TRANSPORTATION INFRASTRUCTURE PROJECTS CONCEPTION TO EXECUTION (TIP-CE 2017)

Horizontal Curve from Driver's Perspective

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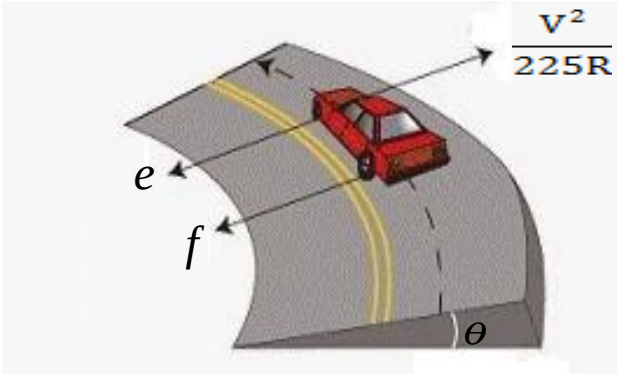
Introduction

- Conventional geometric design (*AASHTO 2011*; *IRC: 73 1980*)

Newtonian mechanics



Limitation: human factors

Speed

- Speed choice prediction models

Influence of geometric parameters

Driver's speed choice

Driver's perception of horizontal curves

Introduction

❖ Poor alignment coordination between successive elements

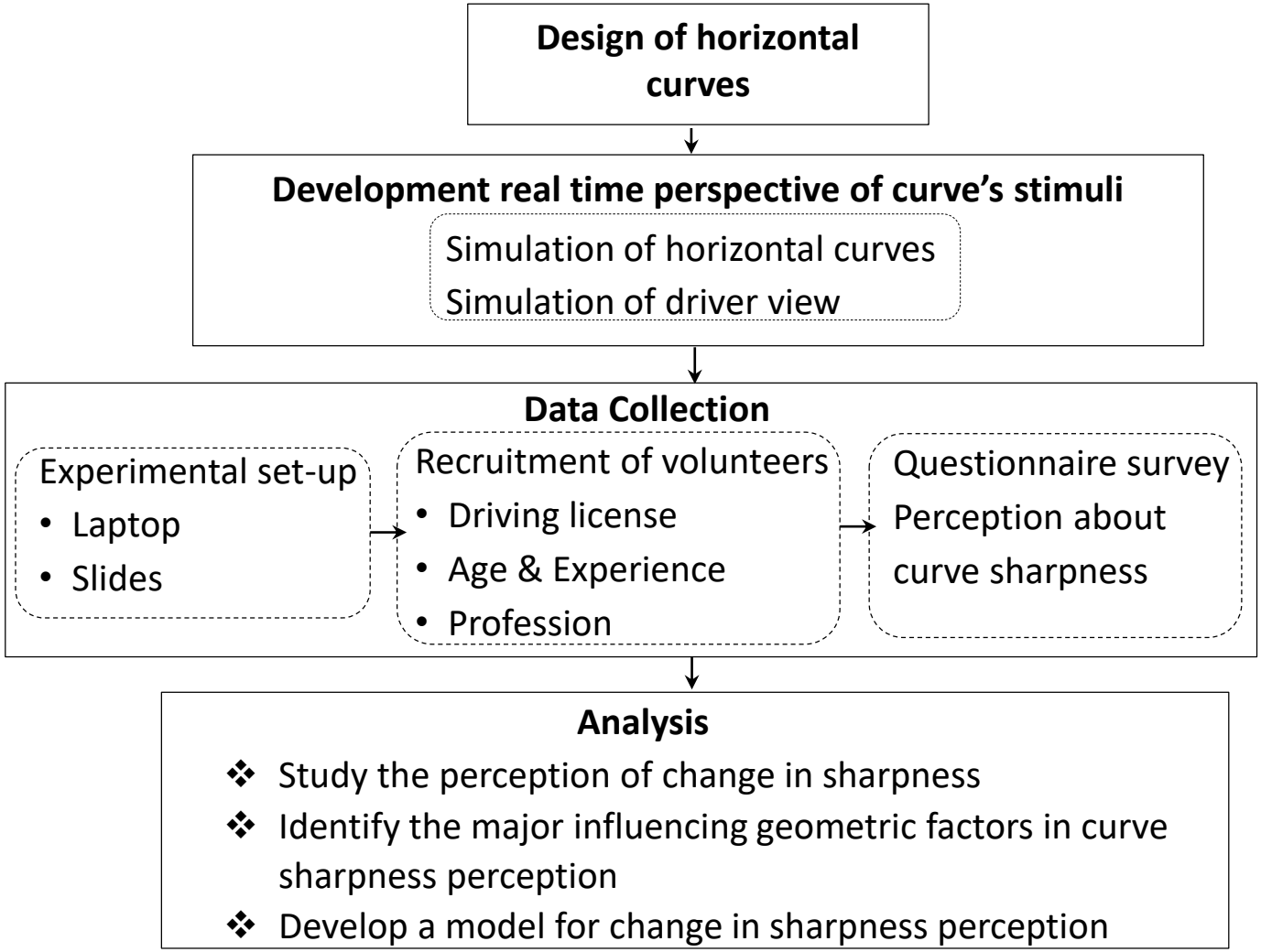
- ❑ Erroneous perception of horizontal curve sharpness.
- ❑ It can be hazardous:
  - Driver perceives a sharp curve as a flat.
  - In turn, choose a speed higher than the safe limit.

❖ Objectives

- ❑ To understand driver's perception in distinguishing the sharpness of varying curve geometry.
  - ✓ To identify the major influencing geometric factors in curve sharpness perception.
  - ✓ Develop a model to estimate the probability of positive identification of changes in circular curve geometry.

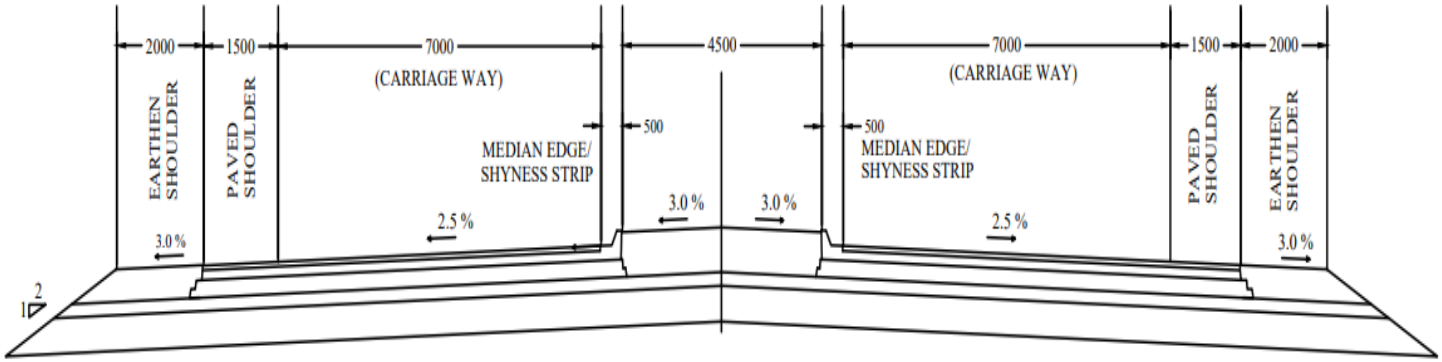
It will help in designing a consistent and well-coordinated highway alignment

Methodology



Investigation Approach

Design of Horizontal Curves



		Radius, R in m						
		100	150	200	250	300	350	400
Deflection angle, Δ in °	10	NF						
	20	NF				105	123	140
	30	NF	79	105	131	158	184	210
	40	70	105	140	175	210	245	280
	50	88	131	175	219	263	306	350
	60	105	158	210	263	315	368	420
	70	123	184	245	306	368	429	490
	80	140	210	280	350	420	490	560
	90	158	236	315	394	473	551	630
	100	175	263	350	438	525	613	700
V_d		50	60	70	80	85	95	100
L_s		55	70	80	90	95	105	110

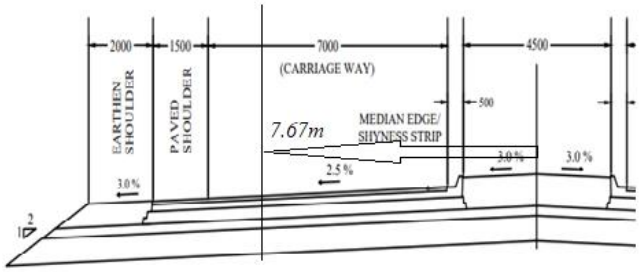
Where, NF= Not feasible (because, L_s>CL), L_s=Transition length in m, CL= Curve length in m, V_d= Design speed in kmph

Investigation Approach

Development of Real Time Perspective Curve Stimuli

AutoCAD® Civil 3D

Fig. Typical Perspective Curve Stimuli



- Flat grade (0%)
- Daylight driving at 12:00 PM
- The clear sky
- Eye offset of 7.67m
- Eye position of 0.33m *(Zwahlen and Schnell 1999)*.

- An unlimited sight distance (i.e., unrestricted by any obstruction except the alignment itself)

- Eye height and object height were 1.05m and 0.15m above the road surface, respectively. *(AASHTO 2011; IRC: 73 1980)*.

- A preview distance of 50m in advance of the beginning of a curve, which equates to a reaction time of approximately 2 sec for a vehicle traveling at 100 kmph,

Investigation Approach

Volunteers

- Students, researchers, staffs, visitors and professional drivers
- Age: 21 to 60 years
- Experience: 3 to 40 years
- Valid driving license
- Total 68 drivers (33 non-professional and 35 professional)
- December, 2017 to March, 2018

Sessions

- Training in a practice session
- Two sessions: (δR) and(δΔ)
- 30 min each & break of 15 minutes

Data

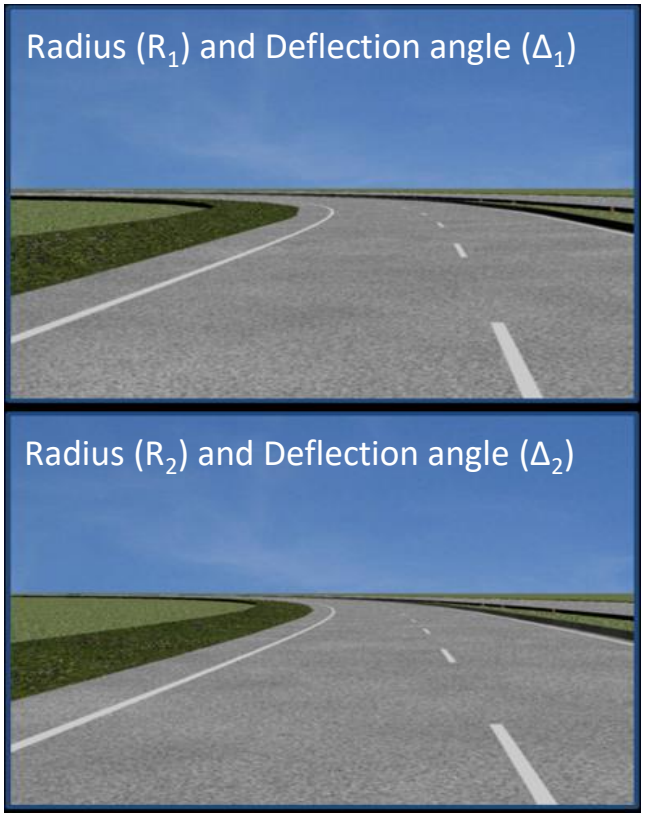
25,704 responses
68 drivers
378 combinations
67 horizontal

Process

- 14 inch computer screen using Microsoft® power point
- Viewed from a 0.5m to 0.6m *(as recommended by Hassan and Easa 2003)*
- Presented for 4sec & blank transition slide of 2sec

Drivers reviewed the difference in sharpness: "yes" and "no"

Independent Parameters



Parameters

(i) Any Radius (R_1 or R2) = R

(ii) Any Deflection angle (Δ_1 or Δ_2) = Δ

(iii) $|R_1 - R_2| = \delta R$

(iv) $|\Delta_1 - \Delta_2| = \delta\Delta$

Modelling of The Perception

Probit(p)= Pr[Yes]= $\int_{-\infty}^{X'B} \frac{1}{\sqrt{2\Pi}} e^{-\frac{1}{2}Z^2} dz = \Phi(X'B)$

Average Marginal effect= $\sum_{i=1}^{n} \phi(X'B) \times B$

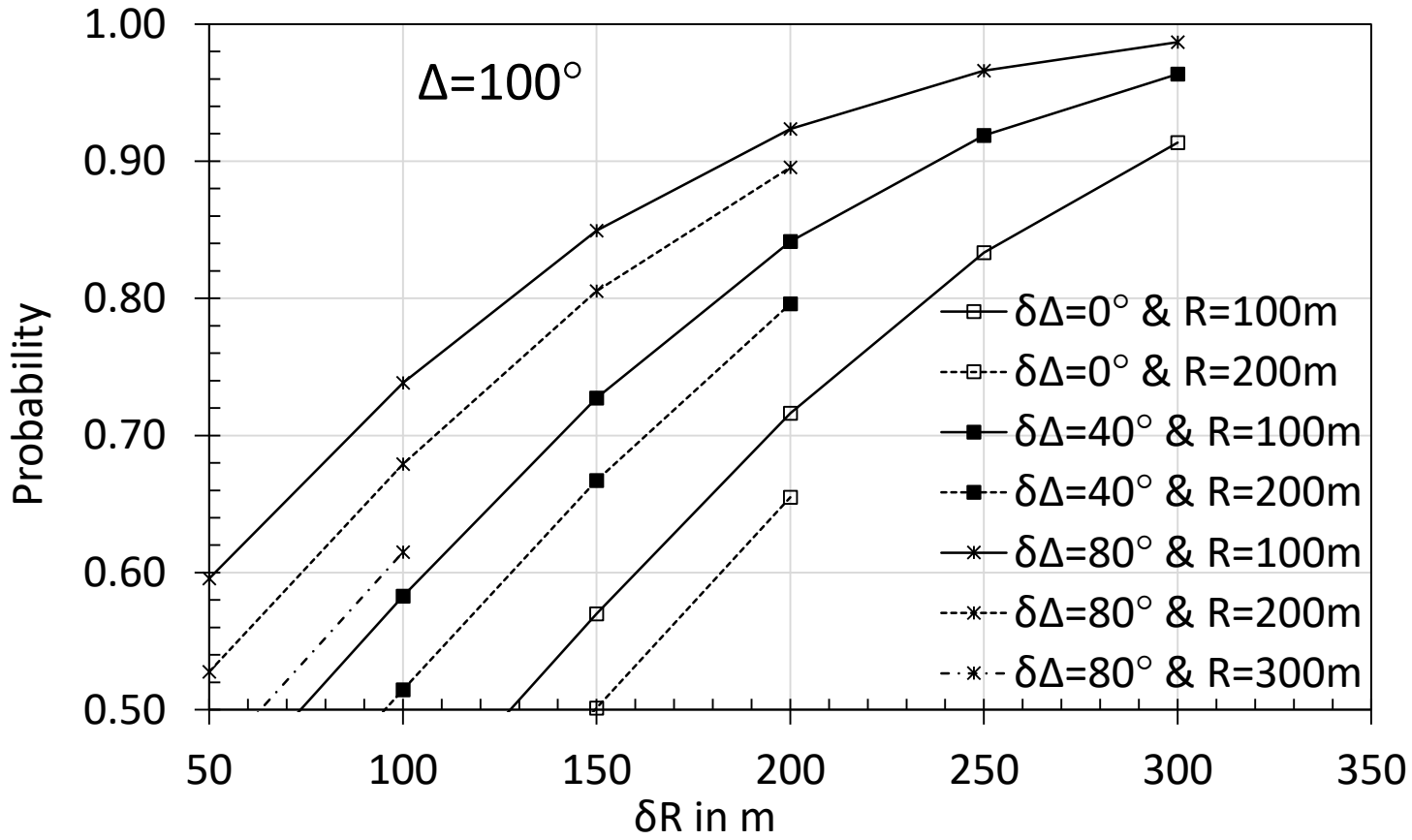
Where, X= parameters, B= Coefficients, Z=Standard normal deviate, n=Total of combinations

Model Summary				
Parameter	Coefficient	Standard Error	Average Marginal effect	p-Value
Constant	-0.336	0.0438	NA	<0.0001
R	-0.002	0.0001	-0.02	
δR	0.008	0.0001	0.12	
Δ	-0.005	0.0004	-0.01	
δΔ	0.011	0.0005	0.03	
Probit (X'B)= −(0.0017×R)+(0.0079×δR) −(0.0050×Δ) + (0.0107×δΔ) −0.3358				
Where, δ= Difference, R= Radius in m, Δ= Deflection angle in°				

Findings

- Model for predicting probability of sharpness perception.
- Negative coefficients of R and Δ indicate that they reduce the probability of the sharpness perception.
- It indicated that decreasing curve angle led to perceptually flatter curve and reduction in curve radius resulted in a paradoxical decrease in perceived sharpness.
- These observed geometric effects are in conformation with the findings of Fildes and Triggs (*1982*).
- Positive coefficients of δR and $\delta\Delta$ indicate that they improve the probability of perception.
- The marginal effects explains the sensitivity.
- Sensitivity $\delta R>>>\delta\Delta>R>\Delta$.
- These sensitivity the parameters can help the practitioners and policy makers to develop optimum curve design procedure considering the perception of sharpness.

Nomogram for Design



Limitation and Future Scope

- Extension for other safety measures.
- Extension for other performance category.
- Perception study:
  - Combined effect of horizontal and vertical curve geometry.
  - Perception comparison for turning direction.
  - Extension for other type facilities (two-lane).
  - Day versus nighttime.

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Thank You