

## **Sidewalk Cross-Slope Design: Analysis of Accessibility for Persons with Disabilities—A Summary**

### **What We Did...**

The maximum cross-slope of sidewalks in this country is currently a subject of serious conversation. The proposed ADA guidelines in their different manifestations have consistently maintained a 2 percent maximum cross-slope requirement, carried over from previous accessibility guidelines (Uniform Federal Access Standards, 1984) and variously expressed as 1:50 or (more recently) 1:48 (Public Rights of Way Access Advisory Committee, 2001). This requirement possibly derives from construction standards for a minimum required slope for drainage purposes, but review of the literature has not determined the original basis for this requirement (Taylor et al. 1999; Kockelman et al. 2000 and 2001).

Though there has been a lack of solid research until now, final standards have been adopted by the U.S.

Access Board and the Texas Department of Licensing and Regulation at a maximum of 2 percent. Title II of the Americans with Disabilities Act (ADA) requires that the programs, activities, and services of public entities be accessible to and usable by individuals with disabilities (28 CFR 35.149-35.150). Cross slopes are an important feature of the public rights of way, which must provide required access. The Texas Department of Transportation intends to have solid research in order to support variance requests to the Texas Department of Licensing and Regulation for situations where designs must exceed the 2 percent maximum cross slope standard. This research provides data, behavioral models, and rigorous results on the issue of cross-slope design.

The research team examined the heart rate response to and user percep-

tion of a variety of pedestrian pathways. Heart rate is a strong proxy for oxygen uptake and thus work or effort. User perception (of comfort or discomfort, on a five-point scale) relates individuals' somewhat subjective beliefs about pathways, yet it is very useful for characterizing accessibility from the perspective of the population with disabilities.

The major aims in participant recruitment for the recent surveys were to have a large sample (50 persons) and a strong representation of the U.S. population of mobility aid users. These were combined with the data sets from the 1999 project (as described in Report 4933-S, titled "Methods for Meeting the ADA in Sidewalk Cross-Slope Design"). A U.S. profile of mobility aid users was developed by calculating percentages of respondents to the 1994 National Health Institute Survey -



**Table 1: Sample Population, by Gender, Age, and Mobility Aid (1999 & 2001 Samples Combined)**

Mobility Aid Type	Male			Female		
	16-35	36-65	66+	16-35	36-65	66+
Cane	1.493	5.970	4.478	0.000	8.955	2.985
Crutches	2.985	1.493	0.000	0.000	1.493	0.000
Walker	1.493	0.000	1.493	0.000	1.493	8.955
Manual Wheelchair	2.985	11.94	0.000	1.493	5.970	2.985
Electric Wheelchair	0.000	4.478	0.000	2.985	7.463	0.000
Scooter	0.000	0.000	0.000	1.493	1.493	0.000
Leg Brace	0.000	1.493	0.000	0.000	0.000	0.000
White Cane (Blind)	2.985	2.985	0.000	2.985	2.985	0.000

(N<sub>obs</sub>=67, Units: %)

Disability (NHIS-D) across age, gender, and mobility aid type (National Center for Health Statistics 1998). The actual sample was highly varied (Table 1) and the resulting data observations were weighted during analysis to correct for sample deviations from population percentages. This weighting of data allows parameter estimates to reflect the proper population of persons with disabilities.

A variety of sidewalk sites were tested, including several long pathways in a large parking lot (which were used to stabilize the heart rate data). A summary of these sites' attributes is provided in Table 2.

### What We Found...

In order to predict comfort perceptions and heart-rate changes for sidewalk sections, the work relied on two statisti-

cal methods. One was a linear regression with correlated random effects that minimized the weighted sum of squared residuals (i.e., WLS). This was used to estimate heart rate changes of the subjects before and after crossing sidewalk sections. The other model was based on an ordered response structure for user perceptions of comfort; it required maximizing a likelihood function. Explanatory variables included test section length, main slope, cross slope, and time (from start to finish), as well as participant age, gender, fitness level, resting heart rate, and mobility aid type.

Heart rate data were gathered from a large parking lot where test-section lengths were long enough for heart-rate stabilization, but whose cross-slopes were not highly varied (minimum = 4.8 percent, maximum = 6.15 percent). An analysis of these data was unable to find a positive effect of cross-slope on heart rate; the impacts of cross-slope were ambiguous. Expectations of effort are that cross-slope should increase effort and thus heart rate; however, individuals' compensation mechanisms (such as slowing) and the correlation with other explanatory variables can obscure such relationships, particularly when deviations in this variable are minimal. However, as expected, heart rate changes were predicted to rise with higher main slopes (even when rates were measured after partici-

**Table 2: Basic Statistics for Attributes of Sidewalk Survey Sites**

Survey Sites	Attributes	Mean	Std.Dev.	Max	Min	Model
Guadalupe Street (9 sites)	Primary Slope (%)	2.681	2.23	8.300	0.600	OP*
	Cross Slope (%)	7.410	4.01	13.77	2.500	OP
	Length (ft)	24.49	9.52	37.0	11.25	OP
South Lamar Boulevard (7 sites)	Primary Slope (%)	-1.267	2.68	2.43	-6.28	OP
	Cross Slope (%)	2.029	1.52	4.86	0.410	OP
	Length (ft)	47.74	27.2	95.75	21.0	OP
Faith United Methodist Church Parking Lot (5 long sections)	Primary Slope <sup>§</sup> (%)	0.815	0.969	1.425	-0.900	RE**
	Cross Slope (%)	5.490	0.550	6.150	4.850	RE
	Length (ft) – 1 direction	105.4	11.7	114.6	85.8	RE

\* OP = Ordered Probit Model of Sidewalk Discomfort Assessment

\*\* RE = Random-Effects Model of Heart Rate Changes

§ Primary slope was somewhat negated in the models because participants traversed the sections forward and back (in order to better stabilize heart rates).



pants had gone out and back, on opposing main slopes), longer sections, and manual wheel chairs users.

The perception models produced cross-slope estimates that met expectations, and every percentage point increase in cross-slope was estimated to affect a user’s perception of comfort much more than primary slope increases. Female manual wheelchair and cane/crutch/leg brace users were the most critical populations for this model. Critical cross-slopes were computed by assuming a variety of user and site types—including a female, 80 years of age, of average fitness in a manual wheelchair on a 45-foot, 5-percent main slope section. These computations also assumed that a critical cross slope would be one where 25 percent of users would rate the section as uncomfortable or worse. They resulted in critical cross slope estimates of 5.5 percent and higher.

In terms of a cross-slope that is wholly inaccessible to certain users, a critical cross-slope for the most sensitive participants in these tests was on the order of 12 percent, a point at which these persons could not negotiate two particular survey sites.

### Implementation Considerations

This research provides rigorous experimental support and other documentation for assessing requests for variances to the sidewalk cross-slope standards held by the U.S.

Access Board and the Texas Department of Licensing and Regulation. The research results suggest that cross slopes as high as 10 percent are accessible to a wide variety of disabled persons. However, 6 percent is the maximum cross slope for designs which accommodate quite elderly manual wheel chair users under adverse main slope conditions (i.e., 5 percent main slope). Based on these results, cross-slopes higher than the current design standards are likely to be highly viable, when needed.

### The Researchers Recommend...

1. The researchers recommend that cross-slopes greater than 2 percent be considered a possible design strategy when right-of-way or other construction limitations make 2 percent cross-slopes a costly endeavor.

2. In locations where the 2 percent standard presents serious design difficulties, the researchers recommend that final plans be allowed to have cross-slopes of up to 10 percent, if main slope is minimal. When main slope is five percent or more, the researchers recommend that cross-slope not exceed 6 percent.

3. For detailed prediction of percentages of specific users with specific disabilities unable to negotiate sidewalks of known length, cross slope and main slope, the researchers recommend that one review Project Research Report 4171-1 to make use of its predictive models and multiple probability plots. (This summary report’s Figure 1 is an example of a probability plot.)

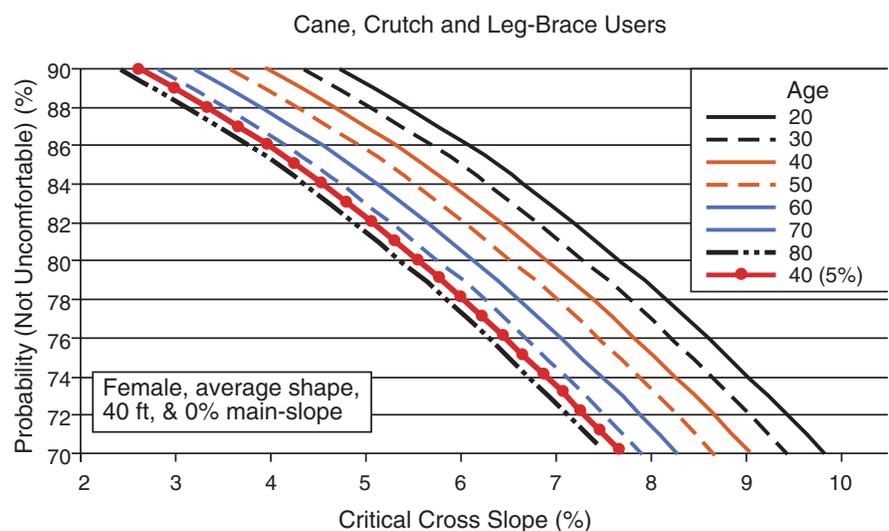


Figure 1: Probability That Critical Class of Users Would Not Be Uncomfortable (or Worse) on a Standard Sidewalk Section, as a Function of Cross-Slope



## For More Details...

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The research is documented in the following reports:

4171-1: *Sidewalk Cross-Slope Design: Analysis of Accessibility for Persons with Disabilities (in progress at CTR)*

4933-S: *Methods for Meeting the ADA in Sidewalk Cross-Slope Design*. Published, peer-reviewed summaries of the earlier work can also be found in the "Journal of Rehabilitation Research and Development" 38 (2001) and "Transportation Research Record" (2000).

To obtain copies of a report: CTR Library, Center for Transportation Research, (512) 232-3138,  
email: ctrlib@uts.cc.utexas.edu

## TxDOT Implementation Status January 2002

The research evaluated the ability of persons with disabilities to navigate sidewalks with greater than the ADA 2-percent maximum cross slope requirement for new construction. The research indicated that persons with disabilities may be able to utilize sidewalk sections that exceed the 2-percent maximum cross slope requirement under a variety of common circumstances. This information will be useful in assessing requests for variances to cross-slope design standards in circumstances where limited right-of-way or other issues require critical attention.

**Your Involvement Is Welcome!**

## Disclaimer

This research was performed in cooperation with the Texas Department of Transportation and the U.S. Department of Transportation, Federal Highway Administration. The contents of this report 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 view or policies of the FHWA or TxDOT. This report does not constitute a standard, specification, or regulation, nor is it intended for construction, bidding, or permit purposes. Trade names were used solely for information and not for product endorsement. The research supervisor in charge was Dr. Kara M. Kockelman.



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