Implementing field work in teaching Transportation Engineering course

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Abstract – Classically, the Transportation Engineering course has been taught in the classroom through a format consisting only of lectures, homework, and exams. Transportation engineering course material includes many traffic studies that require field work to comprehend. A need for having a hands-on experience in this class was found necessary. This paper describes the vital value of field work to the students by implementing hands on transportation field projects. Two main projects were adopted: (1) spot speed study and (2) traffic signal design and assessment. Improvements of the course were significantly recognized by the following aspects: the students practiced group work, used standard and specialized reporting, trained on professional software "HCS2000", improved presentation skills, and experienced self evaluation. This paper illustrates how the aforementioned improvements took place and includes samples of students work.

Keywords: Transportation, Projects, Traffic, Speed, Signals

INTRODUCTION

The Transportation engineering course is an upper division technical elective for the civil engineering concentration at the University of Tennessee at Martin. The course is an entry-level transportation course that covers general knowledge in different transportation fields including traffic characteristics and flow theory, geometric design of highways, transportation planning, roadway capacity and level of service, highway materials, and pavement design. The Transportation engineering course material includes many traffic studies that require field work to comprehend. A need for having a hands-on experience in this class was found necessary. A main reference that includes several dozen types of transportation studies is the Manual of Transportation Studies [Robertson 3]. Many of the transportation studies described in the manual are rarely used by local jurisdictions based on the fact that they are not common or due to the complexity and associated cost for such studies. Several summaries are available of the aforementioned manual as to include major implemented transportation field studies like: spot speed study, traffic volume study, vehicle delay study, parking study, queue length study, crash analysis, vehicle occupancy study, origin-destination study, and trip generation study [Curren 1, Garber 2]. Based on the limited time and nature of the class, only two traffic related studies are adopted for the course: (1) spot speed study and (2) traffic signal and volume study. Related material for the traffic studies is studied in depth in the classroom by means of theory and extensive analytical solutions. Students are assigned into groups and each group selects a location (street segment for speed study, and intersection for signal assessment study). Basic requirements for the two studies are described to the class by handouts. Students are required to submit a final report for each study and present the work at a formal presentation session at the end of semester. The sections of this paper describe the assigned work and the scope of each study with samples of students' work along with conclusion and future work.

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SPOT SPEED STUDY

Spot speed studies are vital for measuring different variables and factors needed in the design and analysis of the highway system. Observed speeds are used for capacity analysis, geometric design, safety measures, speed trends and assessment. Speed studies aid in the decision making processes and in before-and-after studies to assess the effectiveness of roadway modifications. Also, speed observations help determine whether the roadway is in need of new law enforcement, realignment, or reconstruction. Spot speed data have a number of safety applications, including the following: determining existing traffic operations and evaluation of traffic control devices, establishing roadway design elements, and measuring effectiveness of traffic control devices or traffic programs, including signs and markings, traffic operational changes, and speed enforcement programs [Robertson 3]. Because of the importance of such speed studies, data has to be collected properly and presented effectively.
Students are required to select a section of a road around the university campus but away from close intersections and unusual traffic activities. Information about the selected section of the road is gathered such as section speed, number of lanes, and general description of location. Data is to be collected during off peak periods on a week day. The equipment used for data collection procedure is a hand-held STALKER radar as seen in Figure 1.

Figure 1 STALKER ATS hand-held radar used for collecting speed data [Stalker 5]

Collecting the data had to be done without any influence on the actual speeds and drivers' behavior. This is accomplished by choosing a location behind a tree or building or inside the car. An example of a segment and location of a road for one of the groups is shown in Figure 2.

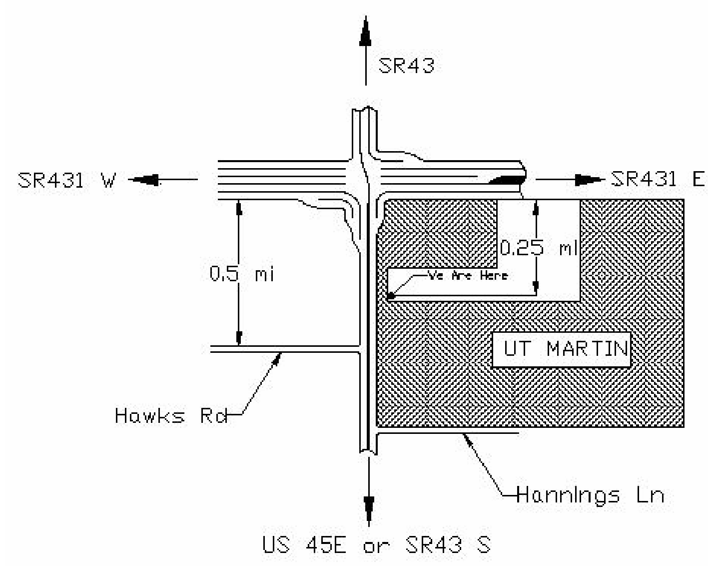

Figure 2 AutoCAD drawing for segment location

Students are required to collect data for 300 vehicles in each direction at the segment of the road and fill a standard form used by Tennessee Department of Transportation (TDOT) for such task. Once the data has been collected, "office work" for data analysis takes place. Data analysis is based on basic statistical analysis for the observations made. The analysts should group the raw data by the nearest one-mile-per-hour speed, starting with the lowest speed observed and ending with the highest. For example, if the lowest observed speed was 31.3 mph, then the first speed group would be 31 mph. The second would be 32 mph and so on. Then, the analyst enters the number of observations falling within the corresponding speed group as Class frequency. The arithmetic mean speed, u, and standard deviation, S, for the specified groups is then calculated by equations 1 and 2 below.

$$\bar{u} = \frac{\sum f_i u_i}{\sum f_i} \ldots (1)$$

$$S = \sqrt{\frac{\sum (u_j - \bar{u})^2}{N-1}} \ldots (2)$$

Observations are then presented in a frequency histogram, frequency distribution curve, and cumulative frequency curve. Examples of speed presentations are shown in Figures 3, 4 and 5.

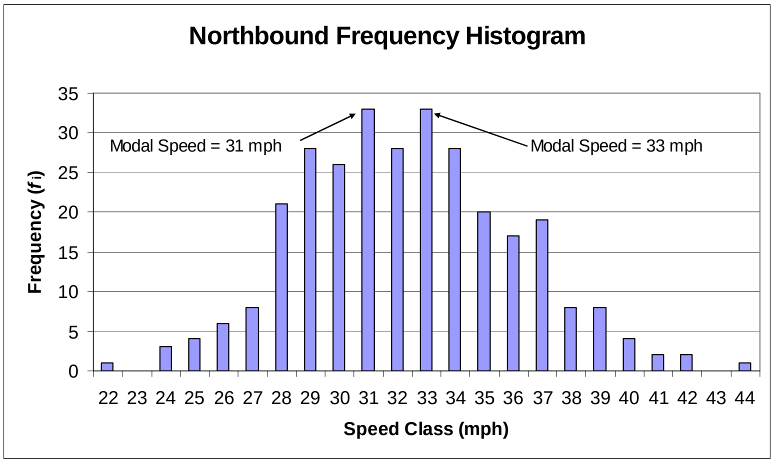

Figure 3, frequency histogram example for the speed groups

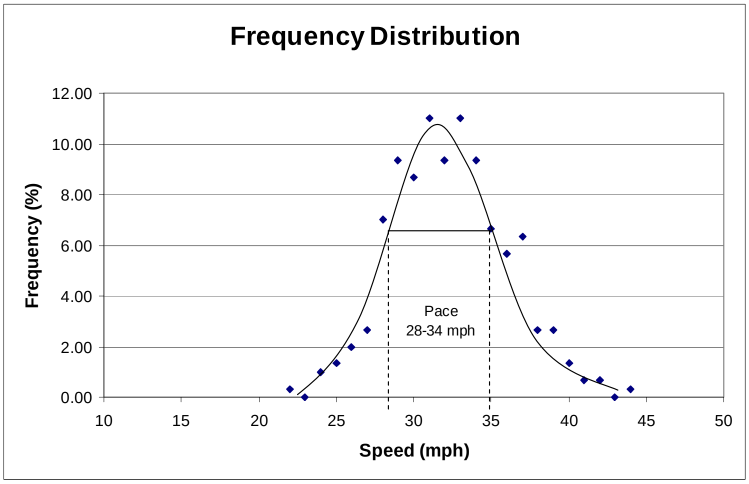

Figure 4, frequency distribution curve example for the speed groups

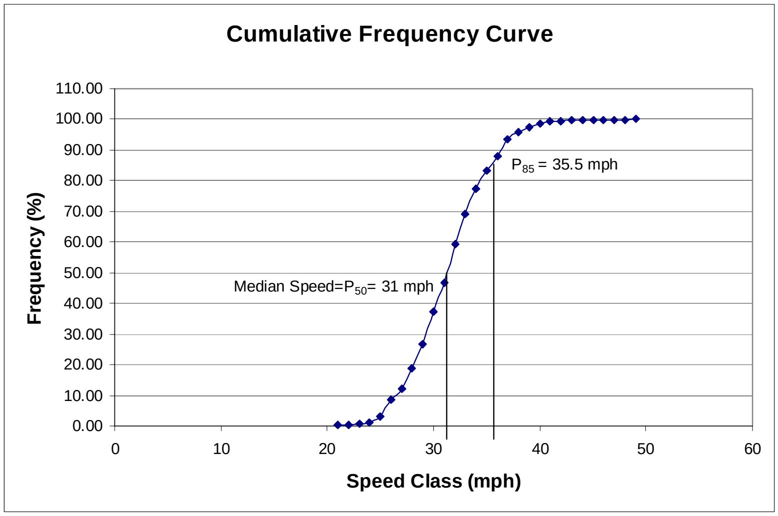

Figure 5, cumulative frequency distribution curve example for the speed groups

The 50th and 85th percentile speeds are two important measures found directly from the plotted cumulative frequency curve. The 50th percentile speed represents what many people mistakenly consider the average speed on the roadway since it is but the median of speeds and not the average. The observed 85th percentile speed is what engineers consider as the design speed viewed by drivers [Garber 2]. The pace of traffic, the section of the curve having the highest percentage of observations, is then calculated. For the example curve shown, the 50th percentile speed is 31 mph; the 85th percentile speed is 35.5 mph; and the speed range is 28 to 34 mph. The posted speed for the example above is 35 mph. Students are required to interpret their results and curves and try to answer some questions such as, how do the 85th percentile speed and the posted speed limit compare? What percentage of traffic observed was traveling over the speed limit? Is the range of speeds particularly broad or narrow? Why? Is there an indication that drivers view the design speed of the roadway as higher than it is? The last step in the analysis is to draw conclusions based on the observed data. The report, at a minimum had to include the following: Cover page, Abstract, Introduction, Objective, Data collection (section description, Pictures of the section, CAD drawing for section, raw data collection form included here), Data analysis and conclusions. Students perform the presentations of the project using PowerPoint slide shows (professional presentation for each group member is expected). Finally, each team member evaluates the other team members based on their contribution to the total work in this project including himself or herself.

TRAFFIC SIGNAL ANALYSIS AND ASSESSMENT

Traffic signal analysis and assessment comprises the second study assigned for the transportation engineering class. Intersection-control based on traffic light signals requires proper evaluation and analysis. Intersection volume count and traffic signal assessment is a significant study for intersection evaluation in terms of proper signal timing, intersection capacity, and level of service. Traffic volume data can help identify critical flow time periods, determine the influence of vehicles or pedestrians on vehicular traffic flow, or document traffic volume trends. Similar to the spot speed study, each group is required to choose an intersection at different locations around the campus. Unlike a spot speed study, the individual conducting the turning movement count (TMC) does not need to be invisible to the drivers. The driver performance will not be affected by such data collection. The count period is an important factor in this study where it should avoid special event or compromising weather conditions [Sharma 4]. Tally sheets and electronic counters for collecting data were used. Data using the tally sheets was recorded with a tick mark on a pre-prepared standard form. Electronic counters were provided by TDOT. Figure 6 shows an example of electronic counters (JAMAR) used by groups.

Figure 6 electronic counter [JAMAR 6]

Data is observed in fifteen minute increments throughout the count period of 1.5 hours. Before starting, the times marking the beginning of each fifteen minute observation period are recorded. Then the watch is started, and the volume count begins. During each time period, the approach that each vehicle used to enter the intersection is recorded specifying whether it turned left, right, or continued straight when exiting the intersection. Table 1 shows an example of a TMC summary table. It is also required to record the signal timing for each approach/phase using the stop watch and find the time of green, yellow, red, and all red intervals. The period during which traffic volume is at its highest is critical for the design of traffic signals. The peak hour and the peak-hour factor (PHF) are computed from the entries on the summary sheet. PHF is the hourly volume during the maximum-volume hour of the day divided by the peak 15-minute flow rate within the peak hour. The PHF is a valuable indicator of flow fluctuation within the peak hour. It is computed by dividing the peak-hour volume by the Peak Rate of Flow. The Peak Rate of Flow is four times the peak fifteen-minute flow within the peak hour. One more summary for the TLC is required in a graphical presentation, an example is shown in Figure 7. The graphical summary is a typical presentation required for the traffic count studies.

Table1 turning movement count summary

	Northbound				Southbound				Eastbound				Westbound				Intersection
Time	**L**	**S**	**R**	**Total**	**L**	**S**	**R**	**Total**	**L**	**S**	**R**	**Total**	**L**	**S**	**R**	**Total**	**Total All**
3:30	7	42	16	65	6	36	6	48	14	15	9	38	3	19	12	34	185
3:45	7	46	16	69	6	40	13	59	11	25	7	43	6	15	8	29	200
4:00	12	53	7	72	5	42	15	62	6	27	10	43	12	21	6	39	216
4:15	11	40	16	67	7	48	7	**62**	10	21	8	39	7	13	8	28	196
4:30	8	57	20	**85**	4	45	12	61	11	21	13	**45**	14	23	12	**49**	**240**
4:45	11	39	18	68	1	38	6	45	10	20	5	35	13	19	7	39	187
	3:30 - 4:30			797													
	3:45 - 4:45			**852**	**Peak Hour**												
	4:00 - 5:00			839													
3:45 - 4:45	38	196	59	**293**	22	175	47	**244**	38	94	38	**170**	39	72	34	**145**	852

Intersection PHF	=	852 / (4* 240) = 0.8875 ≈ 0.89	**PHF = 0.89**		**Signal Timing**	
Northbound PHF	=	293 / (4*85) = 0.8617 ≈ 0.86	NB PHF = 0.86		Green	25 sec
Southbound PHF	=	244 / (4 * 62) = 0.9838 ≈ 0.98	SB PHF = 0.98		Yellow	5 sec
Eastbound PHF	=	170 / (4 * 45) = 0.9444 ≈ 0.94	EB PHF = 0.94			
Westbound PHF	=	145 / (4 * 49) = 0.7398 ≈ 0.74	WB PHF = 0.74			

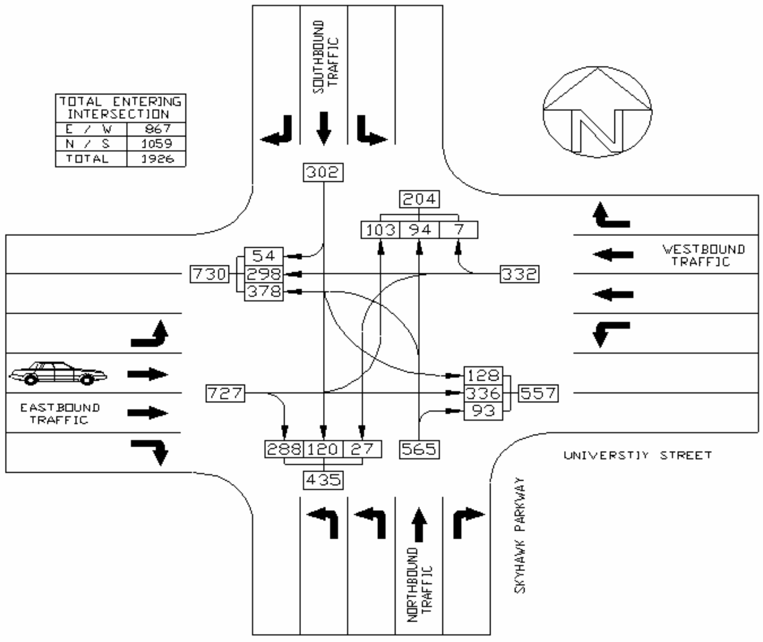

Figure 7 TLC graphical summary

Finally, the use of HCS 2000 software is the last step in the data analysis. HCS 2000 implements the procedures defined in the Highway Capacity Manual (HCM 2000) and analyzes capacity and determining level of service (LOS) for signalized intersections [McTrans 7]. Students are required to get all necessary input to use the software. Necessary input include: TLC counts for each approach, PHF, Geometric dimensions, Signal phasing and timing, and saturation conditions of lanes. A snapshot for the software interface is shown in Figure 8. Figure 8 shows the phasing design input. Table 2 shows results of HCS 2000 obtained by one of the groups. Results of HCS 2000 software include analysis of intersection traffic light timing, volume to capacity ratio, approaches delays, and levels of service.

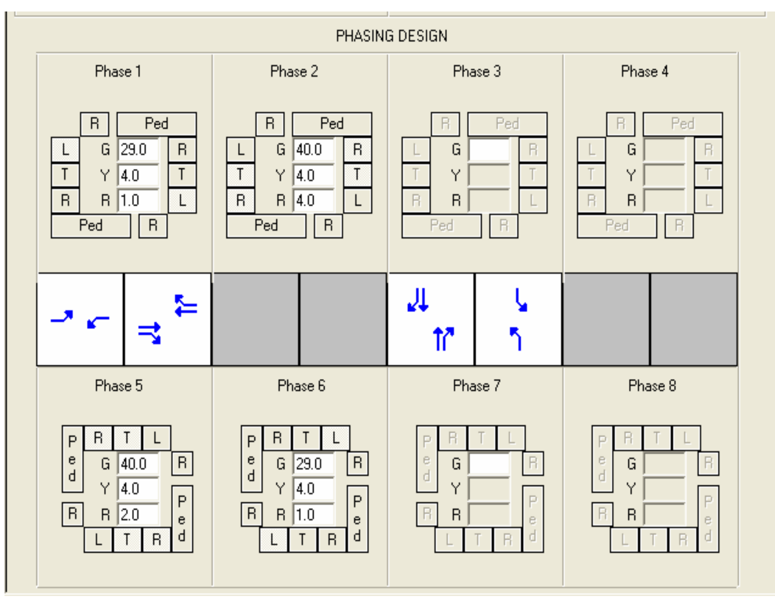

Figure 8 HCS 2000 software

Table 2 Results obtained by HCS 2000 for the analyzed signalized intersection

Lane Group Capacity, Control Delay, and LOS Determination												
	EB			WB			NB			SB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Adjusted flow rate, v		*180*			*196*			*341*			*249*	
Lane group capacity, c		*698*			*679*			*720*			*737*	
v/c ratio, X		*0.26*			*0.29*			*0.47*			*0.34*	
Total green ratio, g/C		*0.42*			*0.42*			*0.42*			*0.42*	
Uniform delay, d_1		*1.4*			*11.6*			*12.7*			*11.9*	
Progression factor, PF		*1.000*			*1.000*			*1.000*			*1.000*	
Delay calibration, k		*0.50*			*0.50*			*0.50*			*0.50*	
Incremental delay, d_2		*0.9*			*1.1*			*2.2*			*1.2*	
Initial queue delay, d_3												
Control delay		*12.3*			*12.7*			*15.0*			*13.1*	
Lane group LOS		*B*			*B*			*B*			*B*	
Approach delay	*12.3*			*12.7*			*15.0*			*13.1*		
Approach LOS	***B***			***B***			***B***			***B***		
Intersection delay s/v	*13.5*			$X_c = 0.38$			**Intersection LOS**			***B***		

The report requires each group to produce an approximate AutoCAD drawing for the analyzed intersection. Example of such a drawing can be seen in Figure 9. Finally, interpretation of volume data and conclusions on the existing intersection condition, intersection LOS, and cycle length are done.

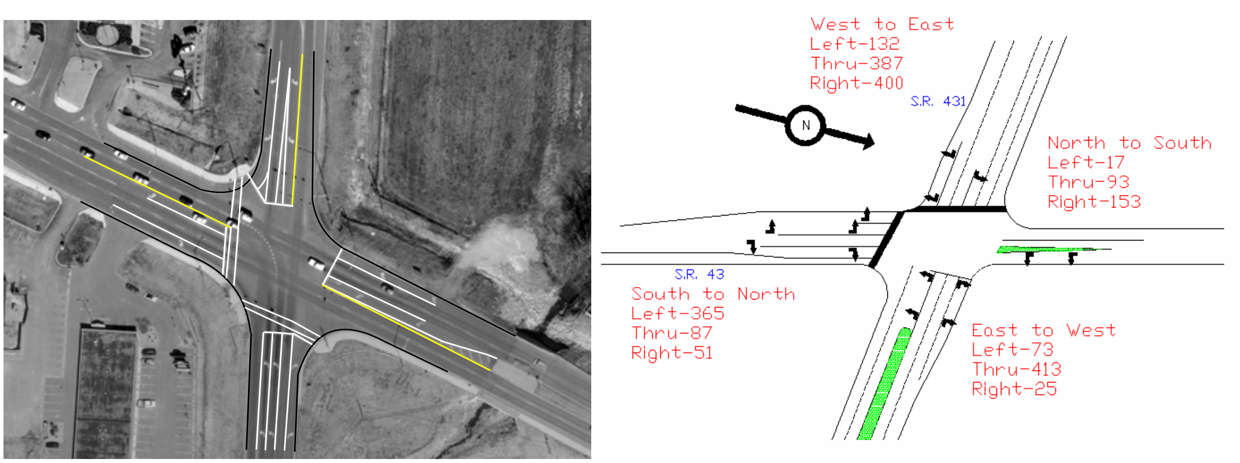

Figure 9 AutoCAD drawing for the analyzed intersection

CONCLUSIONS

Field traffic studies strengthened the traffic theories presented in the class room. Spot speed study and intersection analysis and signal assessment helped students gain the following benefits: Spot speed study and intersection analysis and signal assessment field study implementations, familiarity with standard procedures and standard forms, data presentation techniques, data analysis, field experience and applications, group work, professional presentation skills, interpretations of results, and professional software implementation. Students presented their suggested solutions to improve the studies intersections such as signal timing modifications, intersection widening, geometric adjustments, and realignments. This paper described the minimum requirements for establishing the aforementioned studies and intended objectives. Future plans are to develop an additional three-hour laboratory to accompany the transportation engineering class. The laboratory will include additional studies and projects that will embrace the transportation material taught in the classroom environment.

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