TECHBRIEF

The Bicycle Compatibility Index: A Level of Service Concept

Pedestrian & Bicycle Safety

The Pedestrian & Bicycle Safety Research Program focuses on identifying problem areas for pedestrians and bicycles, developing analysis tools that allow planners and engineers to better understand and target these problem areas, and evaluating countermeasures to reduce the number of crashes involving pedestrians and bicycles.

U.S. Department of Transportation
Federal Highway Administration

Currently, no methodology is widely accepted by engineers, planners, or bicycle coordinators that will allow them to determine how compatible a roadway is for allowing efficient operation of both bicycles and motor vehicles. Determining how existing traffic operations and geometric conditions impact a bicyclist's decision to use or not use a specific roadway is the first step in determining the bicycle compatibility of the roadway. The Bicycle Compatibility Index (BCI) can be used by bicycle coordinators, transportation planners, traffic engineers, and others to evaluate existing facilities in order to determine what improvements may be required, as well as to determine the geometric and operational requirements for new facilities to achieve the desired level of bicycle service.

Development of the BCI Model

The approach used in developing the BCI model was to obtain the perspectives of bicyclists by having them view numerous roadway segments captured on videotape and rate these segments with respect to how comfortable they would be riding there under the geometric and operational conditions shown. More than 200 bicyclists participated, rating 80 unique roadway segments on a six-point scale. A rating of one indicated that the individual would be "extremely comfortable" riding there, while a six indicated that the individual would be "extremely uncomfortable" riding under those conditions.

Using these perspectives, the BCI model was developed as shown in table 1 (on the following page). The model is applicable to urban and suburban roadway segments (i.e., midblock locations that are exclusive of major intersections) and incorporates those variables that bicyclists typically use to assess the "bicycle friendliness" of a roadway (e.g., curb lane width, traffic volume, and vehicle speeds).

The model predicts the overall comfort level rating of a bicyclist using the eight significant ($p < 0.01$) variables shown and an adjustment factor (AF) to account for three additional operational characteristics. The basic model (excluding the adjustment factor) has an R^2-value of 0.89, indicating that 89 percent of the variance in the index or comfort level of the bicyclist is explained by the eight variables included in the model. In other words, the model is a reliable predictor of the expected comfort level

Table 1. Bicycle Compatibility Index (BCI) model, variable definitions, and adjustment factors.

$$\mathbf{BCI} = 3.67 - 0.966\mathbf{BL} - 0.410\mathbf{BLW} - 0.498\mathbf{CLW} + 0.002\mathbf{CLV} + 0.0004\mathbf{OLV} + 0.022\mathbf{SPD} + 0.506\mathbf{PKG} - 0.264\mathbf{AREA} + \mathbf{AF}$$

where:

BL = presence of a bicycle lane or paved shoulder > 0.9 m
no = 0
yes = 1

BLW = bicycle lane (or paved shoulder) width
m (to the nearest tenth)

CLW = curb lane width
m (to the nearest tenth)

CLV = curb lane volume
vph/h in one direction

OLV = other lane(s) volume - same direction
vph/h

SPD = 85th percentile speed of traffic
km/h

PKG = presence of a parking lane with more than 30-percent occupancy
no = 0
yes = 1

AREA = type of roadside development
residential = 1
other type = 0

AF = $f_t + f_p + f_{rt}$

where:

f_t = adjustment factor for truck volumes (see below)

f_p = adjustment factor for parking turnover (see below)

f_{rt} = adjustment factor for right-turn volumes (see below)

Adjustment Factors

Hourly Curb Lane Large Truck Volume[1]	f_t	Parking Time Limit (min)	f_p	Hourly Right-Turn Volume[2]	f_{rt}
≥ 120	0.5	< 15	0.6	≥ 270	0.1
60-119	0.4	16-30	0.5	< 270	0.0
30-59	0.3	31-60	0.4		
20-29	0.2	61-120	0.3		
10-19	0.1	121-240	0.2		
< 10	0.0	241-480	0.1		
		> 480	0.0		

[1] *Large trucks are defined as all vehicles with six or more tires.*
[2] *Includes total number of right turns into driveways or minor intersections along a roadway segment.*

of bicyclists on the basis of these eight variables describing the geometric and operational conditions of the roadway.

The variable with the largest effect on the index is the presence or absence of a bicycle lane (BL) or paved shoulder that is at least 0.9 m wide; the presence of a bicycle lane (paved shoulder) reduces the index by almost a full point, indicating an increased level of comfort for the bicyclist. Increasing the width of the bicycle lane or paved shoulder (BLW) or the curb lane (CLW) also reduces the index, as does the presence of residential development along the roadside (AREA). On the other hand, an increase in traffic volume (CLV and OLV) or motor vehicle speeds (SPD) increases the index, indicating a lower level of comfort for the bicyclist. The presence of on-street parking (PKG) also increases the index. The adjustment factor accounts for three specific operating conditions also shown to negatively impact the comfort level of bicyclists, namely the presence of: (1) large trucks or buses, (2) vehicles turning right into driveways or minor intersections, or (3) vehicles pulling into or out of on-street parking spaces.

Level of Service for Bicycling

There are no level of service (LOS) criteria presently provided in the *Highway Capacity Manual*. However, the definition of the LOS according to the manual is based on the concept of users' perceptions of qualitative measures that characterize the operational conditions of the roadway. Two of the terms used in the manual to describe LOS are comfort/convenience and freedom to maneuver; both of these terms are applicable to bicyclists and are directly reflected in the BCI since the rating scale used by the study participants was an indication of comfort level. Thus, using the BCI values produced from the set of locations included in this study, LOS designations were established for LOS A through LOS F as shown in table 2.

Table 2. Bicycle Compatibility Index (BCI) ranges associated with level of service (LOS) designations and compatibility level qualifiers.

LOS	BCI Range	Compatibility Level
A	< 1.50	Extremely High
B	1.51 - 2.30	Very High
C	2.31 - 3.40	Moderately High
D	3.41 - 4.40	Moderately Low
E	4.41 - 5.30	Very Low
F	> 5.30	Extremely Low

BCI Applications

The BCI model and the subsequent LOS designations provide bicycle coordinators, transportation planners, traffic engineers, and others with the capability to better plan for and design roadways that are bicycle compatible. Specifically, the BCI model can be used for the following applications:

Operational Evaluation

Existing roadways can be evaluated using the BCI model to determine the bicycle LOS present on all segments. This type of evaluation may be useful in several ways. First, a bicycle compatibility map can be produced for the bicycling public to assist them in making informed decisions regarding route selection (see figure 1 on the following page). Second, the most appropriate routes for inclusion in the community bicycle network can be identified. In addition, "weak links" in the network can be determined, and prioritization of sites needing improvements can be established based on the index values. Finally, alternative treatments (e.g., addition of a bicycle lane vs. removal of parking) for improving the bicycle compatibility of a roadway can be evaluated using the BCI model.

Design

New roadways or roadways that are being re-designed or retrofitted can be assessed to determine whether they are bicycle compatible. The planned geometric parameters and predicted or known operational parameters can be used as inputs to the model to produce the BCI value and to determine the bicycle LOS that can be expected on the roadway. If the roadway does not meet the desired LOS, the model can be used to evaluate changes in the design necessary to improve the bicycle LOS.

Planning

Data from long-range planning forecasts can be used to assess the bicycle compatibility of roadways in the future using projected volumes and planned roadway improvements. The model provides the user with a mechanism to quantitatively define and assess long-range bicycle transportation plans.

BCI and LOS Workbook

The BCI and LOS criteria have been incorporated into a Microsoft Excel workbook to simplify using the model in real-world applications. The workbook includes three separate worksheets that are linked together to produce the BCI and LOS results. The Data Entry worksheet allows the user to enter location information, geometric and roadside data, traffic operations data, and parking data. The Intermediate Calculations worksheet calculates the adjustment factors and makes several other key computations using the raw data. Finally, the BCI and LOS Computations worksheet calculates the BCI using the nine variables that make up the model and provides the bicycle LOS and compatibility level.

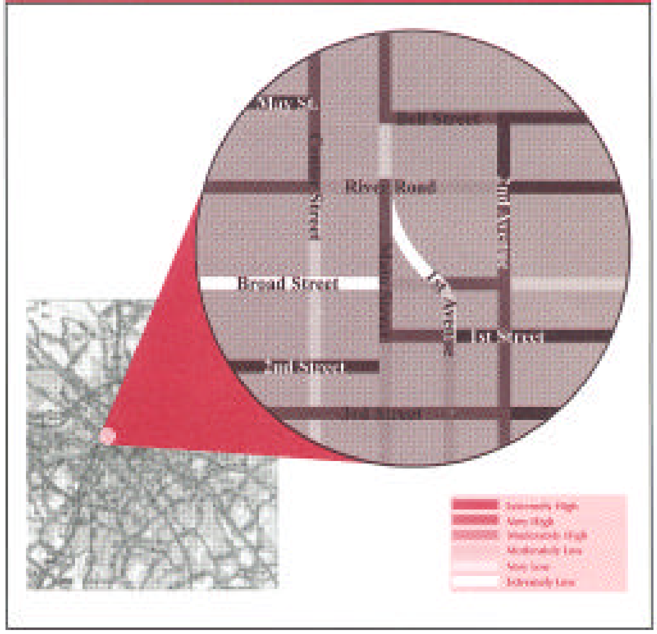
Availability of Reports and Workbook

The results of this research effort are documented in two reports published in December 1998. The first is *Development of the Bicycle Compatibility Index: A Level of Service Concept, Final Report* (FHWA-RD-98-072), which documents the re-search project and includes a comprehensive literature review, field data collection procedures, and the results of the data analysis. The second is *The Bicycle Compatibility Index: A Level of Service Concept, Implementation Manual* (FHWA-RD-98-095), which provides practitioners with a guide to using the BCI instrument, along with several real-world examples. Both of these documents are available from FHWA or can be found on the web at the following address: www.hsrc.unc.edu/research/pedbike/bci/. The BCI workbook that can be used for entering data and producing BCI and LOS results can be downloaded from the same site.

For More Information

This research effort was conducted by David L. Harkey, Donald W. Reinfurt, and J. Richard Stewart of the University of North Carolina Highway Safety Research Center; Matthew Knuiman of the University of Western Australia; and Alex Sorton of Northwestern University Traffic Institute. For more information about this effort and the subsequent reports, please contact either of the individuals below:

Figure 1. One use of the BCI model may be the production of bicycle compatibility maps to assist the bicycling public in making informed decisions regarding route selection.



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