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ROAD USER COST ANALYSIS -- SH 249

CSJ # 0720-03-081

Background

Plans have been developed for the upgrading of an approximate 3.04 mile stretch of SH 249 in northwest Harris County between Grant Road and Huffsmith-Khorville Road. The project provides for the conversion of a non-freeway facility to a freeway facility with continuous frontage roads and diamond interchanges. Project construction is scheduled to begin in late 1993.

Although the public will benefit from the added roadway capacity, motorists will experience delays throughout the duration of the construction. The Texas Department of Transportation (TxDOT) has requested that the Texas Transportation Institute (TTI) complete a road user cost analysis for each stage of the project. This road user cost analysis will compare traffic conditions expected to exist after project completion with those predicted during the construction activities. After the additional delay is determined, the current value of time is applied to any delay increase in excess of the final geometrics and a monetary cost to the public is calculated. This "cost" can then be used as guidelines for determining liquidated damage costs to be placed on the selected contractor for milestone and/or project completion deadlines as may be required.

Construction Sequencing

The first step in the analysis was to review the traffic control plans for each construction stage to determine the impacts on motorists. In most cases, the impacts consist of narrow lanes and turn restrictions at signalized and unsignalized intersections. This project is to be completed in three stages. The initial stages concentrate on the frontage roads and the new intersections while the last stage constructs the new freeway mainlanes.

Major impacts to traffic will occur at all intersections that will be reconstructed during the project. A review of the traffic control plans indicates that the lanes will be narrowed at these intersections at various times throughout the project. Delays will be minimal during Stage 3 when the frontage road construction is completed. The traffic control plan also considered the traffic at the SH 249 at Jones/Lake Road intersection. However, at the present time the Jones portion of the two roadways does not exist. Therefore, this intersection was not considered to contribute to any construction related delays.

Traffic Demands

In addition to the construction sequencing and traffic control plan, a major input to the road user cost determination is the availability of recent traffic volume data within the area. TTI completed 24-hour traffic studies throughout the corridor for a six-day period to aid in determining allowable lane closure periods and to document general traffic conditions in the SH 249 corridor prior to the start of the construction. In addition to the collection of approach volume data, TTI completed turning movement studies at the Gatsden/Rogers, Louetta, Chasewood, Cypresswood, and Perry intersections of SH 249 in May 1993. This data was used as the basis to complete the road user cost analysis. The peak and off peak hour turning movement counts were then used as inputs to the TRANSYT-7F signal timing model.

Analysis Procedures

The TRANSYT-7F traffic signal timing simulation and optimization model was used to determine the existing levels of congestion and those projected to occur during each of the construction phases. The model was applied to each construction phase for the AM, PM, and off peak traffic periods. The delay results for the AM and PM peak hour studies were each multiplied by three to obtain peak period results; assuming that the intersections are impacted by peak traffic conditions for six hours each day during each typical weekday. The off peak hour results were each multiplied by ten to account for an assumed ten hours of off peak traffic demands: 9:00 a.m. to 4:00 p.m. and 7:00 p.m. to 10:00 p.m. The delays to traffic between 10:00 p.m. and 6:00 a.m. were not considered to be significant and were not determined. Other construction related delays requiring re-routing of a motorist's normal routes (such as that occurring during total closures due to beam erection) were also not considered in this analysis.

The model used for this analysis can optimize a network of traffic signals as well as an isolated intersection. TRANSYT-7F is a macroscopic, deterministic simulation and optimization model. It may be used for isolated intersections, a single arterial, or a network. Inputs to the model include: 1) network data; 2) signal timing parameters; 3) geometric and traffic data; and 4) control data which selects actions of the program. Program outputs include: 1) input data echo including detection of errors; 2) MOE's for each link, subtotalled by intersection and totaled for then network; 3) signal controller settings for simulation and/or optimization; 4) flow profile and time-space diagrams; 5) cycle length evaluation summary if a range has been input; 6) route summary report; and 7) other special outputs as requested. Model outputs for each link include travel times and delays, number of stops, maximum queue lengths, and estimated fuel consumption. A Performance Index is also estimated based upon stops, delays, and/or operating costs as requested by the user.

The version of TRANSYT-7F used for this analysis can analyze a network of up to 50 nodes and 250 links. A separate link is needed at each intersection for each exclusive movement. A 4-leg intersection with geometrics of an exclusive left-turn lane, two thru-lanes, and an exclusive right-turn lane on all approaches requires twelve links. A similar intersection with a shared thru/right-turn lane consists of eight links. Since all movements for each approach at a split diamond intersection are moving simultaneously, coding of separate links for each movement (except for exclusive turn lanes) was not necessary. The total interchange delay (combining that for all individual intersections in this case) is used for comparison.

Each intersection was evaluated for all three traffic volume scenarios for each stage as included in the traffic control plan. The model was allowed to optimize the traffic signal(s) at each intersection assuming isolated control. This will provide for a conservative user cost estimate since the signals may not necessarily be re-timed for each construction stage change. It is also assumed that any presently existing traffic signal interconnect within the corridor will not be operating during the construction.

Value of Time

Currently, the basis for determining the value of time is a TTI report "The Value of Travel Time: New Estimates Developed Using a Speed Choice Model," Research Report No. 396-2F. This study derived the value of time using a speed choice model (HEEM) assuming a rational driver chooses a speed so that the total driving costs are minimized. Total driving costs include value of time and vehicle operating costs, accident costs, and traffic violation costs. The study recommends the following values of time (in 1985 dollars):

Drivers - $ 8.03 per person-hour.

Passenger Car - $10.44 per vehicle-hour (assumes 1.3 persons/vehicle).

The value of time may be adjusted using the current Consumer Price Index (CPI). Table 1 illustrates the CPI and the value of time from 1985 to 1993. Current CPI values may be obtained from the *Wall Street Journal* or other economic publications. For this study, the value of time was assumed at $10.68 per person-hour and at $13.35 per vehicle-hour to provide user cost estimates in terms of 1993 dollars.

Table 1. Annual Cost for Value of Time

Year	CPI[1]	Value of Time	
		Drivers[2]	Passenger Cars[2,3]
1985	322.2	$ 8.03	$10.04
1986	238.4	8.24	10.30
1987	240.4	8.48	10.60
1988	118.2[4]	8.82	11.03
1989	124.0[4]	9.26	11.58
1990	130.7[4]	9.76	12.20
1991	136.2[4]	10.17	12.71
1992	140.3[4]	10.47	13.09
1993[5]	143.1[4]	10.68	13.35

Notes:
[1] CPI values are annual percentages.
[2] Costs represent only value of time.
[3] Passenger car cost based on drivers value of time multiplied by vehicle occupancy rate of 1.25.
[4] CPI base was changed in 1988. A multiplication factor of 2.995566 must be used with CPI published after 1988.
[5] First quarter of 1993.

Results of Simulation Analysis

The results of the simulation analysis for each of the four intersections studied in detail are presented in the following tables. The tables present the hourly total interchange delay for each of the three time periods based upon the geometrics for each stage. The total daily delay is then estimated for sixteen hours of operation. The difference between the existing total delay and that for each stage/step was used to estimate user costs for the first two construction stages. The total daily delay as estimated for the assumed final geometrics was used as the base delay value form which the additional delay due to the Stage 3 construction was estimated. This value is then multiplied by the assumed value of time of $13.35 to place a weekday cost value on the total daily delay. Each intersection as analyzed is described in more detail below.

Table 2 presents the user costs as determined for the SH 249 at Chasewood intersection. The highest delays are incurred in Stage 1-3 as the single intersection is converted to a diamond interchange. The lanes along Chasewood are reduced in width which reduces the capacity for that movement. Completion of the additional lanes within the interchange in Stage 3 reduces the overall delay to less than that observed for the existing geometrics.

Table 2. Delay Value Results for SH 249 at Chasewood

Construction Phase	Total Interchange Delay (veh-hours/hour)			Total Daily Delay[1] (veh-hours)	Road User Costs[2] ($/day)
	AM Peak	Off Peak	PM Peak		
Existing	125.8	11.6	27.6	576.2	—
Stage 1-2	250.3	68.0	255.1	939.3	$ 4,847
Stage 1-3	476.8	30.8	177.6	2,271.2	22,628
Stage 1-5	335.3	21.9	100.7	1,527.0	12,693
Stage 3	24.9	10.0	16.2	223.3	1,781[3]
Final	12.8	3.8	4.5	89.9	—

Notes: [1] Total Daily Delay = (AM Peak * 3) + (Off Peak * 10) + (PM Peak * 3).
[2] Road User Costs = (Stage Delay - Existing Delay) * $13.35/day.
[3] Road User Costs = (Stage 3 Delay - Final Delay) * $13.35/day.

User cost values for the SH 249 at Louetta intersection are presented in Table 3. The highest delays are incurred during Stage 1-2; the intersection total capacity is reduced by the removal of the turn lanes for the eastbound and westbound Louetta approaches. The narrowing of the travel lanes from twelve to ten feet in width also impacts the available intersection capacity. The conversion of the intersection to a diamond interchange in Stage

1-3 reduces the overall delay when compared to the previous stage. Implementation of Stage 3 and the final geometrics results in the least overall intersection delays.

Table 3. Delay Value Results for SH 249 at Louetta					
Construction Phase	Total Interchange Delay (veh-hours/hour)			Total Daily Delay[1] (veh-hours)	Road User Costs[2] ($/day)
	AM Peak	Off Peak	PM Peak		
Existing	98.0	27.8	145.3	1,007.9	—
Stage 1-2	298.9	44.9	391.0	2,518.7	$20,169
Stage 1-3	87.5	23.6	226.7	1,178.6	2,279
Stage 1-6	103.9	26.1	109.6	901.5	—
Stage 3	25.8	19.5	31.0	365.4	2,160[3]
Final	13.4	11.0	17.8	203.6	—

Notes: [1] Total Daily Delay = (AM Peak * 3) + (Off Peak * 10) + (PM Peak * 3).
[2] Road User Costs = (Stage Delay - Existing Delay) * $13.35/day.
[3] Road User Costs = (Stage 3 Delay - Final Delay) * $13.35/day.

Table 4 presents the user costs as determined for the SH 249 at Cypresswood intersection. The capacity for the SH 249 movements are not significantly changed during the construction. However, the Cypresswood approaches are without exclusive left and right turn lanes for extended periods of time. Total intersection delays are not significantly reduced until the final diamond interchange geometrics are completed in Stage 3.

Table 4. Delay Value Results for SH 249 at Cypresswood					
Construction Phase	Total Interchange Delay (veh-hours/hour)			Total Daily Delay[1] (veh-hours)	Road User Costs[2] ($/day)
	AM Peak	Off Peak	PM Peak		
Existing	126.4	21.4	132.1	989.5	—
Stage 2-1	183.3	23.4	165.6	1,282.2	$3,908
Stage 2-2	256.6	26.9	199.2	1,636.4	8,636
Stage 2-3	199.0	18.6	160.7	1,265.1	3,679
Stage 2-4	168.7	23.2	89.7	1,007.2	236
Stage 3	39.5	16.9	41.5	412.0	3,819[3]
Final	9.9	6.2	11.4	125.9	—

Notes: [1] Total Daily Delay = (AM Peak * 3) + (Off Peak * 10) + (PM Peak * 3).
[2] Road User Costs = (Stage Delay - Existing Delay) * $13.35/day.
[3] Road User Costs = (Stage 3 Delay - Final Delay) * $13.35/day.

Road user costs as determined for the SH 249 at Perry intersection are presented in Table 5. The construction related delays at this intersection are consistent throughout the project. It must be pointed out that the section of Perry to the east of SH 249 was not considered in the estimation of road user costs. During the times of completion of the turning movement studies, the portion of Perry to the east was not constructed. As it is completed during the construction, additional traffic could be attracted to Perry Road.

Table 5. Delay Value Results for SH 249 at Perry

Construction Phase	Total Interchange Delay (veh-hours/hour)			Total Daily Delay[1] (veh-hours)	Road User Costs[2] ($/day)
	AM Peak	Off Peak	PM Peak		
Existing	1.8	12.1	26.7	206.5	—
Stage 2-3	38.7	13.3	27.8	332.5	$1,682
Stage 2-4	32.4	12.6	25.8	300.6	1,256
Stage 3	12.5	7.1	13.0	147.5	1,271[3]
Final	3.8	2.8	4.3	52.3	—

Notes: [1] Total Daily Delay = (AM Peak * 3) + (Off Peak * 10) + (PM Peak * 3).
[2] Road User Costs = (Stage Delay - Existing Delay) * $13.35/day.
[3] Road User Costs = (Stage 3 Delay - Final Delay) * $13.35/day.

The intersection of SH 249 at Gatsden/Rogers was not used in determining road user costs. It is located at the northern end of the construction project; details on the phasing of that intersection was not included in the traffic control plan. Upon completion of the construction, Gatsden and Rogers will have access only to the one-way frontage roads. The SH 249 at Jones/Lake road intersection was also not considered in this analysis. That intersection as included in the traffic control plan does not presently exist. It could be assumed that some of the traffic from the Gatsden/Rogers intersection could be diverted through the Jones/Lake Road intersection at various stages. However, because of the small volume of traffic from the minor streets, any delay costs estimated would be minimal.

Road User Cost Determination

Using the user costs at each of the four intersections as evaluated for each stage and prorating these costs based upon time estimates for each stage, an average road user cost estimate of $6,980 per day for typical weekday traffic has been estimated. It is recommended that this value be used for liquidated damages for the selected contractor for failure of completion of the project as required. This is based upon the delays presented in Tables 2 through 5 and the current value of time of $13.35 per vehicle hour. Should milestones for completion of critical stages be considered is interim deadlines, the values presented in the tables for the individual intersections should be utilized.

Turning movement data was not available for weekend traffic conditions. However, 24-hour traffic count data was available from studies that were completed in May 1993. Considering both the northbound and southbound SH 249 approaches to Louetta, the Saturday 24-hour traffic demand approximates that for a typical weekday; Sunday traffic is almost 75% of weekday traffic. This is typical for traffic in the Houston area. Based upon data collected on SH 249, traffic is heavy from 9:00 a.m. to 8:00 p.m. on a typical Saturday and from 11:00 a.m. until 7:00 p.m. on Sundays. These compare to heavy weekday traffic from 6:00 a.m. until around 10:00 p.m. during the week. It has been assumed that during these eleven hours on Saturday and eight hours on Sunday, the traffic patterns are similar to that experienced during off peak hours on typical weekdays. Therefore, the road user cost estimates for weekends are based upon those hours of weekend operation, using the delay values for off peak weekdays. This results in road user cost estimates of $3,726 per day for Saturdays and $2,710 for Sundays.