HIGHWAY FACTORS GROUP CHAIRMAN'S
FACTUAL REPORT

Highway Attachment 5 – Traffic Control Design E-mail From March 2017, Detailing Rationale for Estimating Lane Capacity and Requirement to Maintain Two Lanes Open in 4-lanes Sections of I-84

Boise, Idaho

HWY18FH015

(5 pages)

I-84, FIVE MILE RD TO ORCHARD RD & RAMPS, BOISE
PROJECT NO. A019(289)

We appreciate your invitation to the meeting last Wednesday Aug 29th and appreciate the information you provided.

As discussed, below is some additional information regarding lane capacity.

As you know, on March 7, 2017 Parametrix submitted an e-mail that recommended maintaining a minimum of two lanes open in the four lane sections. Maintaining two lanes open was partly based on past construction projects and consistency in the I-84 corridor. In addition several projects have used the 10:00 pm to 5:00 am weekday time limitation for construction. Parametrix also reviewed 2016 traffic information supplied by ITD. Two counter locations were reviewed and the location with the highest volumes was used for the highest month and the highest day of the week. This conservative approach was applied to the duration of the project even though some months and days of the week have less volumes. This information was all included in the e-mail on March 7, 2017.

For determining the capacity of a lane, 1500 pc/h/ln is a generally accepted value for short-term work zones. The 2010 Highway Capacity Manual suggests that "a capacity of 1600 pc/h/ln be used for short-term freeway work zones, regardless of the lane-closure configuration. However, for some types of closures, a higher value could be appropriate." The 2010 Highway Capacity Manual goes on to say the base value of 1600 pc/h/ln should be adjusted for other conditions like: intensity of work activity, effects of heavy vehicles, and presence of ramps.

The intensity of work activity is somewhat subjective, a value of 5% reduction seemed appropriate, assuming somewhere between no intensity and the most intense.

The effects of heavy vehicles are based on a simple formula listed in the attached section from the 2010 Highway Capacity Manual.
The following values in the formula were estimated:
P_T = proportion of trucks and buses = 8.5% (based on data from ITD)
P_R = proportion of RVs = there was no data on the amount of RVs but since the work was at night RV presence should be low and a conservative value of 3% was estimated.
E_T the passenger car equivalents for trucks and buses and E_R the passenger car equivalents for RVs are on page 14-15 of the 2010 Highway Capacity Manual for level terrain.
Based on the formula the heavy-vehicle adjustment factor is approximately = 0.954

Based on the criteria listed in the 2010 Highway Capacity Manual the presence of ramps was estimated to not be a factor.

Applying all the adjustment factors results in an estimated lane capacity of approximately 1450 pc/h/l.

Now it is just a matter of comparing this value for each lane needed to the traffic data provided by ITD in each direction.

Strictly speaking, since the traffic data provided by ITD includes all vehicle types the values should be converted to passenger car equivalents by multiplying them by the inverse of the heavy-vehicle adjustment factor above or approximately 1.048.

Thanks

Parametrix
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Step 4: Adjust Segment Capacities

Segment capacities can be affected by a number of conditions not normally accounted for in the segment methodologies of Chapters 11, 12, and 13. These reductions include the effects of short-term and long-term lane closures for construction or major maintenance operations, the effects of adverse weather conditions, and the effects of other environmental factors.

At lane drops, permanent reductions in capacity occur. They are included in the base methodology, which automatically accounts for the capacity of segments on the basis of the number of lanes in the segment and other prevailing conditions.

Capacity Reductions due to Construction and Major Maintenance Operations

Capacity reductions due to construction activities can be divided into short-term work-zone lane closures, typically for maintenance, and long-term lane closures, typically for construction. A primary distinction between short-term work zones and long-term construction zones is the nature of the barriers used to demarcate the work area. Long-term construction zones generally use portable concrete barriers, while short-term work zones use standard channeling devices (e.g., traffic cones, drums) in accordance with the *Manual on Uniform Traffic Control Devices for Streets and Highways* (2). Capacity reductions due to long-term construction or major maintenance operations generally last several weeks, months, or even years, depending on the nature of the work. Short-term closures generally last a few hours.

Short-Term Work Zones

Research (3) suggests that a capacity of 1,600 pc/h/ln be used for short-term freeway work zones, regardless of the lane-closure configuration. However, for some types of closures, a higher value could be appropriate.

This base value should be adjusted for other conditions, as follows:

1. *Intensity of work activity:* The intensity of work activity refers to the number of workers on the site, the number and size of work vehicles in use, and the proximity of the work activity to the travel lanes. Unusual types of work also contribute to intensity in terms of rubbernecking by drivers passing through the site. Research (3) suggests that the base value of 1,600 pc/h/ln be adjusted by as much as ±10% for work activity that is more or less intensive than normal. It does not, however, define what constitutes "normal" intensity, so this factor should be applied on the basis of professional judgment and local experience.

6. *Effects of heavy vehicles:* Because the base value is given in terms of pc/h/ln, it is recommended that the heavy vehicle adjustment factor (f_{HV}) be applied. A complete discussion of the heavy vehicle adjustment factor and its determination are included in Chapter 11, Basic Freeway Segments. Equation 10-8 shows how the factor is determined.

$$f_{HV} = \frac{1}{1 + P_T(E_T - 1) + P_R(E_R - 1)}$$

Equation 10-8

where

f_{HV} = heavy-vehicle adjustment factor,

P_T = proportion of trucks and buses in the traffic stream,

P_R = proportion of RVs in the traffic stream,

E_T = passenger-car equivalent for trucks and buses, and

E_R = passenger-car equivalent for RVs.

Passenger-car equivalents for trucks and buses and for RVs may be found in Chapter 11, Basic Freeway Segments.

7. *Presence of ramps:* If there is an entrance ramp within the taper area approaching the lane closure or within 500 ft downstream of the beginning of the full lane closure, the ramp will have a noticeable effect on the capacity of the work zone for handling mainline traffic. This situation arises in two ways: (*a*) the ramp traffic generally forces its way in, so it directly reduces the amount of mainline traffic that can be handled, and (*b*) the added turbulence in the merge area may slightly reduce capacity (even though such turbulence does *not* reduce capacity on a normal freeway segment without lane closures). If at all possible, on-ramps should be located at least 1,500 ft upstream of the beginning of the full lane closure to maximize the total work zone throughput. If that cannot be done, then either the ramp volume should be added to the mainline volume to be served or the capacity of the work zone should be decreased by the ramp volume (up to a maximum of one-half of the capacity of one lane) on the assumption that, at very high volumes, mainline and ramp vehicles will alternate.

Equation 10-9 is used to estimate the resulting reduced capacity in vehicles per hour.

$$c_a = \{[(1{,}600 + I) \times f_{HV}] \times N\} - R$$

Equation 10-9

where

c_a = adjusted mainline capacity (veh/h);

I = adjustment factor for type, intensity, and proximity of work activity, pc/h/ln (ranges between ±160 pc/h/ln);

f_{HV} = heavy-vehicle adjustment factor;

N = number of lanes open through the work zone; and

R = manual adjustment for on-ramps (veh/h).

There are three categories of general terrain:

- *Level terrain*: Any combination of grades and horizontal or vertical alignment that permits heavy vehicles to maintain the same speed as passenger cars. This type of terrain typically contains short grades of no more than 2%.
- *Rolling terrain*: Any combination of grades and horizontal or vertical alignment that causes heavy vehicles to reduce their speed substantially below that of passenger cars but that does not cause heavy vehicles to operate at crawl speeds for any significant length of time or at frequent intervals. *Crawl speed* is the maximum sustained speed that trucks can maintain on an extended upgrade of a given percent. If the grade is long enough, trucks will be forced to decelerate to the crawl speed, which they can maintain for extended distances. Appendix A of Chapter 11, Basic Freeway Segments, contains truck performance curves that provide truck speeds for various lengths and severities of grade. The same curves may be used for uninterrupted-flow segments on multilane highways.
- *Mountainous terrain*: Any combination of grades and horizontal and vertical alignment that causes heavy vehicles to operate at crawl speed for significant distances or at frequent intervals.

Mountainous terrain is relatively rare. Generally, in segments severe enough to cause the type of operation described for mountainous terrain, there will be individual grades that are longer and steeper than the criteria for general terrain analysis.

The mountainous terrain category is rarely used, because individual grades will typically be longer and steeper than the criteria for general terrain analysis.

Exhibit 14-12 shows PCEs for trucks and buses and RVs in general terrain segments.

Exhibit 14-12
PCEs for Heavy Vehicles in General Terrain Segments

Vehicle	PCE by Type of Terrain		
	Level	Rolling	Mountainous
Trucks and buses, E_T	1.5	2.5	4.5
RVs, E_R	1.2	2.0	4.0

Equivalents for Specific Upgrades

Any grade between 2% and 3% and longer than 0.5 mi, or 3% or greater and longer than 0.25 mi, should be considered to be a separate segment. The analysis of such segments must consider the upgrade conditions and the downgrade conditions separately, as well as whether the grade is a single, isolated grade of constant percentage or part of a series forming a composite grade. Appendix A of Chapter 11 discusses the analysis of composite grades.

Exhibit 14-13 and Exhibit 14-14 give values of E_T and E_R for trucks and buses and for RVs, respectively. These factors vary with the percent of grade, length of grade, and the proportion of heavy vehicles in the traffic stream. Maximum values occur when there are only a few heavy vehicles in the traffic stream. The equivalents decrease as the number of heavy vehicles increases because these vehicles tend to form platoons. Because heavy vehicles have more uniform operating characteristics, fewer large gaps are created in the traffic stream when they platoon, and the impact of a single heavy vehicle in a platoon is less severe than that of a single heavy vehicle in a stream primarily composed of passenger