CONSTRUCTION CONGESTION COST (CO^3)

Road construction and rehabilitation cause major traffic disruption and delay that cost road users time and money. The Construction Congestion Cost System (CO^3) is computer software that estimates impact of alternative road construction traffic maintenance contract provisions on congestion, road user cost, and construction cost, from which engineers produce realistic budgets and select practical contracting methods that provide an acceptable balance between construction cost and congestion delays and costs caused by construction. CO^3 was developed by Prof. Robert I. Carr from 1994 to 1997 at the University of Michigan under a research contract from the Michigan Department of Transportation to fulfill MDOT's need for a practical tool to reduce the impact of road construction on cars and trucks traveling Michigan roads. Michigan state law requires user delay costs to be included in life cycle cost analysis of road construction, and CO^3 is the tool MDOT uses to calculate user delay and user delay costs. Since 1997 MDOT has used CO^3 on all Michigan reconstruction and major rehabilitation projects, which consists of approximately 50 projects as of September 2001, including the following major projects:

- $28 million reconstruction of I-75 in Detroit area
- $55 million reconstruction of US-24 in Detroit area
- $17 million rehabilitation of I-69 in Southwest Michigan
- $146 million reconstruction and new construction of US-131 and M-6 interchange in Grand Rapids

CO^3 is the first software that includes driver behavior in response to delays caused by congestion and speed decreases during construction, such as when traffic backs up as lanes are closed, and many drivers take alternative routes or cancel their trips. It replaces software that unrealistically and incorrectly assumes that no drivers travel other routes or cancel trips when construction causes major congestion, even if backups are miles long and delays take hours. CO^3 is available free to all at www.engin.umich.edu/dept/cee/program/cem/Carr/publications.htm
The CO^3 system consists of several components: ROUTES computes equivalent average values for complex diversion routes. INPUT computes individual vehicle cost for trips through the work zone, diversions, and cancellations. TRAFFIC computes daily traffic impacts and user cost for each construction method. DAILY helps engineers determine contract cost incentives and disincentives. CONSTRUCTION computes impact of different construction methods on construction costs. IMPACT summarizes daily impacts and computes total project traffic impacts, road user costs, and construction costs for all alternatives. These tools provide information needed to select construction methods with acceptable construction and road user costs.

The accompanying figure shows the CO^3 IMPACT output for three construction alternatives for closing a lane and working the following hours on a typical pavement overlay project:

- Alternative 1 – Close lane and work 10 hours a day from 7:00 AM to 5:00 PM
- Alternative 2 – Close lane and work 8 hours a day from 7:00 AM to 3:00 PM
- Alternative 3 – Close lane and work 10 hours a night from 8:00 PM to 6:00 AM.

Alternative 1 is normal construction at lowest construction cost = $501,210. CO^3 estimates this will create 2 mile backups, average delay = 6 minutes, and user cost = $36,676 a day for 12 days = $440,114, for total project cost = $940,114. Alternative 2 works fewer hours to avoid afternoon rush hour, it requires 15.4 days of lane closure and provides little savings. Alternative 3, working at night, reduces user cost from $440,114 to $57,432 at an estimated construction cost increase of only $31,713 and total cost = $590,355 which makes Alternative 3 the preferred construction method.

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IMPACT, USER COST, AND CONSTRUCTION COST SUMMARY SHEET

SUMMARY SHEET Project:	US 01 Overlay					
TRAFFIC IMPACT EACH WAY % closed	50%	50%	50%	50%	50%	50%
traffic method	10 hr day: 7A-5P		8 hr day: 7A-3P		10 hr night: 8P-6A	
direction of travel	southeast	northwest	southeast	northwest	southeast	northwest
total user cost ($)	$35,433	$37,919	$22,466	$29,747	$4,818	$4,275
user cost of delays ($)	$27,903	$29,737	$17,606	$23,288	$4,183	$3,720
user cost of decreases ($)	$7,530	$8,183	$4,859	$6,459	$634	$556
maximum backup (V)	347	264	36	264	0	0
maximum backup length (lane mi)	2.0	1.5	0.2	1.5	0.0	0.0
maximum delay (min.)	23.5	21.5	11.7	21.5	7.4	6.4
average delay (min)	5.9	6.4	3.5	4.8	0.7	0.7
total delay, except diversions (V hr)	2586	2756	1632	2158	388	345
total vehicles canceled (V)	2850	3094	1844	2442	236	207
total vehicles diverted (V)	2960	3216	1910	2538	249	218
total decrease in demand (V)	5809	6310	3754	4981	484	424
% decrease in demand	18.1%	19.6%	11.7%	15.5%	1.5%	1.3%
delay per diverted vehicle (min)	5.2	5.2	5.2	5.2	5.2	5.2
total diversion delay (V hr)	255	277	165	219	21	19
average delay, including diversions (min)	5.8	6.3	3.6	4.8	0.8	0.7
total delay, including diversions (V hr)	2841	3033	1796	2377	409	363
user cost / design demand ($/V)	$1.11	$1.18	$0.70	$0.92	$0.15	$0.13
delay cost / actual demand ($/V)	$1.06	$1.15	$0.62	$0.86	$0.13	$0.12
USER COST, DAILY traffic method	**10 hr day: 7A-5P**		**8 hr day: 7A-3P**		**10 hr night: 8P-6A**	
total user cost, daily ($)	$36,676		$26,106		$4,547	
user cost of delays, daily ($)	$28,820		$20,447		$3,952	
user cost of decreases , daily ($)	$7,857		$5,659		$595	
total delay, except diversions, daily (V hr)	2,671		1,895		366	
total vehicles canceled, daily (V)	2,972		2,143		221	
total vehicles diverted, daily (V)	3,088		2,224		233	
total decrease in demand, daily (V)	6,059		4,367		454	
total diversion delay, daily (V hr)	266		192		20	
total delay, including diversions, daily (V hr)	2,937		2,087		386	
USER COST, TOTAL						
total user cost ($)	$440,114		$402,786		$57,432	
user cost of delays ($)	$345,836		$315,471		$49,914	
user cost of decreases ($)	$94,278		$87,315		$7,518	
maximum backup (V)	347		264		0	
maximum backup length (lane mi)	2.0		1.5		0.0	
maximum delay (min.)	23.5		21.5		7.4	
average delay (min)	6.2		4.1		0.7	
total delay, except diversions (V hr)	3,192		2,957		254	
total vehicles canceled (V)	35,662		33,063		2,792	
total vehicles diverted (V)	37,051		34,319		2,947	
total decrease in demand (V)	72,713		67,381		5,740	
% decrease in demand	18.9%		13.6%		1.4%	
average delay per diverted vehicle (min)	5.2		5.2		5.2	
total diversion delay (V hr)	3,192		2,957		254	
average delay, including diversions (min)	6.1		4.2		0.7	
total delay, including diversions (V hr)	35,244		32,194		4,880	
average user cost / design demand ($/V)	$1.14		$0.81		$0.14	
average delay cost / actual demand ($/V)	$1.11		$0.74		$0.12	
CONSTRUCTION COST method	**10 hr day: 7A-5P**		**8 hr day: 7A-3P**		**10 hr night: 8P-6A**	
lane-closed hours per day (hr/day)	10		8		10	
lane-closed days (day)	12.0		15.4		12.6	
labor cost ($)	$150,000		$154,286		$157,895	
project cost ($)	$500,000		$522,000		$532,923	
TOTAL PROJECT COST	**$940,114**		**$924,786**		**$590,355**	