

TRAFFIC CONTROL DEVICE COMPREHENSION

Differences between Domestic and International Drivers in USA

Sunanda DISSANAYAKE, Ph.D.

*Research Associate
Department of Civil and Environmental Engineering
University of South Florida
Florida, USA*

Jian John LU, Ph.D., P.E.

*Associate Professor
Department of Civil and Environmental Engineering
University of South Florida
Florida, USA*

(Received June 25, 2001)

Due to unfamiliarity, international tourists may have higher potential to be involved in traffic related incidents while driving in foreign countries. The study described in this paper evaluated the traffic control device comprehension by international and domestic drivers in the United States, identified other transportation related concerns, and suggested countermeasure ideas useful in addressing transportation and highway safety needs of international tourists. These objectives were achieved by conducting focus group surveys at the departing areas of two international airports in Florida, which is a popular destination among international tourists. Through the data analyses, it was found that more international drivers lack understanding of traffic signs, markings, and traffic signal indications than domestic persons. Based on the identified problem areas, highway safety related countermeasure ideas were suggested for addressing transportation needs of international drivers.

Key Words: International drivers, Transportation safety, Traffic control devices, Countermeasures, Sign comprehension

1. INTRODUCTION

International tourists play an important role in the United States tourism industry. Florida attracts a considerable percentage of international tourists coming to the U.S. Out of the total 22 million international tourists that came to the U.S. in 1995, 19.2% was attracted to Florida. Statewide total taxable sales as a result of tourism/recreation accounted for \$38 billion in 1996, which was an increase of 7.3% from the 1995 figure¹. Based on the data from the Florida Visitor Study, the countries from which the international tourists to Florida originated were vastly different. There are significant differences between the transportation systems and signing practices used in these originating countries and the U.S. Although traffic signs are rather uniform in the U.S., international tourists may not be able to correctly interpret or promptly respond to some of the traffic control devices. Typical problems may include understanding of words and symbols, abbreviations and connotations of words, order of information, cardinal directions, etc.

International tourists are also unfamiliar with the area in which they are driving. Driver's familiarity with the road indicates the level of knowledge that he/she has with the road in question, including location of signs and exits, roadway surface and geometric conditions, and so

on. A driver in an unfamiliar roadway may have different driving behavior in actions like perception-reaction, car following, lane change, and gap acceptance. In addition, they are unfamiliar with the U.S. driving laws and customs as well. Thus, international tourists may have higher potential to be involved in traffic related incidents. However, this is rather difficult to be quantified due to the lack of information on the amount of driving exposure and deficiencies in the crash reporting systems. Certain highway design and policy changes may be helpful for international tourists so that they are directed and assisted in the guidance and navigation tasks required for safe traversing on unfamiliar roadways. A number of studies conducted regarding the transportation and highway safety needs of international tourists or visitors are extremely limited. One of the only two studies conducted in this area is "Evaluation of International Signing Practices" which was conducted by Wilber Smith and Associates for the Florida Department of Transportation². The other related study conducted in Texas assessed Mexican driver understanding of existing traffic control devices used in Texas³.

By considering all the above-mentioned factors, a research project was conducted to evaluate the highway safety issues and concerns of older drivers and international tourists^{4,5}. The methodologies, results, and findings related to the transportation needs of international tourists are documented in this paper while comparing their

traffic control device comprehension with domestic drivers.

2. METHODOLOGY

In order to better understand the transportation needs and highway safety problems of international tourists, a survey was conducted at the departing areas of two international airports in Florida, Tampa and Orlando. A survey form was prepared where the first page, Section A, listed several general questions that included the respondent's primary mode of transportation in U.S./Florida, input about the transportation related problems, permanent residence location, whether the surveyed trip was the first to U.S./Florida, purpose of the trip, etc. In addition, respondents were also requested to provide satisfaction ratings for seven factors depending on their opinion. The factors were:

- The United States transportation system;
- Ease of finding the destination;
- Comfort in obeying traffic signals, signs, markings, etc.;
- Ease of understanding traffic signs;
- Availability and accuracy of transportation related information;
- Knowledge of English for transportation needs; and
- Transportation safety while traveling in Florida.

Section B, was required to be completed only if the respondent drove in the United States or Florida. This section graphically illustrated four traffic signs, two pavement markings, and two traffic signal indications and respondents were provided with four choices about the meaning of each. They were requested to mark the correct answer depending on their understanding.

In order to properly understand the highway safety situation of the international tourists and visitors, it was necessary to compare them with domestic persons. Thus, the survey was not limited to international visitors but was also provided to Americans where they were considered in two different categories as "In-State Persons/Drivers" and "Out-of-State Persons/Drivers" depending on their permanent residence location in the United States. After the preliminary surveys conducted at the Tampa International Airport, it was understood that conducting the survey in English might bias the results as the international tourists originate from various countries using different languages. However, it was not possible for the research group to translate the survey form into all the different

languages. However, due to the geographic location of Florida, many international tourists were from Latin American countries, who spoke Spanish. In addition, this group also lacked good working knowledge of English compared to most other international tourists/visitors. Thus, the survey form was translated into Spanish as well.

The survey team consisted of six surveyors, two of whom spoke fluent Spanish, approached the departing flights 1–2 hours before the boarding time so that enough time was available to contact everybody. Passengers were then informed about the project and requested to complete the survey form. In the case of Spanish speaking population, they were asked about their choice of language where they picked their more comfortable language. Efforts were made to cover all the international flights within the survey time period. The completed survey forms were gathered and later entered into the computer for analysis.

3. RESEARCH FINDINGS

3.1 General

The survey was provided to air passengers waiting in the departing areas of Tampa and Orlando international airports in Florida. Around 50-60% of the departing passengers who were contacted agreed to fill out the survey form. A total of 740 survey forms were completed by the passengers, where 358 were completed at the Tampa International Airport and 382 were completed at the Orlando International Airport. Out of the total, 70 completed forms were in Spanish, the rest were in English.

All international tourists/visitors were first considered together and general details related to their trips were obtained as presented in Table 1. Out of the total international respondents, 65.4% were Europeans, followed by 20.9% of South/Central Americans and Mexicans. Canadians consisted of 4.3% and Asians 2.6%. The remainder was from many different countries. Europeans were the largest group among all the international respondents. They were also identified as the most willing group towards completing the survey form once contacted. Overall, 13% of international visitors encountered or complained about some sort of transportation related problem that was less than that of domestic respondents. However, this may be due to the limited usage of the transportation system by the international respondents. The percentage of international visitors for whom driving cars was the primary mode of transportation was 68.1% and transit usage was

Table 1 General characteristics about all international respondents

Matter	Response	Frequency	
		Number	Percentage
1. Primary mode of transportation	1. Drive a car	160	68.09
	2. Ride with someone	32	13.62
	3. Taxi	6	2.55
	4. Public transportation	33	14.04
	5. Walking/biking	0	0.00
	6. Other	4	1.70
2. Transportation related problems	1. Yes	30	12.99
	2. No	201	87.01
3. Permanent residence	1. Europe	153	65.38
	2. South/Central America and Mexico	49	20.94
	3. Canada	10	4.27
	4. Asia	6	2.56
	5. Other	16	6.84
4. First trip to U.S./Florida	1. Yes	80	34.48
	2. No	152	65.52
5. Main trip purpose	1. Business	19	8.15
	2. Vacation	192	82.40
	3. Visit relatives/friends	9	3.86
	4. Other	13	5.58

at an encouraging level of 14%. For 34.5% of international visitors the trip was the first trip to U.S./Florida. A high percentage of visitors (82.4%) came for the major purpose of vacation and therefore, it was acceptable to consider international visitors as international tourists in general.

3.2 Comments by respondents

In response to the question asked in Section A of the survey form, respondents listed various concerns in relation to transportation. All these comments were separated by three main permanent resident locations (in-state, out-of-state, and international) and evaluated. In general, traffic congestion, aggressive driving, and tolls received many complaints. Regarding traffic signs, the most commonly identified problem was not providing sufficient early warnings regarding exits or upcoming traffic events such as signals or turn lanes. There have also been several international visitor concerns regarding the lack of transportation related information, in particular about transit information.

3.3 Satisfaction levels

When asked about the satisfaction that each respondent is experiencing regarding the factors mentioned earlier, respondents provided their rating at five levels: very

satisfied; fairly satisfied; neutral; fairly unsatisfied; and very unsatisfied. Satisfaction levels about the seven factors by each of the respondent sub-groups were categorized by the five satisfaction levels as frequency percentages. According to the findings in-state respondents were the least satisfied group regarding many issues and South/Central Americans and Mexicans were the most satisfied group except in the case of knowledge of English for transportation needs. In order to make it easy to compare the differences, mean satisfaction indices were also calculated for each group for each issue that was taken into consideration and the results are given in Table 2. The mean satisfaction index was calculated as the sum of all the ratings divided by the total number of valid respondents within a certain category. As the survey form considered '5' as the highest satisfaction level and '1' as the lowest satisfaction, if the mean index is larger, average satisfaction of the considered group would be greater. According to Table 2, South/Central Americans and Mexicans indicated the highest level of satisfaction for all the issues except for knowledge of English for transportation needs. For that issue, they had the lowest mean satisfaction index than all the other sub-groups. Europeans were considerably well satisfied with their knowledge of English where the index was only slightly smaller than domestic respondents. As for the satisfaction level

Table 2 Mean satisfaction indices for the considered factors

Sub-group	Issue							Average Index
	a	b	c	d	e	f	g	
In-state	3.58	3.80	4.05	4.24	3.77	4.66	3.79	3.98
Out-of-state	3.80	3.89	4.19	4.30	3.89	4.77	4.06	4.13
European	3.73	3.83	3.60	3.60	3.36	4.60	4.01	3.82
South/ Central Americans + Mexicans	4.51	4.34	4.61	4.60	4.23	4.02	4.70	4.43
All International	3.92	3.95	3.85	3.87	3.62	4.44	4.13	3.97

Where, a — The United States Transportation System, b — Ease of Finding the Destination, c — Comfort in Obeying Traffic Control Devices, d — Ease of Understanding Traffic Signs, e — Availability and Accuracy of Transportation Related Information, f — Knowledge of English for Transportation Needs, g — Transportation Safety While Traveling in Florida

about the United States transportation system, ease of finding the destination, and transportation safety while traveling in Florida, international respondents, in general, were more satisfied than domestic respondents. However, for comfort in obeying traffic control devices, ease of understanding traffic signs, availability and accuracy of transportation related information, and knowledge of English for transportation needs all showed lesser satisfactory levels than both in-state and out-of-state United States respondents. In fact, all the respondents, irrespective of whether they are domestic or international, indicated that they have the lowest satisfaction about the availability and accuracy of transportation related information. Therefore, it is important to emphasize the fact that this area needs particular attention and improvement.

3.4 Understanding of traffic control devices

Section B of the survey listed four traffic signs, two pavement markings, and two positions of traffic signal heads where the respondents were requested to mark the meaning of each by selecting from the four possible choices. The fourth choice always indicated 'Don't Know/Not Sure'. The rest of the choices included one correct answer and two incorrect ones. Signs that are important for safe driving, were selected from the Manual on Uniform Traffic Control Devices (MUTCD). Number and percentage of respondents who gave correct answers about the meaning of each traffic control device and the total number of respondents under each sub-group were calculated and the details are given in the following sections.

3.4.1 Traffic signs

Traffic sign comprehension about the commonly used STOP sign, 'Slippery When Wet' sign, 'Divided Highway Ends' sign, and 'Do Not Pass' sign are given in Table 3. Most of the respondents correctly interpreted the meaning of the STOP sign. Out-of-state drivers per-

formed slightly better than in-state drivers and among international drivers, Europeans did slightly better than South/Central Americans and Mexicans when considering the meaning of the STOP sign. For the 'Slippery When Wet' sign, the percentage of respondents who gave the correct answer was 77.5% among the domestic respondents. Out-of-state respondents were even worse than Europeans. Only 57.8% of the South/Central Americans and Mexicans interpreted the sign correctly revealing low traffic sign comprehension associated with that particular group. While both in-state and out-of-state respondents performed fairly well for the 'Divided Highway Ends' sign, all the international respondents including Europeans had very low comprehension levels. Only 54.4% of international respondents correctly interpreted this sign. South/Central Americans and Mexicans performed the worst and only 51.1% could correctly interpret the "Divided Highway Ends" sign. Almost all the in-state and out-of-state drivers indicated a very clear understanding of the 'Do Not Pass' sign where even international drivers performed fairly well. Irrespective of the fact that the sign is in text, 80.4% of South/Central Americans and Mexicans gave the correct answer.

3.4.2 Pavement markings

Understanding about the broken yellow centerline and double solid white line pavement markings are given in Table 4. Both in-state and out-of-state drivers performed fairly well and very similarly to the broken yellow centerline pavement marking. However, international driver understanding was lower than that of domestic drivers. One noticeable difference is that South/Central Americans and Mexicans had a better knowledge on the broken yellow centerline than Europeans. As for the double solid white line pavement marking, in-state and out-of-state drivers gave the correct answer for 83.4% and 85.4% of the time. However, international driver under-

Table 3 Traffic sign comprehension by international and domestic drivers

Driver Group	Correct	Incorrect	Total	Correct %	Correct	Incorrect	Total	Correct %
Driver Group	STOP Sign 				'Slippery When Wet' Sign 			
In-state	255	16	271	94.10	210	61	271	77.49
Out-of-state	183	9	192	95.31	138	55	193	71.50
European	127	14	141	90.07	116	35	151	76.82
South/Central American + Mexican	40	5	45	88.89	26	19	45	57.78
All International	204	26	230	88.70	178	62	240	74.17
Driver Group	'Divided Highway Ends' Sign 				'Do Not Pass' Sign 			
In-state	210	60	270	77.78	264	7	271	97.42
Out-of-state	154	38	192	80.21	184	8	192	95.83
European	74	66	140	52.86	128	13	141	90.78
South/Central American + Mexican	23	22	45	51.11	37	9	46	80.43
All International	124	104	228	54.39	206	24	230	89.57

Table 4 Pavement marking comprehension by international and domestic drivers

Driver Group	Broken Yellow Centerline 				Double Solid White Line 			
Driver Group	Correct	Incorrect	Total	Correct %	Correct	Incorrect	Total	Correct %
In-state	241	29	270	89.26	222	49	271	83.39
Out-of-state	171	20	191	89.53	164	28	192	85.42
European	96	45	141	68.09	122	22	144	84.72
South/Central American + Mexican	36	13	49	73.47	30	15	45	66.67
All International	166	67	233	71.24	190	42	232	81.90

standing was lower than that of domestic drivers for this pavement marking. Only 66.7% South/Central Americans and Mexicans were capable of correctly interpreting the meaning of the double solid white line.

3.4.3 Traffic signal indications

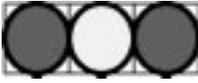
Meanings of two traffic signal indications were tested in this survey where the yellow signal was one of those. The second signal indication was the green arrow. Comprehension levels for these two signal indications by each of the driver groups are presented in Table 5. All the international drivers had a very low understanding about the commonly available yellow signal that might lead to concerns about their highway safety. Only 53.3% of South/Central Americans and Mexicans were capable of correctly understanding the yellow sign whereas Eu-

ropeans could only do little better at 57%. The green arrow used in making exclusive left turns yielded better understanding compared to many other traffic control devices tested in this study. In-state drivers, out-of-state drivers, and Europeans had very similar comprehension levels for the green arrow where the percentage of correct answers was around 92%. South/Central American and Mexican drivers could only interpret the green arrow correctly in 79.2% of the instances.

3.5 Cross analyses with age and gender

Cross-classification analyses between traffic control device comprehension and individual characteristics of the respondent drivers were also conducted to see whether there was a relationship. The null and alternative hypothesis for the testing were:

Table 5 Traffic signal comprehension by international and domestic drivers

Driver Group	Yellow Signal 				Green Arrow Signal 			
	(Vehicles should stop if they can safely do so)				(Turning vehicles have the protective right of way)			
	Correct	Incorrect	Total	Correct %	Correct	Incorrect	Total	Correct %
In-state	229	45	274	83.58	251	20	271	92.62
Out-of-state	166	26	192	86.46	177	15	192	92.19
European	81	61	142	57.04	130	11	141	92.20
South/Central American + Mexican	24	21	45	53.33	38	10	48	79.17
All International	138	92	230	60.00	203	29	232	87.50

H₀: The characteristic and traffic control device comprehension are independent of each other.
 H_a: Null hypothesis is not true.

Expected cell frequencies were compared with the observed cell frequencies using the test statistic χ^2 , as estimated by:

$$\chi^2 = \sum_i^r \sum_j^c \left[\frac{(O_{ij} - E_{ij})^2}{E_{ij}} \right]$$

where,

- O_{ij} = observed cell frequency,
- E_{ij} = expected cell frequency estimated according to the null hypothesis,
- i, j = row and column numbers corresponding to the cell,
- r, c = total number of rows and columns in the classification table.

The estimated chi-square test statistic in each case was compared with the critical chi-square value with (r-

1) x (c-1) degrees of freedom to make a decision regarding the acceptance or rejection of the null hypothesis. Results of the cross-classification analysis to see whether there were relationships between the gender of the respondent and each of the traffic control devices are given in Table 6. It should be noted that the totals do not match due to missing answers. By considering a 5% level of significance the critical chi-square value is 3.84. The estimated chi-square values of all the traffic control devices were smaller than the critical value indicating that there are no reasons to believe that the variables are not independent.

Similarly, the results of the cross-classification analysis to see the relationship between age group and sign comprehension are given in Table 7. Those drivers younger than 25 years were considered as 'young', those older than 50 years as 'older' and the remainder were treated as 'middle age'. The critical chi-square value for a 5% level of significance is 5.99 for this case. For all the devices except the 'Slippery When Wet' sign the test statistics were smaller than the critical value indicating

Table 6 Cross-classification analysis of gender and traffic control device comprehension

Gender	Traffic Control Device															
	STOP Sign		'Slippery When Wet' Sign		'Divided Highway Ends' Sign		'Do Not Pass' Sign		Broken Yellow Centerline		Double Solid White Line		Yellow Signal		Green Arrow Signal	
	C*	NC**	C	NC	C	NC	C	NC	C	NC	C	NC	C	NC	C	NC
Male	349	34	318	95	276	125	349	20	322	56	319	59	299	92	356	38
Female	293	18	208	83	212	77	305	19	256	60	257	60	234	71	275	26
Chi-square Test Statistic	2.36		2.75		1.66		0.06		2.15		1.34		0.01		0.21	
H ₀ Rejected?	No		No		No		No		No		No		No		No	

C* — frequency of correct answers,
 NC** — frequency of incorrect answers.

Table 7 Cross-classification analysis of age group and traffic control device comprehension

Age Group	Traffic Control Device															
	STOP Sign		'Slippery When Wet' Sign		'Divided Highway Ends' Sign		'Do Not Pass' Sign		Broken Yellow Centerline		Double Solid White Line		Yellow Signal		Green Arrow Signal	
	C*	NC**	C	NC	C	NC	C	NC	C	NC	C	NC	C	NC	C	NC
Young	105	14	102	21	79	26	104	3	76	25	84	27	89	29	103	12
Middle-age	377	23	299	104	287	119	371	29	352	67	333	67	322	87	379	31
Older	160	15	125	53	122	57	179	7	150	24	159	25	122	47	149	21
Chi-square Test Statistic	5.18		6.34		1.60		4.66		5.91		5.71		2.96		3.54	
H ₀ Rejected?	No		Yes		No		No		No		No		No		No	

C* — frequency of correct answers,
 NC** — frequency of incorrect answers.

that the null hypothesis of independence could not be rejected. Differences in comprehension level were significant at the 5% level when the age group was considered.

In general, individual characteristics such as age and gender are not found to play highly influential roles towards the traffic control device comprehension. However, exposure measures such as amount of driving and driver license duration could not be tested in this study due to lack of availability of such data.

3.6 Countermeasures

In summary, international respondents indicated higher satisfaction levels regarding the United States transportation system, ease of finding the destination, and transportation safety while traveling in Florida. However, for comfort in obeying traffic control devices, ease of understanding traffic signs, availability and accuracy of transportation related information, and knowledge of English for transportation needs were all at lesser satisfactory levels than both in-state and out-of-state United States respondents. All the respondents, irrespective of whether they are domestic or international, indicated that they have the lowest satisfaction about the availability and accuracy of transportation related information. There are very considerable differences in the comprehension of traffic signs, pavement makings, and traffic signal indications among international and domestic drivers. In particular, South/Central American and Mexican drivers had low levels of understanding about the traffic control devices that are commonly used in the U.S. transportation system. While there could be an effect due to differences in education levels and cultural background leading to this situation, there is very little transportation professionals can do with respect to remedial action. Therefore, the best approach would be to take steps to improve traffic con-

trol device comprehension from a transportation engineering point of view.

Education would be one of the most effective ways to improve this situation, particularly as many international and even domestic respondents complained and expressed their dissatisfaction about the unavailability of transportation related information. As a countermeasure, transportation related information including the general meanings of important traffic signs, markings, etc. could be made available on international flights for those who intend to drive in the United States. Preparing short videotapes summarizing the basic transportation related information for onboard telecast during international flights would be particularly effective when properly arranged. Car rental location would also be one of the best places to distribute basic driving related information. Information and details of the public transportation systems, transit routes, etc. could also be made available at international airports for the use of interested arriving air passengers who might intend to use such systems. Hotels, motels and restaurants could also be used as distribution points of such materials. Availability of such information beforehand will make international drivers more comfortable in understanding and obeying traffic control devices making their stay in the United States/Florida safe and pleasant.

From an engineering point of view, it was evident that some of the traffic signs, even if they are symbolic, are not easy to be interpreted by a foreigner who is not familiar. For example, the 'Slippery When Wet' sign was commonly interpreted as a curved roadway. Further research is needed to improve the clarity of such signs. On the other hand, lack of advance notice about oncoming traffic events was a major comment raised by many international respondents. As such, steps should be taken

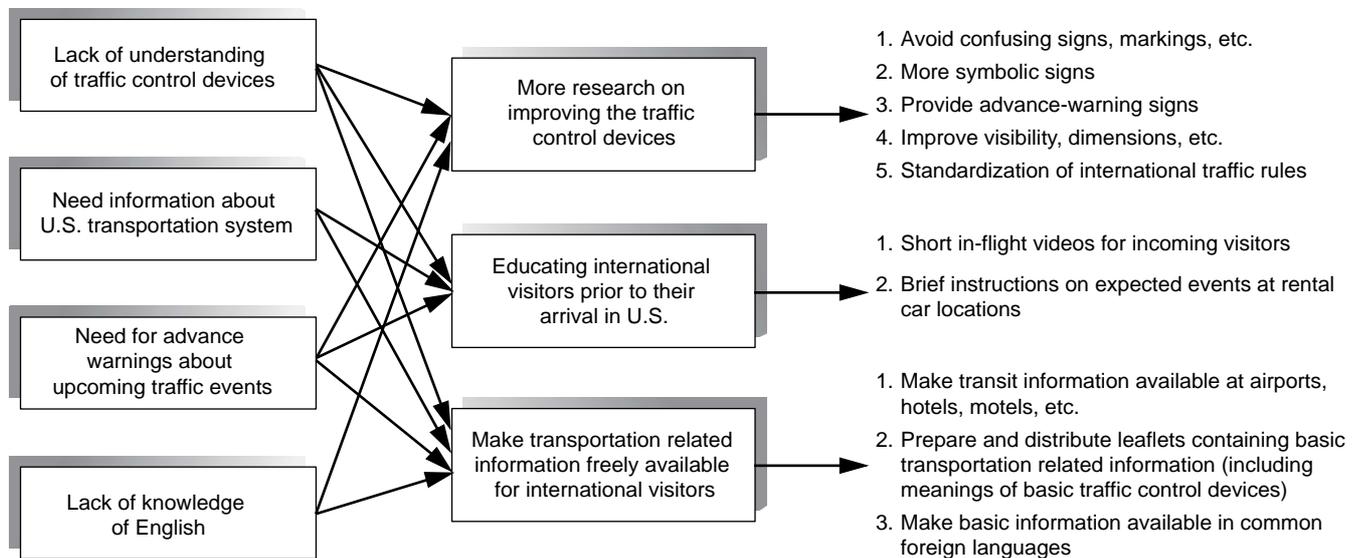


Fig. 1 Highway safety related countermeasure ideas for addressing transportation needs of international drivers

to address this by providing early warnings. Such countermeasures will help international drivers to be well prepared for the oncoming situation making them more comfortable and safe behind the wheel in an unfamiliar driving situation. A brief summary of the traffic safety related countermeasure ideas that could help in addressing the identified highway safety concerns are given in Figure 1. As it could be seen, more than one identified problem area could be addressed through the suggested broad countermeasures making the implementation effective in several ways. In particular, making the transportation related information freely available will address most of the problem areas associated with highway safety and transportation needs of international visitors. The cost associated with this countermeasure is also low compared to the other such recommendations, making it very effective.

4. CONCLUSIONS

By considering the fact that there is a shortage of research studies conducted in the area of the highway safety and transportation needs of international visitors/tourists, this study provided some useful insights. International respondents were less satisfied with their comfort and ease related to traffic control devices and more importantly less satisfied with the availability of transportation related information. When tested about the comprehension of traffic control devices, international drivers

performed well below domestic drivers indicating a need for improvement. Steps should be taken to address the identified weak areas so that highway safety and transportation needs of international visitors could be addressed. The two most general countermeasures would be to make transportation related information available to international visitors and improvements be made to certain components of the transportation system such as traffic signs, markings etc. Further research studies are required on how certain traffic signs could be improved for better clarity. In addition, standardization of traffic rules and regulations would be very useful not only for international visitors in the United States but also throughout the whole world.

REFERENCES

1. Florida Tourism Industry Marketing Corporation. Florida Visitor Study 1996. (1997).
2. Florida Department of Transportation and Wilbur Smith Associates. Evaluation of International Signing Practices – Final Report, Volume 1 and 2. (1994).
3. Hawkins, H. G., D. L. Picha, B. L. Mann, C. R. McIlroy, K. N. Womack, and C. L. Dudek. Assessment of Mexican driver understanding of existing traffic control devices used in Texas. Research Report No. 1274-1. Texas Transportation Institute, The Texas A & M University System. (1996).
4. Dissanayake, S., J. J. Lu, H. Tan, X. Chu, and P. Turner. Evaluation of Highway Safety Needs of Special Population Groups – Phase I. Final Report. Department of Civil and Environmental Engineering, University of South Florida, Tampa, FL (1998).
5. Dissanayake, S., J. J. Lu, H. X. Chu, and P. Turner. Evaluation of critical highway safety needs of special population groups, "ITE Journal", September (1999).