facilities, 4th edition, AASHTO, 2012.
https://bookstore.transportation.org/collection_detail.aspx?ID=116
From the product description:

> This guide provides information on how to accommodate bicycle travel and operations in most riding environments. It is intended to present sound guidelines that result in facilities that meet the needs of bicyclists and other highway users. Sufficient flexibility is permitted

to encourage designs that are sensitive to local context and incorporate the needs of bicyclists, pedestrians, and motorists. However, in some sections of this guide, suggested minimum dimensions are provided. These are recommended only where further deviation from desirable values could increase crash frequency or severity.

This guide has been updated from the previous guide published in 1999. The fact that new guidance is presented herein does not imply that existing bicycle facilities are inadequate or unsafe, nor does it mandate the initiation of improvement projects. The intent of this document is to provide guidance to designers and planners by referencing a recommended range of design values and describing alternative design approaches.

Evaluation of Shared Lane Markings, Federal Highway Administration, December 2010.
http://www.fhwa.dot.gov/publications/research/safety/pedbike/10041/10041.pdf
From the Abstract:

The purpose of this study was to evaluate the impact of several uses of shared lane pavement markings, specifically the sharrow design, on operational and safety measures for bicyclists and motorists. Experiments were conducted in three cities. In Cambridge, MA, there was interest in experimenting with the placement of sharrows at a 10-ft spacing from the curb to prevent dooring from parked vehicles. In Chapel Hill, NC, sharrows were placed on a busy five-lane corridor with wide outside lanes and no parking. In Seattle, WA, sharrows were placed in the center of the lane on a downhill portion of a busy bicycle commuting street. Prior to the sharrows, a 5-ft bicycle lane was added to the uphill portion of the street in conjunction with shifting the center line. A variety of hypotheses were examined, and results were generally positive. Sharrows can be used in a variety of situations, and increased use should serve to raise motorist awareness of bicyclists or the possibility of bicyclists in the traffic stream. It is recommended that trials similar to those performed in this study be continued in other locations and traffic settings to improve guidance for users.

International Guidance

Design Manual for Bicycle Traffic, CROW, June 2007.
http://www.crow.nl/publicaties/design-manual-for-bicycle-traffic
Abstract:

In order to retain the bicycle's rightful position within the traffic system and, where possible, to strengthen it, a bicycle-friendly infrastructure is needed. The new CROW-record 25 entitled "Design manual for bicycle traffic" describes the steps required to achieve such an infrastructure. It is a revision of record 10 "Sign up for the bike."

Manual of Uniform Traffic Control Devices, Part 9: Bicycle Facilities, Australian Standard, Standards Australia, November 2000.
Abstract at http://trid.trb.org/view/732753
Abstract:

This Standard specifies requirements for the signs, pavement markings and other devices to be applied to bicycle facilities both on the road and on paths separate from the road, either for the exclusive use of bicycles or joint use with other users. It includes recommendations for guide signs and other navigational information for cyclists. (a) The standard was approved on behalf of the Council of Standards Australia on 12 May 2000 and supersedes AS 1742.9-1986 (ITRD no. 289723).

Related Research

"The Relative (In)Effectiveness of Bicycle Sharrows on Ridership and Safety Outcomes," Nicholas N. Ferenchak and Wesley E. Marshall, *Transportation Research Board 95th Annual Meeting Compendium of Papers,* Paper #16-5232, 2016.
Abstract at http://trid.trb.org/view/1393928
From the Abstract:

> The purpose of this research is to longitudinally examine the extent to which sharrows induce people to ride bicycles and explore the markings' association with the number of bicyclist injuries. Census block groups in Chicago were designated as having, between a before and after period: i) either no bike infrastructure installed; ii) only sharrows installed; or iii) bike lanes installed. Statistical analysis suggests that block groups that had bike lanes installed experienced a significantly larger increase in bicycle commuters (6.46 more per block group) than block groups with sharrows (2.08) or no infrastructure installed (1.37). In terms of safety outcomes, injury crashes per year per 100 bicycle commuters decreased across the board. However, block groups that had only sharrows installed experienced a significantly smaller drop in injuries per year per 100 bicycle commuters (6.7 fewer injuries) than block groups with bike lanes (27.5) or even those with no infrastructure installed (13.5). This work raises concerns about the effectiveness of sharrows and highlights the importance of providing adequate infrastructure for bicyclists.

"An Assessment of Existing Bicycle Advisory Pavement Marking on Urban Roads," K.P. Nepal, *Road and Transport Research*, Volume 24, Issue 2, pages 42-53, June 2015.
Abstract at http://trid.trb.org/view/1375120
From the Abstract:

> This study assesses the operational and safety issues at three bicycle awareness zone sites by analysing video-assisted observation data collected in 2011 by Queensland Department of Transport and Main Roads, Australia. Of the several applications of bicycle awareness zones, this study only covers a particular application where the centre of the bicycle symbol is placed exactly over the parking edge line. Unlike previous studies, which mostly covered before-and-after evaluations of bicycle advisory pavement markings, the focus of this study is to assess whether the placement of bicycle awareness zone symbols has been successful. The aggregated results from video-assisted observational data show that the cyclists did not always track themselves over the centre of the symbols. Rather, both the cyclists' lateral tracking positions and road user interactions varied with the widths of kerbside parallel parking space. Since the bicycle awareness zone symbols are not positioned on the cyclists' desired line of ride on some roads, their operational effectiveness and safety value are questioned.

"Green Shared Lane Markings on Urban Arterial in Oakland, California: Evaluation of Super Sharrows," Nicole Foletta, Carrie Nielson, Jason Patton, Jamie Parks and Robert Rees, *Transportation Research Record: Journal of the Transportation Research Board*, Paper #15-1965, Issue 2492, pages 61–68, 2015.
Abstract at http://trid.trb.org/view/1337375
Abstract:

> In 2013, the City of Oakland, California, implemented a green shared lane (i.e., super sharrow) treatment, which consisted of a continuous band of green color on the pavement in conjunction with shared lane markings (i.e., sharrows) as an experimental traffic control device. The implementation was an attempt to improve traffic operations on a multilane

urban roadway frequented by cyclists but for which geometric constraints prevented installation of dedicated bicycle lanes. The purpose of the experiment was to promote (a) safe and legal lane positioning by cyclists and (b) safe and legal passing by motorists. Through statistical analysis, the effects of the green band (i.e., green shared lane) on user behavior were isolated for comparison with the effects of no bikeway striping and standard sharrows. The key findings were (a) the green shared lane led cyclists to ride farther from parked cars (i.e., outside of the door zone) than they did with standard sharrows; (b) standard sharrows and the green sharrow lane led motorists to shift more often from the right to the left travel lane than they did with no bikeway striping; (c) the average passing distance for motorists who overtook cyclists did not change significantly; (d) the percentage of motorists who left 3 ft or more when they passed decreased with the presence of the green sharrow lane; and (e) the green shared lane had no negative operational effect on auto operations, auto speed, or transit speed.

"Evaluation of Shared-Use Markings for Cyclists in Auckland,"
A. A. Pol, S. Prasad, S. B. Costello, A. Patel and K. Hancock, *Institution of Professional Engineers New Zealand (IPENZ) Transportation Conference,* March 2015.
Abstract at http://trid.trb.org/view/1357924
Abstract:

Auckland Transport recently trialled a shared-use arrow (sharrow) marking, at a number of sites on the Auckland road network. The marking consists of a bicycle symbol with two chevrons above it, and attempts to create a safer shared lane facility for cyclists in low volume, low speed environments. Sharrow markings remind motorists that cyclists also share the road on which they are travelling. In addition, they direct cyclists away from potential hazards such as parked vehicles and open doors by clarifying where cyclists are expected to ride. This research analysed video footage provided by Auckland Transport from the sites to determine if the sharrow markings influenced cyclist behaviour. Behaviour was assessed by measuring the lateral positioning of cyclists in the pre-marking and post-marking scenarios, and then statistically analysing the data. The results obtained suggest that the sharrow markings were successful in influencing cyclist behaviour, as intended, with the general trend indicating a shift in the lateral positioning of the cyclists towards the sharrow marking.

"Influence of Road Markings, Lane Widths and Driver Behaviour on Proximity and Speed of Vehicles Overtaking Cyclists," Stella C. Shackel and John Parkin, *Accident Analysis & Prevention*, Volume 73, pages 100-108, December 2014.
Abstract at http://trid.trb.org/view/1331035
Abstract:

The proximity and speed of motor traffic passing cyclists in non-separated conditions may be so close and so great as to cause discomfort. A variety of road design and driver behaviour factors may affect overtaking speeds and distances. The investigation presented in this paper builds on previous research and fills gaps in that research by considering the presence of cycle lanes on 20 mph and 30 mph roads, different lane widths, different lane markings, vehicle type, vehicle platooning and oncoming traffic. Data were collected from a bicycle ridden a distance of one metre from the kerb fitted with an ultrasonic distance detector and forward and sideways facing cameras. Reduced overtaking speeds correlate with narrower lanes, lower speed limits, and the absence of centre-line markings. Drivers passed slower if driving a long vehicle, driving in a platoon, and when approaching vehicles in the opposing carriageway were within five seconds of the passing point. Increased passing distances were found where there were wider or dual lane roads, and in situations

where oncoming vehicles were further away and not in a platoon. In mixed traffic conditions, cyclists will be better accommodated by wider cross-sections, lower speed limits and the removal of the centre-line marking.

"Considering Shared Use Bicycle Facilities on Narrow Streets in Norway," Kelly Pitera and Cristina Espinosa Mateo, Norwegian University of Science and Technology, *European Transport Conference 2014: Strands,* 2014.
http://abstracts.aetransport.org/paper/download/id/4265
Abstract:

To accommodate the growing number of cyclists in already congested urban areas, it is important to consider how existing infrastructure could be better utilized. While it is optimal to physically separate bicycle traffic from motorized vehicle traffic, space constraints in the existing built environment often prevent this. One potential solution to accommodate both sets of users is that of shared-use facilities where bicyclists and motorists share the same travel lanes without a designated physical separation between the two modes. The objective of this research is to determine if such facilities can address the mobility needs of both motor vehicles and bicycles in narrow, urban streets in Norway. This was done by studying existing, successful implementations of shared-use facilities and determining if such facilities are appropriate given current Norwegian design standards and policies. Various existing shared-use facilities were found to have similar attributes such as function and placement within the road network, but were adapted within each city to meet the needs of a particular environment and comply with given design standards. Standard facilities include advisory lanes, bicycle streets or woonerfs, contraflow bicycling lanes, and sharrow markings. Factors such as street widths, presence of parking, traffic volumes (motorized and non-motorized) and speed limits were identified as key factors in determining a specific solution. Considering the characteristics associated with successfully implemented shared-use facilities throughout Europe, it was determined that such facilities would be appropriate for numerous configurations of one- and two-lane streets in Norway. Given current Norwegian design standards, these are streets with traffic volumes of less than 4,000 vehicles per day or speeds limits less than 50km/h, and widths between 4 and 6.5 meters. Several specific streets within the road network were suggested by the Norwegian Public Road Administration (NPRA) for further study. These streets are representative of the types of streets which the NPRA would like to consider shared-use facilities for. For these streets, sharrow markings and advisory lanes were the most commonly appropriate facility solutions, and thus are the facilities suggested for further study. While this research has shown that it is physically possible to place share-use facilities on existing urban streets, existing policies and attitudes toward bicycle infrastructure add challenges to the successful implementation of such facilities. Further research should aim to strengthen the case for shared-use facilities. This includes traffic analysis to determine the impact of shared-use facilities on motorized traffic, as well as studying preferences and safety perceptions of both cyclists and motorists on such facilities.

Evaluation of Bicycle-Related Roadway Measures: A Summary of Available Research, University of North Carolina, Chapel Hill; Federal Highway Administration, February 2014.
http://www.pedbikeinfo.org/cms/downloads/06%2013%202014%20BIKESAFE%20Lit%20Review_FINAL.pdf
Abstract:

This document represents an effort to compile all known research on the effect of the bicycle safety countermeasures discussed in BIKESAFE

(http://www.pedbikesafe.org/BIKESAFE). It is intended to serve as a companion document for the guide, providing a complementary overview of the researchers, research methods, and evaluation results that have guided the development and design of bicycle safety countermeasures. Countermeasure topics include: Shared roadway measures, On-Road bike facilities, Intersection treatments, Maintenance, Traffic calming, Trails/Shared-Use paths, Markings, Signs, and Signals.

Operational Analysis of Shared Lane Markings and Green Bike Lanes on Roadways with Speeds Greater Than 35 mph, University of North Florida, Jacksonville; Florida Department of Transportation, January 2014.
http://www.dot.state.fl.us/research-center/Completed_Proj/Summary_RD/FDOT-BDK82-977-04-rpt.pdf
Abstract:

This study analyzed the effectiveness of shared lane markings (sharrows), wide curb lanes, standard and buffered bike lanes, and green bike lanes on improving operations of bicycle facilities. Three measures of effectiveness were used in this study: lateral separation between the motor vehicle and bicyclist, the distance of bicyclists to the curb or edge of pavement, and the yielding behavior of drivers and cyclists at merge points. Also, motor vehicle speeds before, while, and after passing bicyclists were analyzed. Except for the Bridge of Lions site, the before-and-after data indicate that installation of sharrows led to an increase in lateral separation between motor vehicles and bicyclists. At Riverside Drive, the separation increased by 0.67 feet, while at the North 56th Street site, an increase of 2.55 feet was observed after installing sharrows and increasing the outside lane width. Data also suggested a significant improvement in lateral separation of 0.86 feet at Sunset Drive, which was widened to create a wider outside lane (but had no shared lane markings), and Bailey Road, where a marked buffer between the travel lane and bike lane resulted in an increase in separation between motor vehicles and bicyclists of 0.72 feet. It was also observed that bicyclists rode further from the curb/edge of pavement for the after-period compared to the before-period for Riverside Drive, Bridge of Lions, North 56th Street, and Sunset Drive. P-values less than 0.05 were observed for these five sites suggesting that the treatments were effective in moving bicyclists further from the curb/edge of pavement. Data also indicates that drivers slow down as they pass bicyclists on non-limited access roadways (before speed of 32.02 mph to 29.97 mph while-passing) and then increase their speeds after overtaking the bicyclists (30.80 mph while-passing to 32.82 mph after-passing). The difference between the speeds before-passing and while-passing, and while-passing and after-passing, were both significant with a p-value less than 0.000. However, when the before-passing (32.02 mph) and after-passing (32.54 mph), excluding while-passing speeds, were analyzed, no significant difference was found (p-value = 0.110). For limited access facilities, the difference between the overtaking driver's speed before-passing (37.35 mph) and while-passing (34.93 mph) the bicyclists was significant with a p-value of 0.000. However, the difference between motor vehicle speeds while-passing bicyclists (34.94 mph) and after-passing (35.48 mph) was not significant (p-value = 0.150). Contrary to the non-limited access streets, the difference between vehicle speeds before-(37.33 mph) and after-passing (35.48 mph) was significant for the limited access facilities (p-value =0.017).

"On-Road Bicycle Facilities and Bicycle Crashes in Iowa, 2007–2010," Cara Hamann and Corinne Peek-Asa, *Accident Analysis & Prevention*, Volume 56, pages 103-109, July 2013.
Abstract at http://trid.trb.org/view/1251739
From the Abstract:

> The objective of this study was to evaluate the effect of bicycle-specific roadway facilities (e.g., signage and bicycle lanes) in reducing bicycle crashes. Methods: The authors conducted a case site-control site study of 147 bicycle crash-sites identified from the Iowa Department of Transportation crash database from 2007 to 2010 and 147 matched non-crash sites. Control sites were randomly selected from intersections matched to case sites on neighborhood (census block group) and road classification (arterial, feeder, collector, etc.). They examined crash risk by any on-road bicycle facility present and by facility type (pavement markings--bicycle lanes and shared lane arrows, bicycle-specific signage, and the combination of markings and signage), controlling for bicycle volume, motor vehicle volume, street width, sidewalks, and traffic controls. Results: A total of 11.6% of case sites and 15.0% of controls had an on-road bicycle facility. Case intersections had higher bicycle volume (3.52 vs. 3.34 per 30 min) and motor vehicle volume (248.77 vs. 205.76 per 30 min) than controls. Results are suggestive that the presence of an on-road bicycle facility decreases crash risk by as much as 60% with a bicycle lane or shared lane arrow (OR = 0.40, 95% CI = 0.09–1.82) and 38% with bicycle-specific signage (OR = 0.62, 95% CI = 0.15–2.58). Conclusions: Investments in bicycle-specific pavement markings and signage have been shown to be beneficial to traffic flow, and the results suggest that they may also reduce the number of bicycle-motor vehicle crashes and subsequent injuries and fatalities. As a relatively low-cost traffic feature, community considerations for further implementation of these facilities are justified.

"Operational Analysis of 'Sharrows' on Roadways with Narrow Lane Widths," Thobias Sando, Michelle Angel, William Wesley Hunter, Deo Chimba and Valerian Kwigizile, *Transportation Research Board 92nd Annual Meeting Compendium of Papers,* Paper #13-2507, 2013.
Abstract at http://trid.trb.org/view/1241529
Abstract:

> Sharrows are intended to encourage shared use of a facility for both bicycles and motor vehicles, as well as identify the appropriate placement for bicyclists within the roadway. This paper analyzes the influence of several site characteristics on the operational and safety effects on bicyclists and motorists at two curbed roadway segments in Florida. Three main site variables were studied: lateral separation between vehicles and bicyclists, vehicle encroachments to the adjacent inside lane, and distance from face of curb that bicyclists track. Results suggest that installation of sharrows can increase the lateral vehicle clearance significantly. It was also observed that less restrictive lane changing conditions greatly increase the lateral separation between vehicles and bicyclists. Also, the percentage of vehicles that passed along side bicyclists with little to no encroachment was notably reduced after sharrows were placed, suggesting positive safety effects for bicyclists. Overall, operational effects for bicyclists and motor vehicles were positive with the implementation of sharrows.

Evaluation of Shared Lane Markings in Miami Beach, Florida, University of North Carolina, Chapel Hill; Florida Department of Transportation, March 2012.
http://www.dot.state.fl.us/research-center/Completed_Proj/Summary_SF/FDOT_BDM10_977-01_rpt.pdf
Summary: http://www.dot.state.fl.us/research-center/Completed_Proj/Summary_SF/FDOT_BDM10_977-01_sum.pdf
Abstract:

This report is a before-after evaluation of shared lane markings on Washington Avenue in Miami Beach, FL, which requested and received permission from the Federal Highway Administration (FHWA) to conduct a pilot study of shared lane markings. The markings were placed in the center of the outside lane to encourage bicyclists to take control of the lane. The experimental design was to collect videotape data of bicyclists interacting with motorists before and after the installation of the markings. After the markings were placed, approximately 20 percent of the bicyclists rode over the shared lane marking, and another 10 percent avoided the marking when they approached. Thus, 30 percent tracked over or very near the shared lane marking. Some 44 percent were positioned near the center of the lane when interacting with a motor vehicle after the markings were placed on the street. From an analysis of the spatial data, there was an increase of about 10.5 inches between bicycles and parked motor vehicles after the introduction of the shared lane markings. In addition, more bicyclists were riding out of the door zone. The spacing increased about 4.5 inches between motor vehicles in the travel lane and parked motor vehicles. All of these findings were statistically significant. Approximately 2 to 3 percent of bicyclists were riding in the wrong direction in the street, and there was no change after the shared lane marking. However, the percentage of bicycles using the sidewalk decreased from about 55 to 45 percent, and this reduction was statistically significant. Whereas about 10 percent of bicyclists weaved between motor vehicles in the traffic lane and parked motor vehicles in the before period, some 14 percent did so in the after period. This maneuver greatly increases the risk of a dooring crash.

"Effects of Shared Lane Markings on Bicyclist and Motorist Behavior," John Brady, Jeff Loskorn, Alison Mills, Jennifer Duthie and Randy B. Machemehl, *ITE Journal*, Volume 81, Issue 8, pages 33-38, August 2011.
Abstract at http://trid.trb.org/view/1126863
Abstract:

The shared lane marking, also known as a "sharrow," is a new pavement marking that is placed in a lane shared by drivers and bicyclists. The marking is designed to encourage bicyclists to ride at the safest position and to alert motorists to the possible presence of bicyclists. This study evaluates the impact of sharrows on bicyclist and motorist safety at three sites in Austin, Texas. Before-and-after data sets for each site were compared to determine whether safer conditions existed after the installation. Safe motorist behavior was defined by two factors: motorists did not encroach on adjacent lanes when passing, and motorists made complete lane changes when passing. Safe bicyclist behavior was defined by three factors: the bicyclists rode at the lane position indicated by the sharrow; the bicyclist did not ride outside of the lane; and the bicyclist did not ride alongside queues of stopped vehicles. The findings indicate that shared lane markings improved the safety for both bicyclists and motorists. After the installation of the shared lane markings, bicyclists rode further from the curb and closer toward the center of the lane. Motorists were shown to be less likely to pass, more likely to change lanes when passing, and were less likely to encroach on the adjacent lane when passing. The authors recommend that shared lane

markings be considered for multilane facilities where the roadway cannot be reasonably adjusted to accommodate a dedicated bicycle lane. Shared lane markings should be placed in the center of the usable lanes unless it is possible for bicyclists and motorists to share the lane safely side-by-side.

Shared Lane Marking Study, City of Los Angeles, June 2011.
https://ladotbikeblog.files.wordpress.com/2011/06/ladot_slm_final_report_062211.pdf
Abstract:

The city of Los Angeles studied shared lane markings (SLMs), a type of marking to direct bicyclists where to ride when roadway space is shared. The city measured driver response to bicyclists at six locations before shared lane markings were installed and after the shared lane markings had been in place for one month. Results showed that SLMs are effective on most streets in increasing the distance between bicyclists and motorists when motorists are passing bicyclists on their left. In general, driver behavior was less aggressive after SLM installation. Recommendations include placement of SLMs not less than 12 feet from the curbface and alignment of markings to encourage straight-line riding and discourage weaving.

"More Than Sharrows: Lane-Within-a-Lane Bicycle Priority Treatments in Three U.S. Cities," Peter G. Furth and Daniel M. Dulaski, *Transportation Research Board 90th Annual Meeting Compendium of Papers DVD*, Paper #11-1357, 2011.
Abstract at http://trid.trb.org/view/1091900
Abstract:

When a street is too narrow to have exclusive bike lanes, cars and bikes have to share a lane. Without a clear bicyclist zone being designated, bicyclists and motorists have to negotiate for the boundary of the bicycle zone. The dynamics of this negotiation and the stresses it engenders are analyzed. Existing treatments to encourage intended motorist and bicyclist behavior in shared lanes are analyzed, including the increasingly popular "sharrow" and Dutch suggestion lanes or advisory lanes. Criteria for an effective shared-lane treatment are developed. A critical feature is longitudinal markings that delineate a bicycle zone as a lane-within-a-lane, a treatment called a Bicycle Priority Lane. Salt Lake City and Long Beach (CA) have each applied this treatment on a 4-lane road using green carpet color to indicate the priority zone, while Brookline (MA) has recently applied it on a 2-lane road using dotted white lines to indicate the priority zone. Before-after studies show that priority lane treatments have some success in shifting cyclists' position further away from parked cars and curbs and away from using the sidewalk. However, the substantial fraction of cyclists continuing to ride on the sidewalk or in the door zone suggests that the prevailing paradigm in the U.S. of bicycles never blocking automobiles is difficult to overcome.

"Evaluation of Shared Lane Markings in Cambridge, Massachusetts," William W. Hunter, Raghavan Srinivasan, Libby Thomas, Carol A. Martell and Cara B. Seiderman, *Transportation Research Record: Journal of the Transportation Research Board*, Issue 2247, pages 72-80, 2011.
Abstract at http://trid.trb.org/view/1091955
Abstract:

Shared lane markings (sharrows) convey the message that motorists and cyclists must share the travel way on which they are operating. The purpose of the markings is to create improved conditions for bicycling by clarifying where cyclists are expected to ride and

reminding motorists to expect cyclists on the road. A before–after evaluation was conducted to compare how cyclists and motorists operated on a street with parallel parking in Cambridge, Massachusetts, with no markings versus with sharrows placed 10 ft (3.05 m) from the curb. This evaluation, which was part of a broader FHWA study on sharrows, was intended to help determine whether an alternative to the 11-ft (3.4-m) spacing recommended in the 2009 version of the Manual on Uniform Traffic Control Devices would be effective. Operational and safety measures for bicyclists and motorists were examined. Overall, safety effects appeared to be associated with the installation of the sharrows placed 10 ft (3.05 m) from the curb. Perhaps the most important effect was the 14-in. (36-cm) increase in spacing between motor vehicles in the travel lane and parked motor vehicles when no bicycles were present. This effect increased the operating space for bicyclists. Many variables related to the interaction of bicycles and motor vehicles also showed positive operational and safety effects.

"Operational and Safety Implications of Three Experimental Bicycle Safety Devices in Austin, Texas," John Francis Brady, Jeff Aaron Loskorn, Alison Fayre Mills, Jennifer Duthie and Randy B. Machemehl, *Transportation Research Board 90th Annual Meeting Compendium of Papers DVD*, Paper #11-0921, 2011.
http://docs.trb.org/prp/11-0921.pdf
Abstract:

Many cities in the United States are seeking ways to safely and effectively integrate bicycles into the urban transportation network. To address safety issues that arise along bicycle routes in Austin, Texas, this observational study examined the operational and safety implications of three new bicycle safety devices—Shared Lane Markings, "Bicycles May Use Full Lane" signs, and colored bicycle lanes at conflict areas—to determine what improvement in safety they offer. When the existing right-of-way cannot accommodate bicycle lanes, Shared Lane Markings and "Bicycles May Use Full Lane" signs improved the safety of bicyclists occupying the full lane by encouraging bicyclists to ride at a more central position in the lane, but did not always reduce unsafe bicycling behavior (like sidewalk riding or bypassing queues of stopped vehicles). Motorists at the study sites often provided greater space while passing and were less likely to pass bicyclists. Other safety concerns arise where a bicycle lane crosses a motor vehicle lane, such as at a freeway entrance ramp or where motorists accessing a right-turn bay must cross a bicycle lane. These conflict areas are traditionally dashed, but this study examined the improvement in safety that could be acquired by applying yellow-green thermoplastic to the dashed conflict area. Motorists were more likely to utilize turn signals when crossing the conflict area at all sites and were more likely to yield to bicyclists where the motor vehicle lane was guided across the conflict area.

"Overview of Shared Use Lane Pavement Markings for Cyclists," M. Jacobson, M. Skene, G. Davidson and D. Rawsthorne, *2009 Annual Conference and Exhibition of the Transportation Association of Canada—Transportation in a Climate of Change,* 2009.
Abstract at http://trid.trb.org/view/911664
Abstract:

The provision of cyclist markings on roadways is increasingly important as a means of encouraging cycling, which can help achieve greenhouse gas emission reduction goals, improve personal health, and alleviate traffic congestion. While reserved bicycle lanes are a common measure, there are situations where roadway geometry and/or operations do not readily lend themselves to bicycle lane implementation. As an alternative marking option,

the shared-use pavement marking symbol, or "sharrow" may be used, and was recently adopted by TAC for use in Canada. The sharrow marking consists of two chevron markings placed in front of a bicycle stencil. The general purpose of the sharrow symbol is to indicate to cyclists the correct positioning on the roadway, and to indicate to drivers the position where cyclists may be expected. There are three general applications of this marking: 1) side-by-side cyclist-motorist operation, 2) single file cyclist-motorist operation, and 3) conflict zones. An overview of the marking design will be given, as well as an overview of the three applications in terms of marking placement, spacing, signage considerations and the range of applicability. Finally, a review of several case studies of actual device implementation will be presented, highlighting emergent issues with the use of this device.

U.S. Department
of Transportation
**Federal Highway
Administration**

1200 New Jersey Avenue, SE
Washington, D.C. 20590

APR 15 2016

In Reply Refer to:
HOTO-1

Wayne Moody, P.E.
County Engineer
Unified Government of Wyandotte County & Kansas City, KS
701 North 7th Street
Kansas City, KS 66601

Dear Mr. Moody:

Thank you for your March 29, 2016 letter requesting approval to use green-colored pavement for marked bicycle lanes and bicycle lane extensions on a county-wide basis in Wyandotte County & Kansas City, Kansas. Your request was made under the provisions of Section 1A.10 in the 2009 edition of the *Manual on Uniform Traffic Control Devices for Streets and Highways* (MUTCD) and Interim Approval Memorandum IA-14, dated April 15, 2011.

Your request is approved.

Per Paragraphs 20 and 21 of Section 1A.10, please inform the Kansas Department of Transportation of the locations of such use and please check for any State laws and/or directives covering the application of the MUTCD provisions that might exist in the State of Kansas.

For recordkeeping purposes, we have assigned your Interim Approval request the following number and title: "IA-14.92 – Green Colored Pavement for Bicycle Lanes – Unified Government of Wyandotte County & Kansas City, KS." Please refer to this number and title in any future correspondence.

Thank you for your interest in improving bicycle safety. If we can be of further assistance on this matter, please contact Mr. David Kirschner at david.kirschner@dot.gov.

Sincerely yours,

Mark R. Kehrli
Director, Office of Transportation
Operations

Appendix B

Michigan DOT's Use of Green Boxes Within Designated Bike Lanes in Advance of or Within Traffic Crossing Locations