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SANTA CLARA UNIVERSITY

Department of Civil Engineering

I HEREBY RECOMMEND THAT THE SENIOR DESIGN PROJECT REPORT PREPARED
UNDER MY SUPERVISION BY

Melissa Elian-Carrillo

ENTITLED

Analysis and Redesign of I-680 and Mission Boulevard Interchange

BE ACCEPTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

BACHELOR OF SCIENCE
IN
CIVIL ENGINEERING

10/03/18

Advisor: Dr. Rachel He — Date

10-3-2018

Advisor: Dr. Hisham Said — Date

10.3.2018

Acting Chair of Department — Date

Analysis and Redesign of I-680 and Mission Boulevard Interchange

By

Melissa Elian-Carrillo

SENIOR DESIGN PROJECT REPORT

Submitted to
the Department of Civil Engineering

of

SANTA CLARA UNIVERSITY

in Partial Fulfillment of the Requirements
for the degree of
Bachelor of Science in Civil Engineering

Santa Clara, California

Fall 2018

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Karen Pachmayer (Thesis Advisor) for providing guidance while writing this thesis.

ANALYSIS AND REDESIGN OF I-680 AND MISSION BOULEVARD INTERCHANGE

Melissa Elian-Carrillo

Department of Civil Engineering
Santa Clara University, Fall 2018

ABSTRACT

The existing four cloverleaf design of the I-680 Mission Boulevard Interchange in Fremont, California, was analyzed at merge, diverge, basic, and weaving freeway segments. After the traffic analysis of all the segments, the critical segment for redesign was the merge segment of I-680 South to Mission Boulevard westbound, due to a failing Level of Service. Over a span of 17 years (2018-2035) a comparison of the current condition and the redesign was executed for crashes, congestion, air pollution, noise, greenhouse gases, and required road facilities and traffic services. The construction costs of the redesign as well as aesthetic, health, disaster mitigation, and environmental impacts were also considered for a life cycle analysis. A concrete was designed for this redesign to maximize sustainability, while keeping strength, and improving early strength gain. The concrete was tested in accordance with ASTM C109 standard. Strength results were recorded at seven days and 28 days.

TABLE OF CONTENTS

Project Background and Location

The I-680 and Mission Boulevard Intersection, is located in the city of Fremont, California. Fremont is in Alameda County in between the East Bay Area hills and the San Francisco Bay as depicted in Figure 1. I-680 is a North South freeway in California, which curves around the northeastern cities of California, while Mission Boulevard is a principal street in Fremont. Currently, the I-680 and Mission Boulevard interchange has a four clover leaf design implemented by Caltrans. Caltrans, the State of California, Department of Transportation, is responsible for the construction, maintenance, and operation of the California Highway System, as well as the portion of the Interstate Highway System within the state's boundaries. A map of the location of I-680 Mission Boulevard four clover leaf is shown in Figure 2.

Figure 1: Map of Fremont, California.

Figure 2: Location of four clover leaf in Fremont, California

The volume of commuters from the greater East Bay, as well as commuters from the South Bay that utilize this interchange has been increasing yearly. From 2008 to 2018, there has been a traffic volume increase of about 10 percent as dictated by the Alameda County Transportation Authority (DKS Associates, 2008). The large traffic volume going through both I-680 and the weaving segments of the interchange cause slow downs and low speeds. The Alameda County Transportation Commission, has recognized the I-680 Mission Boulevard interchange as an issue, and has solicited studies regarding traffic volumes, existing conditions, corridor studies, and an express lane feasibility study. Currently, the Alameda County Transportation authority is preparing a project initiation document with the City of Fremont, and the Santa Clara Valley Transportation Authority to solicit federal and state funding to improve the I-680 Mission Boulevard interchange. The current four clover leaf design is depicted in Figure 3. The traffic analyses section, delves further into the results regarding the traffic and existing conditions reports solicited from the Alameda County Transportation Commission.

The proposed redesign will account for current traffic conditions and projected traffic growth. The traffic conditions and growth will be analyzed to determine which sections of the interchange are critical for a redesign. A cost benefit analysis of the proposed redesign is included in the scope of this report which will assess how much the redesign will cost and benefit taking into account traffic parameters, such as crashes, congestions, and travel time. A sustainable concrete option for this project was designed and tested.

Figure 3: Bird's Eye View of I-680 and Mission Boulevard, four clover leaf

Traffic Analyses Current Condition

The Alameda County Transportation Authority has recognized a need for improvement of the I-680 and Mission Boulevard interchange, and has embarked "on preparing a project initiation document (PID) for the project, in cooperation with the City of Fremont and Santa Clara Valley Transportation Authority"; this document will be used to provide federal and state funding for the project. Current design alternatives presented by the Alameda Country Transportation include but are not limited to: improve geometry of the I-680 and Mission Boulevard Interchange and widen the lanes on Mission Boulevard. In order to move forward with the PID to apply for funding, a traffic volume analysis of the I-680 and Mission Boulevard Interchange was done by DTS Associates. The traffic volume analyses were done for peak hour morning (AM) and afternoon (PM) volume, for the years 2008 and 2035. These traffic volume reports are included in Appendix A. In order to reach the current time condition (2018) for the traffic volume, linear interpolation was used.

The basic, merge, diverge, and weaving segments were all analyzed of the I-680 and Mission Boulevard intersection. This interchange includes: two basic freeway segments which include 680 North and 680 South, four diverge and merge segments, and four weaving segments.

The determinant for redesigning a section of a freeway is the Level of Service (LOS). The Level of Service is defined by the Highway Capacity Manual (HCM) of 2010, as the chief measure of quality of a road, which is based on density, the units of density being passenger car, per mile, per lane. Table 1 manifests the LOS ranges from A to F reflective of the density; A has the lowest density and F has the highest density. The HCM defines LOS E as operation at capacity, and LOS F as breakdown or unstable flow, both E and F require redesign.

Table 1: Level of Service ranges according to the Highway Capacity Manual 2010

LOS	Density (pc/mi/ln)
A	<=11
B	>11-18
C	>18-26
D	>26-35
E	>35-45
F	Demand exceeds capacity >45

For this traffic analysis, the program HCS 2010 by McTrans was used to calculate LOS. The LOS is calculated based on: geometric data (lane width, or segment length) demand volume, free flow speed, peak hour factor, number of lanes, and heavy vehicle factor. The analysis was done for AM peak hour volumes and PM peak hour volumes.

The LOS levels that are indicators of redesign are E and F as defined by the HCM 2010. In Tables 2-5, the segments that result in LOS E and LOS F are highlighted in red. In AM 2018 results, shown in Table 2, the basic segments, 680 North and 680 South are at LOS E as well as the merge segment from Mission 680 South to Mission Westbound. In AM 2035 the LOS for 680 North and 680 South decrease to LOS F, in accordance with Table 3. The diverge segment from 680 South to Mission Westbound is at LOS F for AM 2035, as well as the merge segment from 680S to Mission westbound.

Table 2: HCS 2010 Level of Service AM 2018 Results

Segment	LOS A	LOS B	LOS C	LOS D	LOS E	LOS F
680 North					X	
680 South					X	
Diverge fr 680 N to Mission Eb		x				
Diverge fr Mission Eb to 680S		x				
Diverge fr Mission Wb to 680N		x				
Diverge fr 680S to Mission W		x				
Merge fr 680N to Mission Eb	x					
Merge fr Mission Eb to 680S	x					
Merge fr Mission W to 680N		x				
Merge fr 680S to Mission Wb					x	
Weaving Segment 1		x				
Weaving Segment 2			x			
Weaving Segment 3	x					
Weaving Segment 4		x				

Table 3: HCS 2010 Level of Service AM 2035 Results

Segment	LOS A	LOS B	LOS C	LOS D	LOS E	LOS F
680 North						x
680 South						x
Diverge fr 680 N to Mission Eb	x					
Diverge fr Mission Eb to 680S			x			
Diverge fr Mission Wb to 680N		x				
Diverge fr 680S to Mission W						x
Merge fr 680N to Mission Eb	x					
Merge fr Mission Eb to 680S		x				

Merge fr Mission W to 680N		**x**				
Merge fr 680S to Mission Wb						**x**
Weaving Segment 1			**x**			
Weaving Segment 2			**x**			
Weaving Segment 3		**x**				
Weaving Segment 4		**x**				

For the PM results, Table 4 identifies the current condition (2018) of 680 North to be LOS F. In 2035, 680 North continues to be LOS F. The merge segment from 680 South to Mission westbound is at LOS F as identified by Table 5.

Table 4: HCS 2010 Level of Service PM 2018 results

	LOS A	**LOS B**	**LOS C**	**LOS D**	**LOS E**	**LOS F**
680 North						**x**
680 South			**x**			
Diverge fr 680 N to Mission Eb		**x**				
Diverge fr Mission Eb to 680S		**x**				
Diverge fr Mission Wb to 680N	**x**					
Diverge fr 680S to Mission W		**x**				
Merge fr 680N to Mission Eb		**x**				
Merge fr Mission Eb to 680S		**x**				
Merge fr Mission W to 680N		**x**				
Merge fr 680S to Mission Wb				**x**		
Weaving Segment 1		**x**				
Weaving Segment 2			**x**			
Weaving Segment 3			**x**			
Weaving Segment 4			**x**			

Table 5: HCS 2010 Level of Service PM 2035 Results

	LOS A	LOS B	LOS C	LOS D	LOS E	LOS F
680 North						x
680 South				x		
Diverge from 680 N to Mission Eb			x			
Diverge from Mission Eb to 680S			x			
Diverge from Mission Wb to 680N	x					
Diverge from 680S to Mission W		x				
Merge from 680N to Mission Eb			x			
Merge from Mission Eb to 680S		x				
Merge from Mission W to 680N			x			
Merge from 680S to Mission Wb					x	
Weaving Segment 1			x			
Weaving Segment 2			x			
Weaving Segment 3			x			
Weaving Segment 4				x		

The results of the traffic analyses of current and future volumes proved the basic freeway segments of 680 South, and 680 North as the most critical to redesign; following with the merge segment from 680 South to Mission Westbound.

Due to the size of the team, solely the merge segment from 680 South to Mission Westbound was chosen to redesign. The merge segment is shown in Figure 4 from a bird's eye view.

Figure 4: Merge segment from 680 South to Mission West circled on four clover leaf interchange.

Proposed Design: Criteria and Constraints

To improve the LOS of the merge segment from 680 South to Mission West, the proposed design was to construct an additional lane on the ramp preceding the merge segment. Figure 5 shows the location of additional lane on the ramp. The ramp was added on the eastern side of the interchange.

Figure 5: Merge segment from 680 South to Mission West circled in red on four clover leaf interchange, addition of lane location in red arrow.

The addition on the eastern side was made to avoid trespassing onto any person's property. After measuring distances with Google Earth, there was sufficient clearance (40.79 feet) between the existing North West clover leaf and the existing ramp to add an additional lane. Auto CAD drawings and Specifications of measurements are in Appendices B and C.

The design criteria for the lane addition was in accordance with the Highway Design Manual published by Caltrans; I-680 is a freeway in California, therefore under Caltrans jurisdiction. The lane width of the proposed design is 12 feet. Due to the addition of the lane on the eastern side, the distance between properties on the western side of the ramp was kept the same. The minimum curve radius was 316 feet throughout the ramp addition. The curve radius was found using Equation 1. The factors in Equation 1 to determine the minimum curve radius (r) include superelevation (e), a coefficient for side friction (f_s), and velocity (v).

$$e + f_s = \frac{v^2}{15r} \qquad \text{(Eq. 1)}$$

Conservative values were used for superelevation and the coefficient for side friction, .04 and .15 respectively. The velocity or speed limit of the ramp is 35 miles per hour (mph). The terrain was assumed to be level. At the merge segment, the existing shoulder, and 12 feet of the existing barrier will be taken out to account for the lane addition and shoulder. The shoulder will be kept to existing standard of a width of five feet.

Figure 6: Bird's eye view of existing conditions at merge segment. Red line indicates what will be taken out to account for ramp lane addition.

Details with dimensions and dimension for proposed lane addition are included in Appendix B and Appendix C.

Traffic Analyses of Proposed Design

The proposed design was input into HCS 2010 to determine the LOS for AM and PM, as well as present and future values.

Table 6: Comparison of Level of Service for Current and Proposed Designs.

Current Design	Proposed Design					
	LOS A	LOS B	LOS C	LOS D	LOS E	LOS F
AM 2018			x		x	
AM 2035					x	x
PM 2018		x		x		
PM 2035		x			x	

There was a great improvement in LOS of the merge segment for AM 2018, PM 2018, and PM 2035. Table 6 indicates an improvement to LOS B for PM volumes of both 2018 and 2035. AM 2018 Level of Service improved to C. AM 2035 improved to LOS E from LOS F. For AM 2035, even with the proposed design, the merge segment is at capacity. This can occur when the volume of a segment is really high.

Table 7: Density values for current and proposed design, AM 2035 highlighted

	Current Condition Density (pc/mi/ln)	Proposed Solution Density (pc/mi/ln)	Percent Reduction (between Current and Proposed)
AM 2018	35.8	23.3	42.3%
AM 2035	50.9	35.2	36.5%
PM 2018	30.4	14.7	69.6%
PM 2035	36.0	23.5	42.0%

In taking a closer look at the improvement of density, there is a significant reduction of density of 36.5 percent of the proposed versus current design. The limit for LOS D is a density of 35 (pc/mi/ln) as seen in Table 1, so with a density of 35.2, the LOS for the AM

2035 volume is on cusp of LOS D and E. The segment redesign can be monitored throughout future years for AM values, to assure the design is performing above LOS E. Overall, the improvements of density of the proposed design were significant, and did help improve the Level of Service, as well as traffic flow. The proposed design also, reduced travel time of people and congestion.

Benefit Cost Analysis

A benefit cost analysis was performed to assess social, environmental, and financial impacts of the redesign. The comparison, was between the present condition and redesign of the freeway segment over a period of 17 years (2018-2035). Victoria Transport Policy Institute which is an independent research company dedicated to transportation planning and policy analysis, was used to quantify values for traffic costs and benefits, including construction costs and benefits. The goals of this institute are to identify better solutions to transportation problems, identify the benefits of alternative transportation programs and policies, and be able to compare and evaluate alternatives. The institute has published values to quantify problems such as construction costs, congestions, environmental impacts, road wear, car wear, which are listed in Table 8.

The costs of the redesign included construction, and loss of natural vegetation. The redesign included .347 miles, and .054 miles in shoulder improvements. The total cost of construction for the ramp addition and shoulder improvements was $1,235,996, in accordance with costs in Table 8 rows 1-2. The total amount of loss of natural vegetation was .007 acres. The factors for loss of natural vegetation include aesthetic, health (exercise and mental health), disaster mitigation (e.g. flood protection), and environmental (water, air, material, etc.) as listed in Table 8, rows 5-7. The total cost for loss of natural vegetation was $168.23. The present design had a net cost of zero for construction and loss of natural vegetation.

Table 8: Costs of constructing a new lane taken from the Victoria Transport Policy Institute.

Description	Cost ($) inflated to 2018 dollar value
Construction of a new lane	$3,302,727 per lane mile
Resurfacing and Shoulder improvements	$575,800.11 per lane mile
Crashes, congestion, air pollution, noise, greenhouse gases, and required road facilities and traffic services	$.38 per vehicle mile
Aesthetic	$1590.88 per acre per year
Health (exercise and mental health)	$12.73 per acre per year
Disaster mitigation (e.g. flood protection)	$11,163.62 per acre per year
Environmental (water, air, material, etc.)	$11,265.79 per acre per year

The life cycle analysis included the difference between the present condition and redesign condition for: crashes, congestion, air pollution, noise, greenhouse gases, required road facilities and traffic services, and travel time, over a period of 17 years (2018-2035).

$$D = x * \frac{m}{y} * z * v \qquad \text{(Eq.2)}$$

where

D = cost of crashes, congestion, air pollution, noise, greenhouse, gases, and required road facilities and traffic services

x = $.38 from Table 8 row 3

m = speed limit posted (miles per hour)

y = speed of current or redesign condition (miles per hour)

z = distance of the ramp (miles)

v = Volume (cars per peak hour)

In Equation 2, the variable was y, the speed of current or redesign condition, which is found in Appendix D, from the HCS 2010 reports. The speed for each year between 2018 and 2035 was done with linear interpolation. Equation 1 was carried out for the AM and PM current condition over 17 years, and then for AM and PM for the redesign condition, also for

17 years. The distance of the ramp in miles is .284 miles. The volumes are found in Appendix A, and for each year in between 2018 and 2035, linear interpolation was done. The difference was taken between both conditions, which resulted in a positive benefit.

$$B = \Delta t * v * \frac{5}{7} * 365 \frac{days}{year} * f \qquad \text{(Eq.3)}$$

where

B = dollar value of travel time saved between current condition and redesign, if greater than zero, B is a benefit

Δt = difference in travel time between the current and redesign condition. Taken from dividing the speeds from HCS 2010 reports in Appendix D by the distance of the ramp in miles.

v = volume (cars per peak hour)

f = the average hourly salary in Fremont, California

In Equation 3, the 5/7 value represents the weekdays in which peak hour volume occurs. The dollar value of $19.52 if f which represents the average hourly salary for Fremont, California from the US Census Bureau salaries.

When taking into account the difference between both the redesign and current condition in Equation 2, and taking into account Equation 3, the result was a total positive benefit of $253,605.49 over a span of 17 years . Overall, this redesign proved a positive impact in terms of crashes, congestion, air pollution, noise, greenhouse, gases, required traffic services, and travel time.

Sustainable Concrete Design

Another element to this redesign is the concrete, or asphalt used for the additional lane. “It is known that cement pavements have lower technical characteristics than asphalt pavements in terms of evenness and serviceability but their durability is higher.” (Materials and Science Engineering, 2017). The funding for this project was not yet defined, therefore, concrete was chosen for the lane addition, because the durability is higher. High traffic volumes in this lane made durability an essential material property, for this project.

The critical qualities of the designed concrete were: sustainability, durability, and strength. Concrete is a byproduct of mixing cement, sand, and water. The reaction of calcium hydroxide (CH) and calcium silicate hydroxide (CSH) occurs to create concrete. In order to make a concrete sustainable, a pozzolan can be added to mix instead of cement. Pozzolans are compounds that react with water and CH to form CSH. CSH is the matrix that binds concrete together; it is also responsible for the strength in concrete (Nilsson, 2018). Lesson 7 Materials Handout. CH is the crystalline structure that fills the voids in CSH to improve durability (Nilsson, 2018). Although it is known, CSH is the matrix that binds concrete together, it is also known that it is a variable nonstoichiometric composition (Materials Research Society, 2012) which in turn makes strength testing for concrete essential.

There are many different types of pozzolans: volcanic ash, fly ash (a byproduct of coal production), silica fume, rice husk ash, and slag (a byproduct of steel production). Caltrans has published a wide variety of use of fly ash in their roadwork, and it is also a pozzolan that has a lot of extensive research for example, the US Army Corps of Engineers published a Technical Report SL 95-9 in 1995, that discussed the strength effects of different percentages of fly ash in concrete.

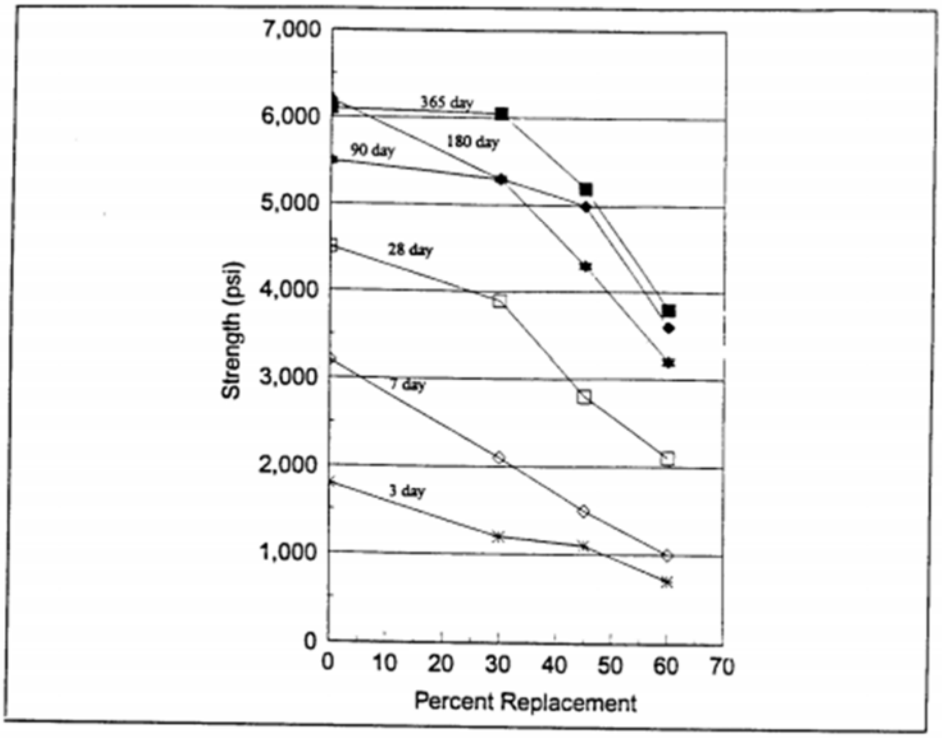

Figure 7: Strength versus percent replacement of cement with fly ash w/c = 0.5. US Army Corps of Engineers, Technical Report SL 95-9 (1995)

Figure 7 makes clear that the more percent replacement of fly ash in concrete the less strength the concrete has. The construction requirement for rigid pavement (concrete) according to the US Department of Transportation, Federal Highway Administration is 4000 pounds per square inch (psi).

Although the required 28 day strength for a concrete used on freeways is 4000 psi, the available concrete in the lab had an average strength of 2450 psi. The testing was done on the concrete with an average strength of 2450 psi, due to materials available in the lab. In order to assure the strength is met for implementation, testing on a concrete with an average strength of 4000 psi or higher would need to be done.

Another element of this designed concrete, is the need to set and harden quickly. The freeway lane cannot be out of service for a long time, because that means more cost and time waiting for the benefits of the addition.

Holistically the mix that was chosen was: a mixture of silica sand from Ottawa, Type one-two cement (30%), and Class F Fly Ash (70%), Lime with a chemical composition of calcium hydroxide (30% of the amount of fly ash) , and a calcium chloride accelerator. The silica sand, and type one-two cement was chosen due to materials available in the lab, as well as the Class F Fly Ash. The percentage of cement and fly ash was chosen to maximize sustainability. As seen in Figure 7, a 70 percent cement replacement would have more than a 73 percent difference in strength, from a zero percent cement replacement. In order to account for this large decrease in strength, the addition of Lime was chose due to its, chemical composition. In theory, the lime would bond with the pozzolan early on to create an increase in strength earlier, and an accelerator would speed up the process of the cement and water mix. The main purpose was to see the effects of lime and pozzolans mixed with traditional cement, and if the mixture would prove to have early strength gain, which could be important for applications of concrete such a ramp on a freeway, when concrete needs to gain set and gain strength quickly.

There were two batches that were tested: one batch with simply the silica sand from Ottawa, Type one-two cement (30%), and Class F Fly Ash (70%) which is defined as the control, and the other batch with the addition of the lime and accelerator. This designed concrete was tested by ASTM C109 standard, which is included in Appendix E.

Sustainable Concrete Testing and Results

Overall, the lime and accelerator did not contribute to early strength gain at 7 days, however did contribute to later strength gain at 28 days.

Table 9: Seven and 28 day strength results of designed concrete.

	Load (lbs) Control	Load (lbs) Lime + Accelerator	Compressive Strength (psi) Control	Compressive Strength (psi) L+A
7 day test	2331	1564	583	391
28 day test	7730	8250	1932	2063

The batch with the lime and accelerator had a lower 7 day strength at 391 psi in comparison to the control which yielded 583 psi, as listed in Table 9. The batch with the lime and accelerator had a 7 percent higher strength than the control. Overall the lime and accelerator decreased initial strength, and did not make a significant difference in long term strength. The designed concrete is not recommended for this ramp design.

In order to meet the US Federal Highway requirements of 28 day strength 4000 psi, the recommended concrete would include 20 percent fly ash and 80 percent cement with a water to cement ratio of 0.4, in accordance with Figure 7.

For future testing, a different cement type, or pozzolan could be used. There is a Class C fly ash that could have proven to be more efficient with lime. Possibly silica fume or slag, could have reacted differently with the lime to create more early strength gain. Although in this test, a calcium chloride accelerator was used, in future testing a non chloride accelerator should be used to avoid corrosion of rebar.

Conclusion

In performing a traffic analysis of the I-680 Mission Boulevard interchange with future growth, the merge segment of I-680 South to Mission Boulevard westbound was a critical segment for redesign due to the failing LOS now, and the projected LOS in 2035. After performing a life cycle cost analysis, the redesign proved to be beneficial in reducing crashes, congestion, air pollution, noise, greenhouse gases, required road facilities and traffic services, and travel time. One factor for future analysis, would be how to reduce construction costs of the redesign, and how to reproduce the natural vegetation lost from taking out the shoulder in the redesign. The sustainable concrete designed for this project, did not prove to be effective after testing. However, further testing of cement, pozzolans, and additives, such as lime to make pozzolans react quicker with the byproduct of cement and water are encouraged for future research. This research could discover concrete mixes that are more sustainable, but have the same amount of strength as a solely cement water mixture, if not more strength.

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Appendix A: Traffic Volume Reports

Route 262 Improvements Existing Conditions Traffic Operations Report

Prepared for

Alameda County Congestion
Management Agency
and
HQE Incorporated

Draft Report

Prepared By

***DKS** Associates*
1000 Broadway, Suite 450
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June 23, 2008

DKS Associates
TRANSPORTATION SOLUTIONS

DRAFT

TABLE OF CONTENTS

List of Figures

List of Tables

1 INTRODUCTION

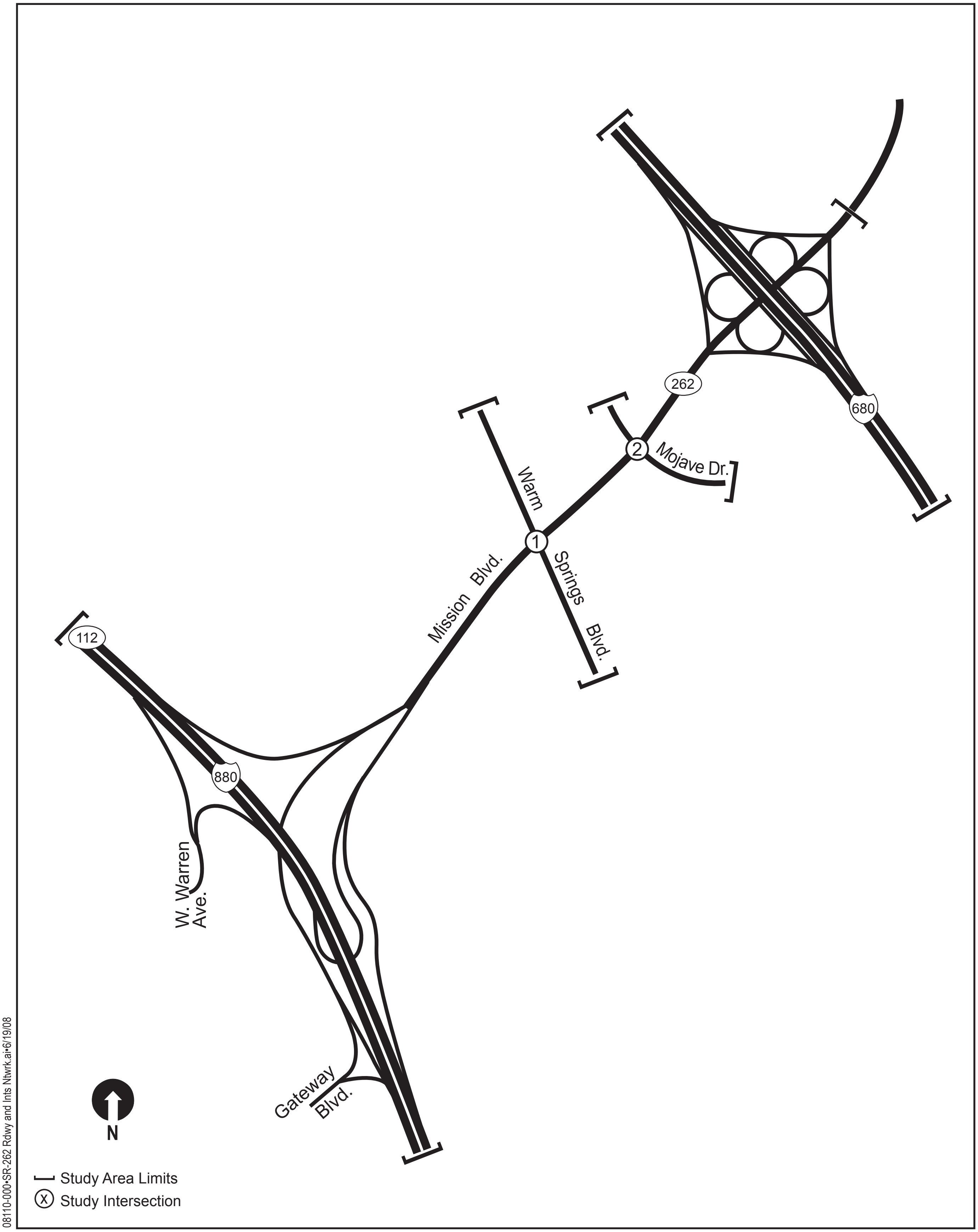
The Alameda County Congestion Management Agency (ACCMA), in partnership with the City of Fremont and Caltrans, has contracted with HQE, Inc. and DKS Associates to prepare a Project Study Report (PSR) for potential improvements to State Route 262 (Mission Boulevard) between I-880 and I-680 in the City of Fremont. The Route 262 Improvements PSR will address the need and purpose of the proposed project, identify the potential environmental impacts, and identify the estimated costs and timeline for delivery. The PSR will consist of evaluating the following project components:

- Widening of Route 262 (Mission Boulevard) from four to six lanes between Warm Springs Boulevard and I-680;
- Modification of the I-680/Route 262 interchange to improve operations; and
- Tight Diamond Interchange and/or intersection improvements at Route 262/Warm Springs Boulevard.

The purpose of this report is to describe the existing conditions within the study area with respect to key roadway infrastructure and traffic performance.

While the proposed project components focus on improvements to SR 262 and the I-680/SR 262 interchange, the traffic analysis network includes all ramps and mainlines at the I-680/SR 262 and I-880/SR 262 interchanges plus the arterial segment of SR 262 between these interchanges. This arterial segment includes the signalized intersections at Warm Springs Blvd and Mohave Drive. The study area and intersections are illustrated in Figure 1.

Section 2 of this report identifies the various data and information sources used in preparing this memorandum. The existing roadway infrastructure is described in Section 3. A summary of the traffic data is presented in Section 4. A summary of the congestion and queuing characteristics within the study area is presented in Section 5. The level-of-service (LOS) analysis results for the study intersections are provided in Section 6, while the freeway merge, diverge and weave analysis results are presented in Section 7.



DKS Associates
TRANSPORTATION SOLUTIONS

Figure 1
Roadway Network and Study Intersections

2 DATA SOURCES

This study includes the analysis of operating conditions during both the weekday AM peak period (6:00 AM to 10:00 AM) and PM peak period (3:00 PM to 7:00 PM). To support this analysis, extensive field observations, data compilation, and data collection were conducted. The types of data relevant to this effort and the sources for these data are presented in Table 1.

Table 1 Relevant Data Sources

Data Type	Source (s)	Dates	Comments
Freeway and arterial geometry	Aerial photographs	June-08	
	DKS field review	June - 08	
Intersection signal timing	Caltrans		
Freeway mainline traffic volumes	PeMS	Real-time data	Multiple locations within study area, however reliability varies
Freeway ramps and connectors traffic volumes	DKS 4-hour manual counts during AM/PM peak	June - 08	Counts performed: NB I-880 off to Mission SB I-880 overpass to Mission SB I-880 to West Warren Ave WB Mission to NB I-880 WB Mission to SB I-880 WB Mission to Gateway EB Gateway to SB I-880
	Prior Study (Fremont Bayside EIR)	Feb - 08	2-hour manual counts
	Caltrans Census	2004 and 2006	
Freeway truck volumes/percentages	PeMS database	June - 07	
Arterial segment traffic volumes	DKS 1-week tube counts	June - 08	Count performed: Segment of Mission Blvd East of I-680
Intersection traffic volumes	DKS 4-hour manual traffic counts	June - 08	Counts performed: Mission Blvd at Warm Springs Blvd Mission Blvd at Mohave Drive
	Prior Study (Fremont Bayside EIR)	Feb - 08	2-hour manual counts
Source: DKS Associates, 2008			

3 EXISTING ROADWAY INFRASTRUCTURE

The study network is comprised of two interchanges and two intersections. The design characteristics of each interchange and each intersection are described below.

3.1 I-680/SR-262 Interchange

The interchange at I-680 and SR-262 is a cloverleaf interchange as illustrated in Figure 2. With this design, there are collector/distributor roads to provide a buffer between weaving vehicles using the interchange and mainline traffic on I-680. Within the study area, I-680 has three mixed lanes in the northbound direction. In the southbound direction, the mainline includes three mixed lanes and one HOV lane. There is also a southbound auxiliary lane between the Auto Mall/Durham Road on-ramp and the SR 262 off-ramp. SR-262 (Mission Boulevard) is an east-west highway and it has two lanes on each direction. Within the interchange there are auxiliary lanes between the loop ramps on SR 262.

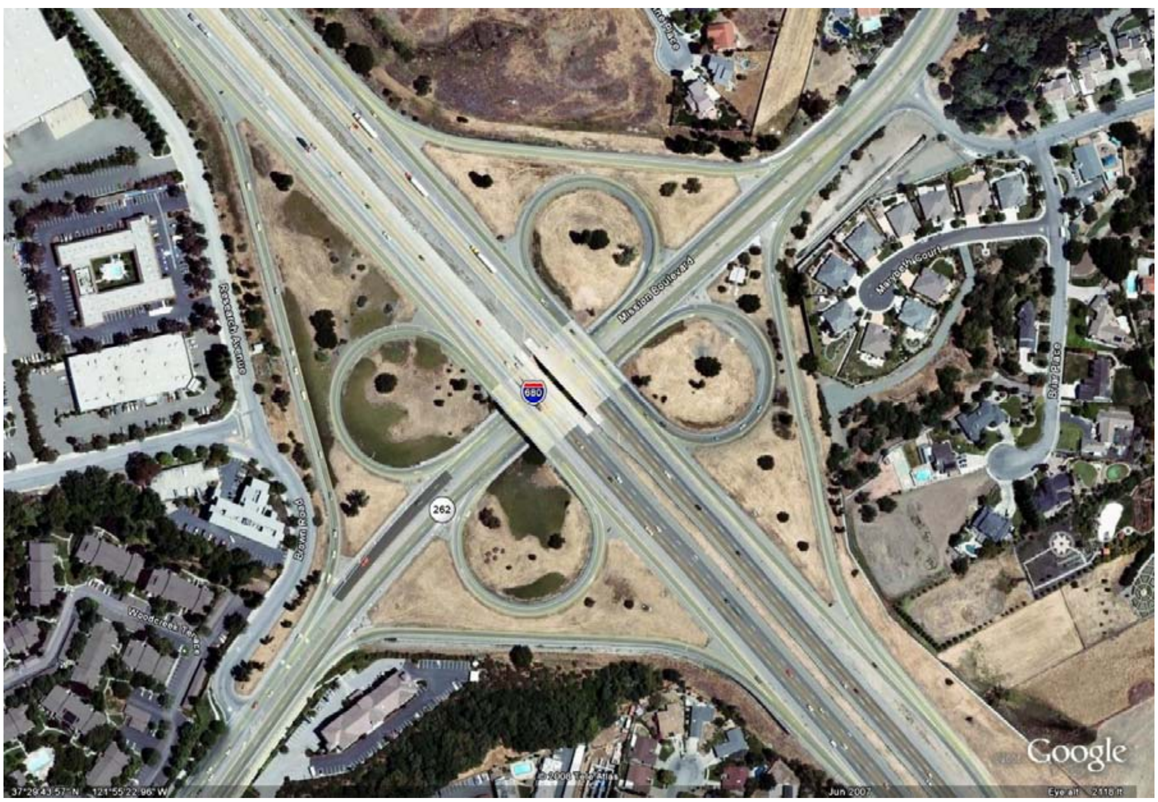


Figure 2 I-680/SR 262 Interchange

3.2 I-880/SR-262 Interchange

Unlike the I-680/SR-262 Interchange, the I-880/SR-262 Interchange is not a standard interchange as illustrated in Figure 3. Currently, there are three lanes on each direction of I-880 through the interchange and two lanes on each direction of SR-262 to the east of the interchange. However, improvements to this interchange and segment of I-880 are currently under construction. These improvements will include new connectors and extension of the HOV lanes in both direction through the interchange.

Figure 3 I-880/SR 262 Interchange

3.3 Warm Springs Blvd/SR-262 Intersection

The intersection of Warm Springs Boulevard and SR-262 (Mission Boulevard) is shown in Figure 4. Warm Springs Boulevard is a major north/south arterial with two lanes in each direction, widening to five or six lanes at the intersection. To the west of Warm Springs, SR 262 is two lanes in each direction but widens to three continuous lanes between Warm Springs and Mohave in both directions. SR 262 also widens to five or six lanes at the intersection. There are striped bike lanes on Warm Springs Blvd south of SR 262, and on SR 262 east of Warm Springs Blvd.

The intersection geometry is summarized below:

- Northbound (Warm Springs Blvd): 2 left-turn lanes + 2 through lanes + 1 right-turn lane
- Southbound (Warm Springs Blvd): 2 left-turn lanes + 1 through lanes + 1 shared lane (through and right-turn) + 1 right-turn lane
- Eastbound (SR 262): 2 left-turn lanes + 3 through lanes + 1 right-turn lanes
- Westbound (SR 262): 2 left-turn lanes + 3 through lanes + 1 right-turn lane

Figure 4 Warm Springs Blvd/ SR 262 Intersection

3.4 Mohave Dr/SR-262 Intersection

The intersection at Mohave Drive and SR-262 (Mission Boulevard) is shown in Figure 5. Mohave Drive is a local collector with one lane in each direction. The intersection geometry is:

- Northbound (Mohave Drive): 1 left-turn lane + 1 through lane + 1 right-turn lane
- Southbound (Mohave Drive Blvd): 1 left-turn lane + 1 shared lane (through and left –turn) + 1 right-turn lane
- Eastbound (SR 262): 1 left-turn lane + 3 through lanes + 1 right-turn lane
- Westbound (SR 262): 1 left-turn lane + 2 through lanes + 1 shared lane (through and right-turn lane)

Figure 5 Mohave Dr/ SR 262 Intersection

4 TRAFFIC DATA SUMMARIES

4.1 Freeway Mainline Traffic Volumes

Mainline traffic volumes were obtained from PeMS for selected locations on both I-880 and I-680 on a typical weekday in April of 2008. Table 2 summarizes the observed freeway mainline volumes during AM and PM peak periods.

Table 2 Observed Freeway Mainline Volumes

Location	Date	Median Volume (vph)							
		AM				PM			
		6-7	7-8	8-9	9-10	3-4	4-5	5-6	6-7
I-680N before Mission Blvd On-ramp (VDS 400376)	Apr-08	3742	4793	4677	3703	5491	4837	5036	5154
I-680S after Mission Blvd Off-ramp (VDS 400566)	Apr-08	3423	5004	5546	3964	2889	3240	3574	2781
I-880N after Mission Blvd On-ramp (VDS 400189)	Apr-08	3311	4158	3769	3549	5449	5884	6119	5986
I-880S before Lakeview Blvd/West Warren Ave Off-ramp (VDS 400409)	Apr-08	6214	5982	5250	5229	5321	5352	5315	4776

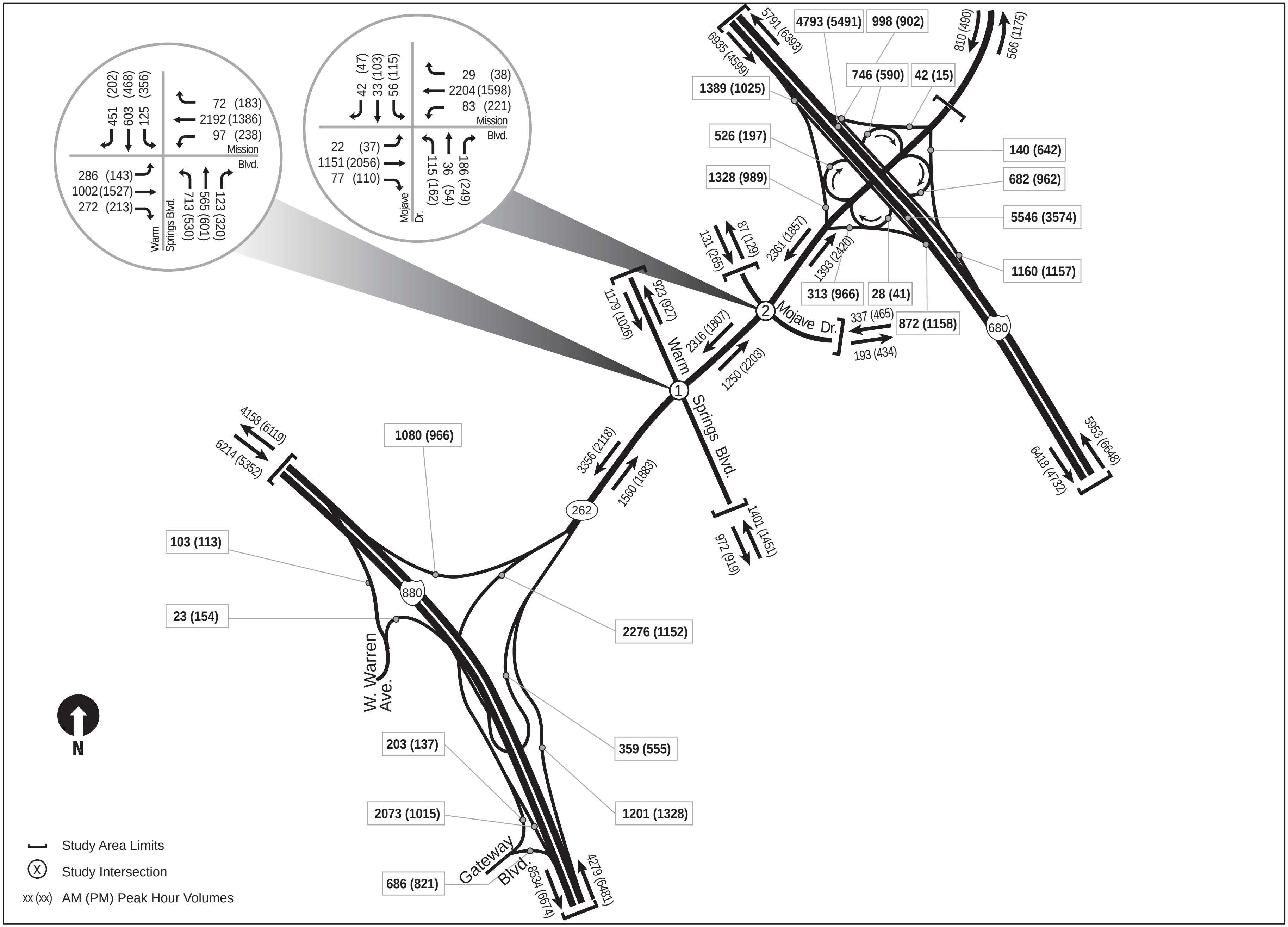
Source: PeMS

Exact locations of the first three detector stations were verified from a field observation. The location of the last detector station is approximated from the PeMS graphical user interface. These four detector stations provide freeway mainline volumes for this study.

4.2 Ramp and Intersection Traffic Volumes

Traffic volumes for the ramps and intersections within the study area were derived from numerous sources including the Caltrans Traffic Volume Census, recent counts conducted for the Fremont Bayside EIR, and new data collected in May/June of 2008. Caltrans Census data included 2004 and 2006 counts for the I-880/SR 262 and I-680/SR 262 interchanges respectively. Manual ramp and intersection counts for the Fremont Bayside EIR were conducted in February 2008. New counts specifically for this study were conducted for all ramps at the I-880/SR 262 interchange, two ramps at I-680/SR 262 interchange. Copies of the data sheets for these new counts are contained in Appendix A.

As would be expected, the counts from the different sources vary, sometimes substantially. Also, the counts for adjacent facilities (i.e. the departure of one intersection and approach for the downstream intersection) do not always match. To support the traffic modeling and analysis activities, the counts compiled from all of the sources mentioned above were used to develop a set of balanced AM and PM peak hour traffic volumes. These values, shown in Figure 6, are the basis for the existing conditions operational analysis presented in Sections 5 and 6 of this report.



08110-000•SR-262AM PM Balanced Vols.ai•6/19/08

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Figure 6
AM and PM Peak Hour Balanced Volumes

4.3 Truck Volume and Percentage

Truck volume and percentage data within the study area were extracted from the PeMS database for freeways. Average peak periods and daily truck volumes and percentages for April of 2008 are presented in Table 3.

Table 3 Freeway Truck Percentages and Volumes

Location	AM Peak Period (6-10 am)		PM Peak Period (3-7 pm)		Average Daily Data	
	Truck Percentage	Truck Volume (veh)	Truck Percentage	Truck Volume (veh)	Truck Percentage	Truck Volume (veh)
I-680 Northbound						
I-680N south of the study area (VDS 400232)	4.9%	728	3.0%	523	4.8%	2,781
I-680N before Mission Blvd Offramp (VDS 401583)	0.7%	110	0.9%	148	0.5%	315
I-680N before Mission Blvd Onramp (VDS 400376)	15.5%	2,633	13.7%	2,812	17.0%	12,572
I-680 Southbound						
I-680S after Mission Blvd Off-ramp (VDS 400566)	1.3%	228	0.9%	110	1.0%	492
I-680S after Mission Blvd On-ramp (VDS 400633)	3.6%	523	3.6%	481	2.8%	1,345
I-880 Northbound						
I-880N before Dixon Landing Rd On-ramp (VDS 401643)	4.6%	744	1.4%	277	5.4%	4,022
I-880N after Mission Blvd On-ramp (VDS 400189)	7.4%	1,086	4.3%	1,007	6.0	4,639
I-880 Southbound						
I-880S before Lakeview Blvd/West Warren Ave Off-ramp (VDS 400409)	5.4%	1,213	2.9%	613	4.2%	3,805
I-880S after Dixon Landing Rd Off-ramp (VDS 401637)	2.0%	352	4.9%	713	4.2%	2,721
Source: PeMS						

For northbound I-680, PeMS Vehicle Detector Station (VDS) 400232, which is located south of the study area, was used to derive truck percentages instead of using VDS 401583 and VDS 400376. That is because data from these two detectors, which are close to each other, are not consistent with one another nor adjacent locations and PeMS detector diagnostics indicate hardware problems.

For SR 262, truck percentages were derived from the intersection counts at Warm Springs Boulevard and Mohave Drive (attached in Appendix C). Table 4 summarizes truck percentages on SR 262.

Table 4 SR-262 (Mission Boulevard) Truck Percentages

Location	AM Peak Hour	PM Peak Hour
SR-262 Eastbound	7.4%	2.6%
SR-262 Westbound	4.9%	3.7%

Source: DKS Associates, 2008

5 CONGESTION AND QUEUING OBSERVATIONS

In this section, the traffic data described in the prior section have been combined with direct observations of traffic operating conditions to develop a profile of the congestion and queuing characteristics within the study area. The field observations were conducted in June 2008. It should be noted that construction of the I-880/SR 262 improvements is underway at this time. These construction activities were observed to impact the travel speed on SR 262, especially eastbound SR 262 during the PM peak.

For each analysis period, the operating conditions and issues within the study area are summarized below and are illustrated in Figure 7.

5.1 Weekday AM Peak Period (6:00-10:00 AM)

During the AM peak period, varying levels of congestion were observed on I-680 southbound, I-880 southbound, and SR 262 westbound. A description of the weekday AM peak period congestion and queuing conditions, broken down by facility and direction, is provided below.

I-680 Northbound
No significant mainline congestion was observed during the AM peak period.

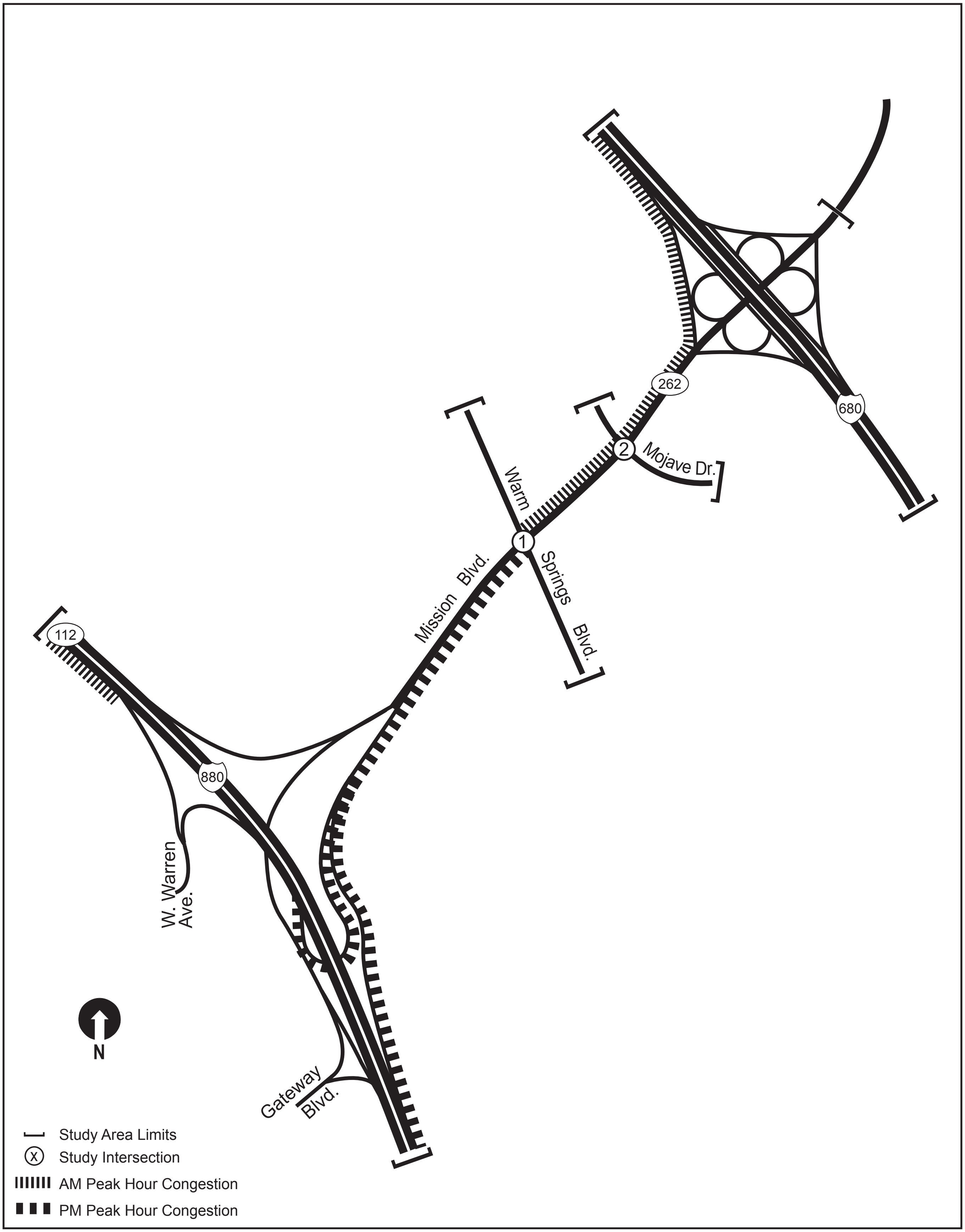
I-680 Southbound
Congestion on I-680 southbound was observed due to the queue spilling back from the downstream intersections on westbound SR-262 at Mohave Drive and at Warm Springs Boulevard. The queue from these intersections extends onto the southbound I-680 off-ramp and mainline I-680. The maximum observed queue extended 1000 ft north of the I-680 off-ramp. This condition was observed to start around 6:00 AM and continued beyond 10:00 AM.

I-880 Northbound
No significant mainline congestion was observed during the AM peak period.

I-880 Southbound
Congestion was observed on I-880 southbound due to the bottleneck between the off-ramp to W. Warren Avenue and the off-ramp to eastbound SR 262. The congestion started around 7:15 AM and continued beyond 10:00 AM. The queue extends beyond the Fremont Boulevard interchange.

SR 262 Eastbound
No significant congestion was observed during the AM peak period.

SR 262 Westbound
Congestion was observed on SR 262 westbound between Warm Springs Boulevard and I-680. It was caused by a high traffic demand from I-680 southbound heading to I-880 southbound. The queue started from the Warm Springs/SR 262 intersection and spills back through the Mohave/SR 262 intersection, onto the I-680 southbound off-ramp, and eventually onto I-680 southbound.



08110-000•Observed AM-PM Congestion.ai•6/19/08

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Figure 7
Observed AM and PM Network Congestion

5.2 Weekday PM Peak Period (3:00-7:00 PM)

During the PM peak period, varying levels of congestion were observed on I-880 northbound, I-880 southbound, and SR 262 eastbound. A description of the weekday PM peak period congestion and queuing conditions, broken down by facility and direction, is provided below.

I-680 Northbound

During the field investigations conducted for this study, no significant mainline congestion was observed during the PM peak period.

I-680 Southbound

No significant mainline congestion was observed during the PM peak period.

I-880 Northbound

Congestion was observed on I-880N, south of the off-ramp to SR 262 eastbound. This condition is the result of several factors including the existing bottleneck downstream of the off-ramp, current construction activities on both the I-880 mainline and the off-ramp, the turbulence caused by the northbound I-880 vehicles merging into the auxiliary lane to get off the freeway at Mission off-ramp, and congestion on the off-ramp itself. It started around 3:00 PM and continued beyond 7:00 PM. The queue extends beyond the Dixon Landing Road interchange.

I-880 Southbound

No significant mainline congestion was observed during the PM peak period. However, queuing was observed on the off-ramp to SR 262 eastbound due to the bottleneck at the downstream intersection at SR 262/Warm Springs. This queue was observed to extend the whole length of the off-ramp to SR 262 eastbound from 4:00 PM to 5:00 PM.

SR 262 Eastbound

Congestion was observed on SR 262 eastbound from Warm Springs Boulevard into the I-880 interchange. It was caused by a high traffic demand from I-880 northbound heading to I-680 northbound and slow travel speed in the construction zone. The demand exceeds Warm Springs/SR 262 intersection capacity causing queues that extend to the off-ramps from both I-880 northbound and I-880 southbound.

SR 262 Westbound

No significant congestion was observed during the PM peak period.

6 INTERSECTION LEVEL-OF-SERVICE

The AM and PM peak hour Level-of-Service (LOS) for each study intersection was determined using Synchro and the procedures from the 2000 Highway Capacity Manual (HCM) Operational methodology. As part of this methodology, the average delay per vehicle is used to determine the LOS. The results of this analysis are presented in Table 5. Synchro Level-of-Service calculations are attached in Appendix B.

Table 5 Existing Intersection Level-of-Service

ID	Study Intersection	AM Peak		PM Peak	
		Delay (sec/veh)	LOS	Delay (sec/veh)	LOS
1	Mission Blvd/SR 262 at Warm Springs Blvd	82.2	F	42.0	D
2	Mission Blvd/SR 262 at Mohave Dr	17.2	B	32.0	C

During the AM peak hour, the SR 262/Warm Springs intersection operates at LOS F. although the analysis results suggest that the SR 262/Mohave intersection operates at LOS B, the queue from Warm Springs spills back through this intersection. Consistent with the field observations, the Simtraffic simulation showed the westbound queue from SR 262/Warm Springs extending back through the SR 262/ Mohave Dr intersection and back to southbound I-680 off-ramp and I-680 mainlines during the AM peak hour. Similarly, the Simtraffic simulation also showed the queue formed on the eastbound Mission Blvd/SR 262 from Mission Blvd/ Warm Springs Blvd intersection and spilled back to northbound I-880 off-ramp to eastbound SR 262 during the PM peak hour.

7 FREEWAY MERGE, DIVERGE, AND WEAVING ANALYSIS

7.1 Methodology

The analysis of merge, diverge and weaving sections was undertaken using the Highway Capacity Software (HCS), which implements the HCM 2000 methodology. The sections that required additional analysis using HCS are listed in the following tables. Some difficulty comes from the presence of the weaving section in the non-freeway lane (SR 262), which is not specifically accommodated in the weaving section analysis in the HCM. Because the minimum free-flow-speed is required to be 55 mph for a weaving segment analysis in the HCM, the free-flow-speed on SR 262 is assumed to be 55 mph even though the posted speed limit in this section is 45 mph. The analysis results will be carefully reviewed to identify any impacts caused by this assumption.

It is noted that when a single-lane off-ramp results in a lane drop, the capacity of the ramp is governed by its geometry, and it is analyzed as a ramp roadway. When a lane drop occurs 2,500 ft or less downstream from a merge point at which a lane was added, a weaving configuration is created and should be analyzed using the weaving analysis procedure. In other cases, the entering and departing freeway segments are analyzed as basic freeway segments having different number of lanes. This will be applied to the following sections: northbound I-680 off-ramp to SR 262, southbound I-680 off-ramp to SR 262, northbound I-880 off-ramp to SR 262, and eastbound SR 262 on-ramp to southbound I-680.

When the number of lanes leaving the diverge area is more than the number entering the segment, it is considered as a major weave.

On-ramps are sometimes associated with the addition of a lane at the merge point. Similar to the lane drop of the diverge area, the analysis of single-lane additions is relatively straightforward. The downstream segment of the merge area is simply considered to be a basic freeway segment with an additional lane.

The analysis is applicable for a single one hour period. In general, data from the peak hour of the peak period was used for the merge, diverge and weaving analysis.

7.2 Input Assumptions

The assumptions made when coding the software are summarized in Table 6.

Table 6 Input Assumptions

Parameter	Assumption
Terrain	Level, with a heavy vehicle factor of 1.5. Rolling (with a heavy vehicle factor of 2.5) was considered, but the observed behavior of trucks in the vicinity of ramps is closer to Level than Rolling
Percentage of trucks	The percentage of trucks varies during both the AM and PM peaks. Data described in Section 4 was used to determine the percentage of trucks in the mainline flows for 7-8 am in the morning peak, and 4-5 pm in the evening peak. The numbers used in the analysis are: • AM – 5% • PM – 4%
Ramp free-flow speeds	There is a wide variety of geometric standards for both on- and off-ramps. In general, the free-flow speed on WB 262 to SB I-880 overpass was assumed 45 mph. In other cases, the default speed of 35 mph was used.
Adjacent ramp	The HCM defines the area of influence of a ramp as being within 1,500 feet of the ramp. It also defines an adjacent ramp as an upstream or downstream ramp (either on or off) that is within the effective influence distance, which is a function of ramp type and traffic volumes. However, the analysis procedure only allows consideration of one adjacent ramp at a time. In several locations, there are two ramps (one upstream, the other downstream) that are within 1,500 ft of another ramp. In these cases, the analysis was repeated for both the upstream and downstream ramps, and the worst case LOS reported in the tables.
Peak hour factor	Based on the 15-min counts at two intersections on SR 262/Mission Blvd, the peak hour factor of 0.92 was used in this section for both AM and PM peaks.

7.3 Results

The results of the merge, diverge, and weaving analyses are illustrated in Table 7 and Table 8 for the AM and PM peak hour, respectively. HCS outputs are attached in Appendix C.

Table 7 Existing AM Peak Merge, Diverge, and Weaving LOS

Route	Section	Analysis type	LOS	Comments
I-680	**Northbound**			
	NB I-680 off-ramp to SR 262	Diverge with lane drop	B	
	NB I-680 segment north of the off-ramp to SR 262		D	
	NB I-680 CD Road	Weave	E	
	On-ramp from 262 to NB I-680	Merge	E	
	Southbound			
	SB I-680 off-ramp to WB SR 262	Diverge with lane drop	D	Queue on the ramp due to the spill back from downstream intersection
	SB I-680 segment south of off-ramp to WB SR 262		C	
	SB I-680 CD Road	Weave	A	
	SB I-880 on-ramp from SR 262	Merge	B	
I-880	**Northbound**			
	NB I-880 off-ramp to SR 262	Diverge with lane drop	B	
	NB I-880 segment north of off-ramp to SR 262		C	
	SR 262 on-ramp to Fremont Blvd off-ramp	Weave	C	
	Southbound			
	Fremont Blvd SB to SB I-880 off-ramp to West Warren	Weave	D	
	SB I-880 off-ramp to SR 262	Diverge	F	
	On-ramp from SR 262	Merge with lane add	F	
SR 262	**Eastbound**			
	SB I-880 off-ramp at NB I-880 off-ramp to SR 262	Merge	B	
	EB 262 on-ramp to I-680 SB	Diverge with lane drop	A	
	EB 262 segment east of on-ramp to I-680 SB		A	
	SB I-680 off-ramp to EB SR 262 TO EB SR 262 on-ramp to NB I-680	Weave	B	
	NB I-680 off-ramp to EB 262	Merge	B	
	Westbound			
	WB SR 262 off-ramp to NB I-880 and SB I-880	Major Diverge	C	
	WB SR 262 on-ramp to NB I-680	Diverge	B	
	NB I-680 off-ramp to WB SR 262 TO WB SR 262 on-ramp to SB I-680	Weave	C	
	SB I-680 off-ramp to WB SR 262	Merge	C	

Table 8 Existing PM Peak Merge, Diverge, and Weaving LOS

Route	Section	Analysis type	LOS	Comments
I-680	**Northbound**			
	NB I-680 off-ramp to SR 262	Diverge with lane drop	B	
	NB I-680 segment north of the off-ramp to SR 262		D	
	NB I-680 CD Road	Weave	D	
	On-ramp from 262 to NB I-680	Merge	E	
	Southbound			
	SB I-680 off-ramp to WB SR 262	Diverge with lane drop	C	
	SB I-680 segment south of off-ramp to WB SR 262		B	
	SB I-680 CD Road	Weave	A	
	SB I-880 on-ramp from SR 262	Merge	B	
I-880	**Northbound**			
	NB I-880 off-ramp to SR 262	Diverge with lane drop	B	Queue on the ramp due to the spill back from downstream intersection
	NB I-880 segment north of off-ramp to SR 262		D	
	SR 262 on-ramp to Fremont Blvd off-ramp	Weave	D	
	Southbound			
	Fremont Blvd SB to SB I-880 off-ramp to West Warren	Weave	C	
	SB I-880 off-ramp to SR 262	Diverge	F	
	On-ramp from SR 262	Merge with lane add	D	
SR 262	**Eastbound**			
	SB I-880 off-ramp at NB I-880 off-ramp to SR 262	Merge	C	
	EB 262 on-ramp to I-680 SB	Diverge with lane drop	B	
	EB 262 segment east of on-ramp to I-680 SB		B	
	SB I-680 off-ramp to EB SR 262 TO EB SR 262 on-ramp to NB I-680	Weave	B	
	NB I-680 off-ramp to EB 262	Merge	B	
	Westbound			
	WB SR 262 off-ramp to NB I-880 and SB I-880	Major Diverge	B	
	WB SR 262 on-ramp to NB I-680	Diverge	A	
	NB I-680 off-ramp to WB SR 262 TO WB SR 262 on-ramp to SB I-680	Weave	B	
	SB I-680 off-ramp to WB SR 262	Merge	B	

Route 262 Improvements
Traffic Forecast Report

Prepared for

Alameda County Congestion Management Agency
and
HQE Incorporated

Draft Report

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August 6, 2008

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

APPENDICES

1. INTRODUCTION

The Alameda County Congestion Management Agency (ACCMA), in partnership with the City of Fremont and Caltrans, has contracted with HQE, Inc. and DKS Associates to prepare a Project Study Report (PSR) for potential improvements to State Route (SR) 262 (Mission Boulevard) between I-880 and I-680 in the City of Fremont. The Route 262 Improvements PSR will address the need and purpose of the proposed project, the potential environmental impacts, and the estimated costs and timeline for delivery. The PSR will consist of evaluating the following project components:

- Widening of Route 262 (Mission Boulevard) from four to six lanes between Warm Springs Boulevard and I-680;
- Widening and realigning the I-680 southbound to westbound exit ramp to a tee intersection with Route 262 and signalizing the new intersection;
- Eliminating the I-680 southbound to eastbound loop exit ramp;
- Realigning the I-680 northbound to eastbound exit ramp to a tee intersection with Route 262 and signalizing the new intersection;
- Eliminating the I-680 northbound to westbound loop exit ramp; and
- Tight Diamond Interchange and/or intersection improvements at Route 262/Warm Springs Boulevard.

The purpose of this report is to present the projected 2035 AM and PM peak traffic demands that will be used to analyze the freeway mainline segments, ramps and intersections within the study area. While the Project may add capacity to portions of SR 262, it is primarily an operational improvement and does not significantly increase corridor capacity. Furthermore, capacity constraints on the study area freeways (I-880 and I-680) effectively constrain traffic demand in the study area. Therefore, the No Project forecasts will also be used for the build project alternatives.

Section 2 summarizes the methodology used to develop the forecasted travel demands. The forecasted peak hour demands for the freeway mainline segments, ramps and intersections are presented in Section 3.

2. FORECAST METHODOLOGY

The future year traffic operations analysis conducted as part of the PSR should evaluate conditions 20 years after the expected completion of the proposed improvements. Assuming that it will take a minimum of seven years to fund, complete the environmental review, design and construct any potential improvements, the first year of operation is expected to be 2015 and the horizon year for the traffic analysis has been defined to be 2035.

The process for developing the constrained 2035 traffic demands for use in the operational analysis involved three steps. In the first step, the ACCMA countywide model was used to generate 2005 and 2035 travel model forecasts (TMF) for the freeway entry, ramp and arterial entry links within the study area. Because the current ACCMA countywide travel demand model only includes a 2005 base year and a 2030 forecast year, the 2035 model forecasts were developed based on linear extrapolation using a five-year growth rate derived from the growth between 2005 and 2030 as illustrated in the following equation:

$$\textbf{2035 TMF} = \textbf{2030 TMF} + \left[\frac{\textbf{(2030 TMF)-(2005 TMF)}}{\textbf{25 years}} \right] \textbf{*(5 years)}$$

This approach for developing the 2035 travel demand model forecasts was discussed with ACCMA staff. It was noted that this same approach had been applied for other studies and was considered appropriate for this effort.

For existing roadway facilities, results from the travel demand model are not used directly in the operational analysis. Instead, in the second step of the process, changes in the forecasted demand between 2005 and 2035 as produced by the travel demand model were added to existing traffic demands. In general this approach is illustrated by the following equation:

2035 demand = Existing demand + (2035 model forecast – 2005 model forecast)

Consistent with the analysis methodology, results from ACCMA's AM and PM peak hour models were used for the forecasting process.

In the third step, a "reasonableness check" of the results was conducted after application of the formulas presented above. This reasonableness check included the implementation of manual adjustments to the forecasts to address any unusual or unreasonable changes that did not match practiced constraints. Adjustments made as part of this effort included:

- Limiting growth on the freeway entering the study area where physical capacity constraints would prevent the forecasted demand from reaching the study area (in turn, downstream demands were also adjusted).
- Modifying travel model forecasts to account for unusual assignment behavior.
- Eliminating projected decreases in demand ("negative growth"), unless such a decrease was relatively small or justifiable.
- Modifying forecasts for intersections that include a freeway ramp to conform to the adjusted ramp demands, in order to maintain consistency in the forecast estimates.

- Modifying forecasts to provide reasonable consistency in the traffic demand flows between adjacent roadway segments (i.e. balancing the departing demands at one intersection and approach demands at a downstream intersection which acknowledging some sources and sinks such as driveways).

3. NETWORK ASSUMPTIONS

As noted in the previous section, the forecasts presented in this report were developed using outputs from the ACCMA countywide travel demand model. The 2030 ACCMA model network (assumed for 2035) included a number of roadway improvements that directly impact the study area. These improvements included:

- Extension of the southbound HOV on I-880 through the I-880/SR 262 interchange to connect to the existing HOV lanes on either side of this interchange.
- Extension of the northbound HOV on I-880 from south of Dixon Landing to the existing lane north of the I-880/SR 262 interchange, plus the addition of one mixed-flow lane before the off-ramp to Mission Blvd.
- The widening of northbound I-680 to add an HOV lane and an auxiliary lane between the Scott Creek Road on-ramp and SR 262 off-ramp.
- Widening of SR 262 (Mission Boulevard) from four to six lanes between I-880 and Warm Springs Boulevard.

However, the original 2030 model network did not include the reconfiguration of the I-880/SR 262 interchange that is currently under construction. Therefore, modifications to the model network to reflect this improvement were made prior to the application of the model for this analysis. Specific elements of the interchange reconfiguration that were added to the model network included:

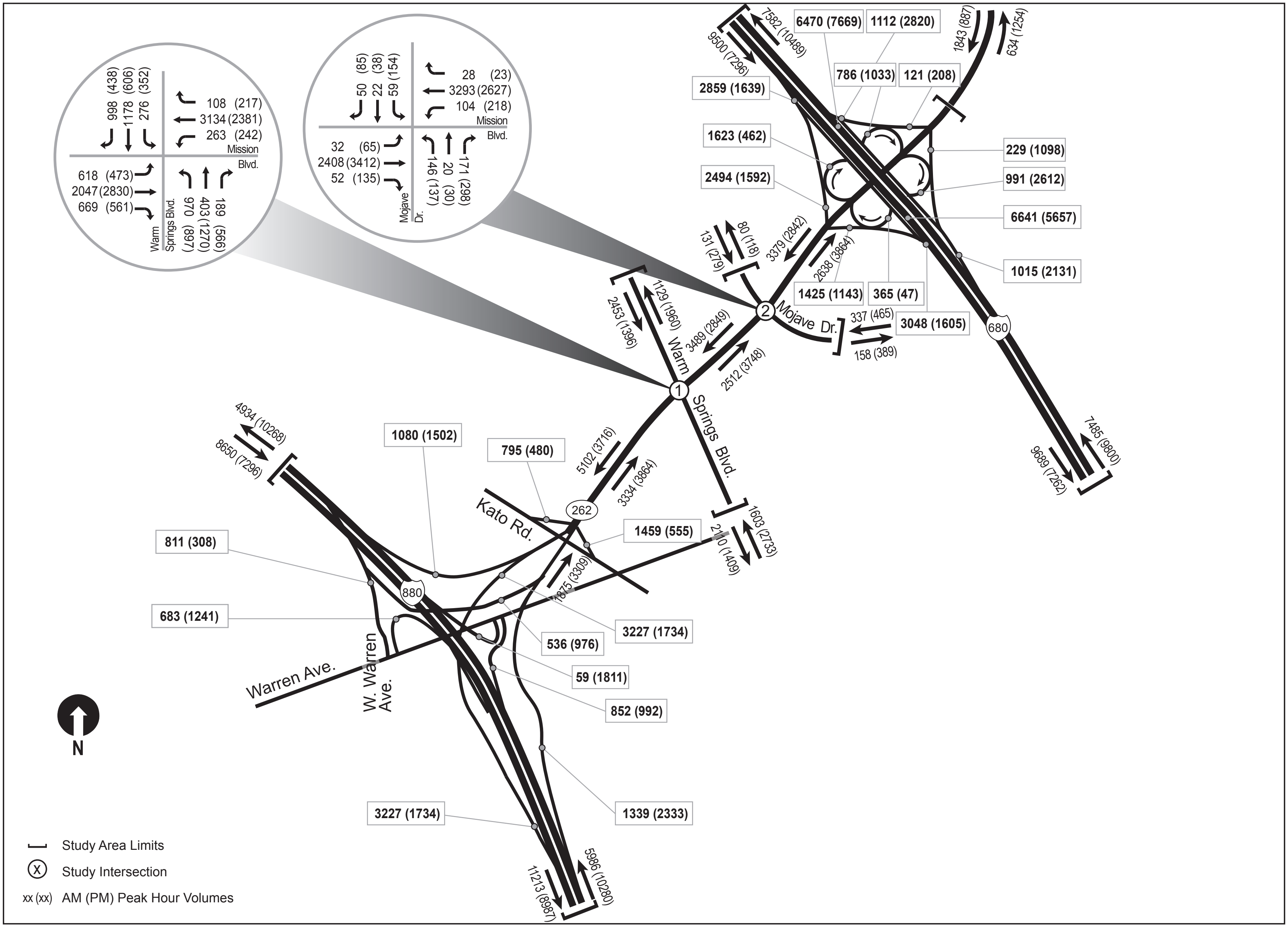
- Modification of the southbound I-880 connector to SR 262 eastbound to include two lanes and split to Warren Avenue.
- Modification of the northbound I-880 connector to eastbound SR 262 to include two lanes.
- Construction of a new Warren Avenue overcrossing and interchange with separate northbound off-ramp, northbound on-ramp and southbound on-ramp (as noted above, southbound off would be via the connector to eastbound SR 262).
- Replacement of the railroad overcrossing to allow for the widening of SR 262 between I-880 and Warm Springs Blvd as noted above, and the construction of new connections from westbound SR 262 to Kato Road and from Kato Road to eastbound SR 262.
- Closure of existing or pre-construction connections between westbound SR 262 and Kato Road, westbound SR 262 and Gateway Blvd, and the I-880 to eastbound SR 262 ramp and Warren Avenue.

4. FUTURE YEAR (2035) DEMAND FORECASTS

Figure 1 presents the constrained 2035 AM and PM peak hour traffic demands for the freeway mainline segments, ramps and intersections within the study area. The term "constrained" is used because the demands presented in this figure have been adjusted to take into account capacity constraints on the freeways entering the study area ("gateway" locations). In the peak direction of each peak period (southbound in the AM and northbound in the PM), the unconstrained 2035 demands on both I-880 and I-680, derived by applying the formulas presented in Section 2 of this report, greatly exceed the mainline capacity at the gateway locations. The projected demands at these locations have been "constrained" to match the estimated capacity. In turn, demands downstream of mainline capacity constraint were also adjusted accordingly. The assumed capacity and demand adjustment for each gateway location is summarized Table 1. The forecast calculations and manual adjustments are presented in more detail in Appendix A.

As shown in Figure 1, the projected growth within the study area varies by peak period and direction. During the AM peak hour, demands on SR 262 are forecasted to grow by approximately 50% in the westbound (peak) direction, and 100 % in the eastbound direction. The higher off-peak direction (eastbound) growth rate is due in part of the upstream capacity constraint on I-680 southbound. In the PM peak hour, the growth rates are near 60% westbound and 70% eastbound.

On I-680, even with the mainline capacity constraints, demands are projected 30% to 40% in the AM peak, and over 40% in the PM peak. Meanwhile, on I-880 the constrained demands represent about a 40% increase over existing demands for all cases except northbound in the PM peak where the projected growth rate is almost 60%.



08110-000•SR-262 Future AM PM Balanced Vols.ai•7/9/08

DKS *Associates*
TRANSPORTATION SOLUTIONS

Figure 1
2035 AM and PM Peak Hour Constrained Demands

Table 1- Freeway Mainline Capacity Constraint Adjustments

Location	Peak	Lane Configuration			Auxiliary Lane Demands		Estimate Capacity	Unconstrained Demand	Constrained Demand
		General Purpose[1]	HOV[2]	Auxiliary[3]	Upstream On	Downstream Off			
I-880 Southbound	AM	3	1	1	668	2127	8650	14296	8650
I-880 Northbound[4]	PM	3	1	2	-	-	10280 [4]	13232	10280
I-680 Southbound	AM	3	1	1	1570	1815	9500	14401	9500
I-680 Northbound	PM	3	1	1	1871	2732	9800	15876	9800

Notes:

1. Capacity of general purpose lane assumed to be 2100vph.

2. Capacity of HOV lane assumed to be 1650vph. Because unconstrained demands significantly exceed capacity it was assumed that HOV demand would also reach or exceed capacity.

3. Auxiliary lane capacity set as lesser of upstream on and downstream off demands.

4. For Northbound I-880, gateway constraint was derived by working backwards expected bottleneck in segment after off-ramp to SR 262. This segment would have 3 GP lanes plus 1 HOV lane (capacity = 6300 & 1650 = 7950) but an unconstrained demand of 10229. This ratio of capacity to demand was applied to the upstream demand to determine the maxium potential flow at the gateway.

Source: DKS Associates (2008)

APPENDIX A – 2035 TRAFFIC FORECAST CALCULATIONS

Table 1 : 2035 Forecast AM Link Demand

LOCATION	Existing AM Peak	Model Demand		Growth 2005 ->2030 AM Peak		2035 Unconstrained			2035 Constrained			Comments
	Peak Hour	2005 1Hr	2030NP 1Hr	1 Hr Diff	1-Hr % Diff	1 Hr Diff	1-Hr % Diff	Peak Hour Demand	1 Hr Diff	1-Hr % Diff	Peak Hour Demand	
I-680												
Northbound Entry Links Total	5953	4038	5315	1276	21%	1532	26%	7485	1532	26%	7485	
(1) NB Off to Mission/262- ALA	886	312	419	107	12%	129	15%	1015	129	15%	1015	
(3) SEG NB OFF TO NB MISSION/RTE 262	140	297	371	74	53%	89	63%	229	89	63%	229	
(4) SEG NB OFF TO SB MISSION/262	746	15	48	33	4%	40	5%	786	40	5%	786	
(7) SEG NB ON FR SB MISSION/262	42	45	110	65	156%	79	187%	121	79	187%	121	
(8) SEG NB ON FR NB MISSION/262	682	254	575	320	47%	384	56%	1066	384	56%	1066	
(11) NB ON FR MISSION/262	724	299	685	386	53%	463	64%	1187	463	64%	1187	
NB OFF to Durham Rd	650	528	977	449	69%	539	83%	1189	539	83%	1189	
Southbound Entry Links Total	6935	7056	13278	6221	90%	7466	108%	14401	2565	37%	9500	SB 680 mainline capacity constraint
(12) SB OFF TO MISSION /262	1356	1289	3770	2482	183%	2978	220%	4334	1503	111%	2859	Adjust demand based on upstream mainline contraint
(9) SEG SB OFF TO SB MISSION/RTE 262	1328	1267	3311	2044	154%	2452	185%	3780	1166	88%	2494	Adjust demand based on upstream mainline contraint
(10) SEGSBOFF TO NB MISSION BL/262	28	22	460	438	1564%	525	1877%	553	337	1204%	365	Adjust demand based on upstream mainline contraint
(5) SEGSB ON FR SB MISSION BL/262	526	832	1746	914	174%	1097	209%	1623	1097	209%	1623	
(6) SEGSB ON FR NB MISSION BL/262	313	406	1422	1016	324%	1219	389%	1532	1112	355%	1425	Adjust demand based on upstream mainline contraint
(2) SB ON FR MISSION BL/262	839	1238	3168	1930	230%	2316	276%	3155	2209	263%	3048	
I-880												
Northbound Entry Links Total	4279	5634	7057	1422	33%	1707	40%	5986	1707	40%	5986	
(1) NB I-880 off to EB Mission	1201	636	751	115	10%	138	11%	1339	138	11%	1339	
NB I-880 off to Warren			710	710		852		852	852	n/a	852	
Warren on ramp to NB 880			49	49		59		59	59	n/a	59	
(4) WB Mission to NB I-880	1080	258	174	-84	-8%	0	0%	1080	0	0%	1080	Eliminate negative growth
SB I-880 off to Fremont	454	241	1397	1156	255%	1387	306%	1841	1387	306%	1841	
Cushing on-ramp to SB I-880	693	1178	1157	-21	-3%	-25	-4%	668	-25	-4%	668	
Southbound Entry Links Total	6214	7082	13817	6735	108%	8082	130%	14296	2436	39%	8650	SB 880 mainline capacity constraint
(3) SB I-880 to West Warren Ave	103	650	1681	1031	1001%	1237	1201%	1340	708	687%	811	Adjust demand based on upstream mainline contraint
W.Warrent to W. Mission	23	21	0	-21	-93%	-26	-111%	-3	-26	-111%	0	
(2) SB I-880 overpass to Mission	336	167	626	459	137%	551	164%	887	200	60%	536	Adjust demand based on upstream mainline contraint
Total overpass to Mission	359	189	626	437	122%	525	146%	884	525	146%	884	Adjust demand based on mainline contrained flow
Warren on ramp to SB 880			569	569		683		683	683		683	
(5) WB Mission to SB I-880	2073	1516	3225	1709	82%	2050	99%	4123	1154	56%	3227	Adjust demand based on upstream mainline contraint
SR 262												
EB SR 262 Entry	1560	825	1377	552	35%	663	42%	2223	315	20%	1875	Adjust demand based on upstream mainline contraint
Kato to EB Mission			1216	1216		1459		1459	1459		1459	
EB Arrival at Warm Spring	1560	825	2593	1768	113%	2122	136%	3682	1774	114%	3334	Adjust demand based on upstream mainline contraint
EB Departure at Warm Spring	1250	740	1985	1244	100%	1493	119%	2743	1262	101%	2512	Adjust demand based on upstream mainline contraint
EB Arrival at Mohave	1250	740	1985	1244	100%	1493	119%	2743	1222	98%	2472	Adjust demand based on upstream mainline contraint
EB Departure at Mohave	1393	799	1996	1198	86%	1437	103%	2830	1245	89%	2638	Adjust demand based on upstream mainline contraint
EB SR 262 End	566	457	830	373	66%	448	79%	1014	68	12%	634	Adjust demand based on upstream mainline contraint
WB SR 262 Entry	810	1741	2602	861	106%	1033	128%	1843	1033	128%	1843	
WB Arrival at Mohave	2361	2146	4105	1959	83%	2350	100%	4711	1064	45%	3425	Adjust demand based on upstream mainline contraint
WB Departure at Mohave	2316	2099	4066	1967	85%	2360	102%	4676	1173	51%	3489	Adjust demand based on upstream mainline contraint
WB Arrival at Warm Spring	2316	2099	4066	1967	85%	2360	102%	4676	1189	51%	3505	Adjust demand based on upstream mainline contraint
WB Departure at Warm Spring	3356	1856	4197	2341	70%	2810	84%	6166	1746	52%	5102	Adjust demand based on upstream mainline contraint
WB Mission to Kato Road			798	798		958		958	795		795	Adjust demand based on upstream mainline contraint
WB SR 262 End	3356	1856	3399	1543	46%	1852	55%	5208	951	28%	4307	Adjust demand based on upstream mainline contraint
NB Arrival at Warm Spring	1401	932	1101	168	12%	202	14%	1603	202	14%	1603	
NB Departure at Warm Spring	923	898	1188	290	31%	348	38%	1271	206	22%	1129	Adjust demand based on upstream mainline contraint
SB Arrival at Warm Spring	1179	1509	2570	1062	90%	1274	108%	2453	1274	108%	2453	
SB Departure at Warm Spring	972	1870	2959	1089	112%	1307	134%	2279	1138	117%	2110	Adjust demand based on upstream mainline contraint
NB Arrival at Mohave	337	66	51	-15	-5%	0	0%	337	0	0%	337	
NB Departure at Mohave	87	#N/A	#N/A	#N/A	#N/A	0	0%	87	0	0%	80	Adjust demand based on upstream mainline contraint
SB Arrival at Mohave	131	#N/A	#N/A	#N/A	#N/A	0	0%	131	0	0%	131	Apply the same growth with SB Departure
SB Departure at Mohave	193	55	78	23	12%	28	0%	221	28	14%	158	Adjust demand based on upstream mainline contraint

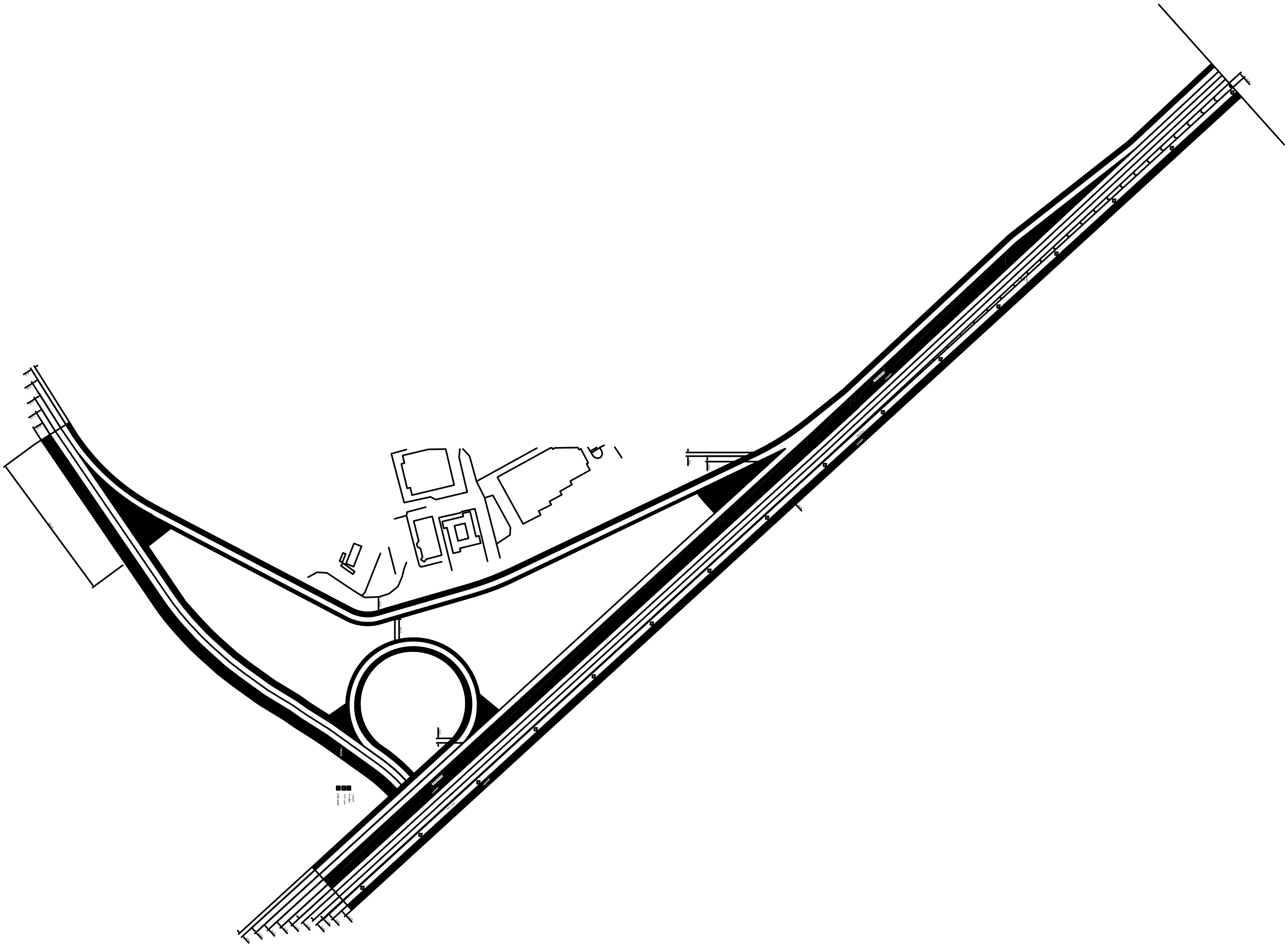
Note: Capacity assumptions: Mainline: 2100 vphph, HOV lane: 1650 vphpl

Table 2 : 2035 Forecast PM Link Demand

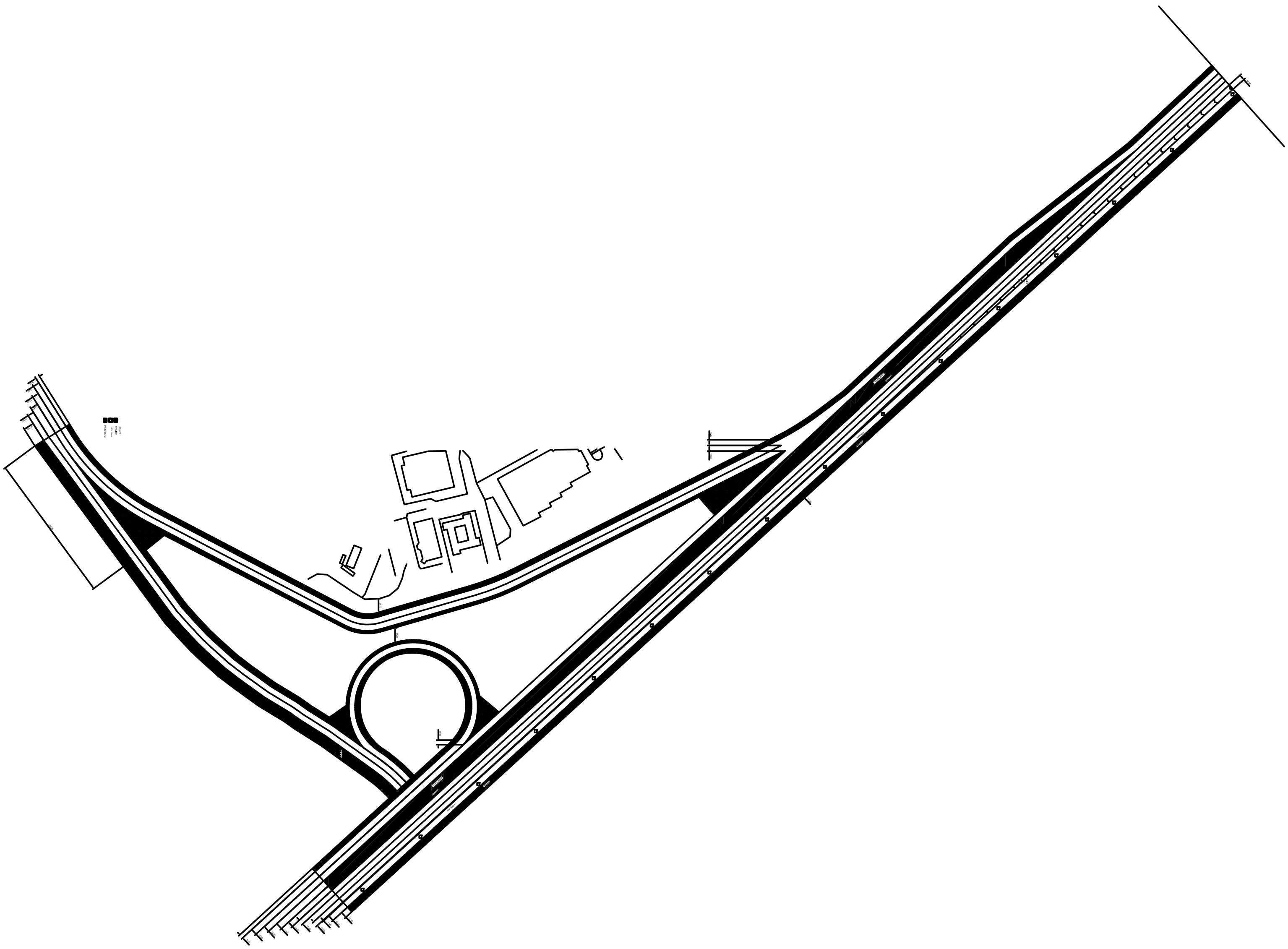
LOCATION	Existing PM Peak	Model Demand		Growth 2005 - PM Peak		2035 Unconstrained			2035 Constrained			Comments
	Peak Hour	2005 1Hr	2030 NP	1 Hr Diff	1-Hr % Diff	1 Hr Diff	1-Hr % Diff	Peak Hour Demand	1 Hr Diff	1-Hr % Diff	Peak Hour Demand	
I-680												
Northbound Entry Links Total	6648	6662	14352	7690	116%	9228	139%	15876	3152	47%	9800	NB 680 mainline capacity constraint
(1) NB Off to Mission/262- ALA	1232	1431	3282	1851	150%	2221	180%	3453	899	73%	2131	Adjust demand based on upstream mainline contraint
(3) SEG NB OFF TO NB MISSION/RTE 262	642	1163	2111	948	148%	1137	177%	1779	456	71%	1098	Adjust demand based on upstream mainline contraint
(4) SEG NB OFF TO SB MISSION/262	590	268	1171	903	153%	1084	184%	1674	443	75%	1033	Adjust demand based on upstream mainline contraint
(7) SEG NB ON FR SB MISSION/262	15	21	182	161	1073%	193	1288%	208	193	1288%	208	Adjust demand based on upstream mainline contraint
(8) SEG NB ON FR NB MISSION/262	962	718	2362	1644	171%	1973	205%	2935	1650	172%	2612	Adjust demand based on upstream mainline contraint
(11) NB ON FR MISSION/262	977	739	2544	1805	185%	2166	222%	3143	1843	189%	2820	Adjust demand based on upstream mainline contraint
Southbound Entry Links Total	4599	4210	5818	1608	35%	1929	42%	6528	1929	42%	6528	
(12) SB OFF TO MISSION /262	1030	593	1100	508	49%	609	59%	1639	609	59%	1639	
(9) SEG SB OFF TO SB MISSION/RTE 262	989	577	1079	502	51%	603	61%	1592	603	61%	1592	
(10) SEGSBOFF TO NB MISSION BL/262	41	16	21	5	13%	6	15%	47	6	15%	47	
(5) SEGSB ON FR SB MISSION BL/262	197	80	301	221	112%	265	135%	462	265	135%	462	
(6) SEGSB ON FR NB MISSION BL/262	966	217	482	265	27%	318	33%	1284	318	33%	1284	
(2) SB ON FR MISSION BL/262	1163	297	783	486	42%	583	50%	1746	583	50%	1746	
I-880												
Northbound Entry Links Total	6481	9024	14650	5626	87%	6751	104%	13232	3799	59%	10280	Capacity constraint at mainline
(1) NB I-880 off to EB Mission	1328	1576	2972	1396	105%	1675	126%	3003	1005	76%	2333	Adjust demand based on upstream mainline contraint
NB I-880 off to Warren			1064	1064		1277		1277	992		992	Adjust demand based on upstream mainline contraint
Warren on ramp to NB 880			1509	1509		1811		1811	1811		1811	
(4) WB Mission to NB I-880	966	596	1044	448	46%	538	56%	1504	538	56%	1502	Adjust demand based on upstream mainline contraint
SB I-880 off to Fremont	414	89	110	21	5%	26	6%	440	26	6%	440	
Cushing on-ramp to SB I-880	757	755	1399	644	85%	772	102%	1529	772	102%	1529	
Southbound Entry Links Total	5352	4341	5960	1620	30%	1944	36%	7296	1944	36%	7296	
(3) SB I-880 to West Warren Ave	113	41	204	163	144%	195	173%	308	195	173%	308	
W.Warrent to Mission	154	131	0	-131	-85%	-157	-102%	-3	-157	-102%	-3	
(2) SB I-880 overpass to Mission	401	124	606	482	120%	578	144%	979	578	144%	979	
Total overpass to Mission	555	255	606	351	63%	421	76%	976	421	76%	976	
Warren on ramp to SB 880			1035	1035		1241		1241	1241		1241	
(5) WB Mission to SB I-880	1015	823	1463	640	63%	768	76%	1783	768	76%	1783	
SR 262												
EB SR 262 Entry	1883	1831	3578	1747	93%	2097	111%	3980	1426	76%	3309	Adjust demand based on upstream mainline contraint
Kato to EB Mission			462			555		555	555		555	
EB Arrival at Warm Spring	1883	1831	4040	2210	117%	2652	141%	4535	1981	105%	3864	Adjust demand based on upstream mainline contraint
EB Departure at Warm Spring	2203	1870	3493	1623	74%	1948	88%	4151	1545	70%	3748	Adjust demand based on upstream mainline contraint
EB Arrival at Mohave	2203	1870	3493	1623	74%	1948	88%	4151	1407	64%	3610	Adjust demand based on upstream mainline contraint
EB Departure at Mohave	2420	1942	3531	1589	66%	1907	79%	4327	1444	60%	3864	Adjust demand based on upstream mainline contraint
EB SR 262 End	1175	2187	2819	632	54%	758	65%	1933	79	7%	1254	Adjust demand based on upstream mainline contraint
WB SR 262 Entry	490	343	674	331	68%	397	81%	887	397	81%	887	
WB Arrival at Mohave	1857	1086	2441	1355	73%	1626	88%	3483	1011	54%	2868	Adjust demand based on upstream mainline contraint
WB Departure at Mohave	1807	1044	2403	1359	75%	1630	90%	3437	1042	58%	2849	Adjust demand based on upstream mainline contraint
WB Arrival at Warm Spring	1807	1044	2403	1359	75%	1630	90%	3437	1033	57%	2840	Adjust demand based on upstream mainline contraint
WB Departure at Warm Spring	1981	1105	2962	1857	94%	2228	112%	4209	1735	88%	3716	Adjust demand based on upstream mainline contraint
WB Mission to Kato Road			455			546		546	480		480	Adjust demand based on upstream mainline contraint
WB SR 262 End	1981	1105	2507	1402	71%	1682	85%	3663	1255	63%	3236	Adjust demand based on upstream mainline contraint
NB Arrival at Warm Spring	1451	2018	3086	1068	74%	1282	88%	2733	1282	88%	2733	
NB Departure at Warm Spring	927	1809	2757	948	102%	1137	123%	2064	1033	111%	1960	Adjust demand based on upstream mainline contraint
SB Arrival at Warm Spring	1026	1047	1355	308	30%	370	36%	1396	370	36%	1396	
SB Departure at Warm Spring	919	1155	1672	517	56%	621	68%	1540	490	53%	1409	Adjust demand based on upstream mainline contraint
NB Arrival at Mohave	465	136	124	-13	-3%	0	0%	465	0	0%	465	
NB Departure at Mohave	129	#N/A	#N/A	#N/A	#N/A	0	0%	129	-11	-9%	118	Adjust demand based on upstream mainline contraint
SB Arrival at Mohave	265	#N/A	#N/A	#N/A	#N/A	14	5%	279	14	5%	279	
SB Departure at Mohave	434	106	124	18	4%	21	5%	455	-45	-10%	389	Adjust demand based on upstream mainline contraint

Note: Capacity assumptions: Mainline: 2100 vphph, HOV lane: 1650 vphpl

Appendix B: AutoCAD of Current Design



Appendix C: AutoCAD of Proposed Design



Appendix D: HCS 2010 Reports

Legend

In top right corner of page:

x -AM 2018 Current Condition
x -AM 2035 Current Condition
x -PM 2018 Current Condition
x -PM 2035 Current Condition

Otherwise listed in Analysis Year

HCS 2010: Freeway Merge and Diverge Segments Release 6.80 X

Phone: Fax:
E-mail:

Merge Analysis

Analyst:
Agency/Co.:
Date performed: 1/26/2018
Analysis time period:
Freeway/Dir of Travel: Merge from 680S to Mission Wb
Junction:
Jurisdiction:
Analysis Year:
Description:

Freeway Data

Type of analysis	Merge	
Number of lanes in freeway	2	
Free-flow speed on freeway	45.0	mph
Volume on freeway	2700	vph

On Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-flow speed on ramp	30.0	mph
Volume on ramp	1717	vph
Length of first accel/decel lane	1000	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	No	
Volume on adjacent Ramp		vph
Position of adjacent Ramp		
Type of adjacent Ramp		
Distance to adjacent Ramp		ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	2700	1717		vph
Peak-hour factor, PHF	0.94	0.94		
Peak 15-min volume, v15	718	457		v
Trucks and buses	4	5		%
Recreational vehicles	0	0		%
Terrain type:	Level	Level		
Grade	%	%	%	
Length	mi	mi	mi	
Trucks and buses PCE, ET	1.5	1.5		
Recreational vehicle PCE, ER	1.2	1.2		

```
Heavy vehicle adjustment, fHV          0.980       0.976                     x
Driver population factor, fP           1.00        1.00
Flow rate, vp                          2930        1872                  pcph

_________________________Estimation of V12 Merge Areas_________________________

                  L   =            (Equation 13-6 or 13-7)
                   EQ
                  P   =    1.000   Using Equation  0
                   FM
                  v   = v  (P  ) =  2930   pc/h
                   12    F   FM

_______________________________Capacity Checks_________________________________

                           Actual        Maximum         LOS F?
     v                     4802          1110704128      No
      FO
     v  or v               0    pc/h     (Equation 13-14 or 13-17)
      3     av34
Is   v  or v      > 2700 pc/h?           No
      3     av34
Is   v  or v      > 1.5 v  /2            No
      3     av34         12
If yes, v    = 2930                   (Equation 13-15, 13-16, 13-18, or 13-19)
         12A

________________________Flow Entering Merge Influence Area_____________________
                      Actual        Max Desirable         Violation?
     v                4802          1110704128            No
      R12
_________________Level of Service Determination (if not F)_____________________

Density, D = 5.475 + 0.00734 v  + 0.0078 v   - 0.00627 L   =   35.8    pc/mi/ln
          R                   R           12             A
Level of service for ramp-freeway junction areas of influence  E

_____________________________Speed Estimation__________________________________

Intermediate speed variable,                 M  = 0.736
                                              S
Space mean speed in ramp influence area,     S  = 42.8    mph
                                              R
Space mean speed in outer lanes,             S  =  N/A    mph
                                              0
Space mean speed for all vehicles,           S  = 42.8    mph
_______________________________________________________________________________
```

X

HCS 2010: Freeway Merge and Diverge Segments Release 6.80

Phone: Fax:
E-mail:

Merge Analysis

Analyst:
Agency/Co.:
Date performed: 1/26/2018
Analysis time period:
Freeway/Dir of Travel: Merge fr Mission W to 680N
Junction:
Jurisdiction:
Analysis Year:
Description:

Freeway Data

Type of analysis	Merge	
Number of lanes in freeway	2	
Free-flow speed on freeway	65.0	mph
Volume on freeway	1036	vph

On Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-flow speed on ramp	40.0	mph
Volume on ramp	68	vph
Length of first accel/decel lane	500	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	No	
Volume on adjacent Ramp		vph
Position of adjacent Ramp		
Type of adjacent Ramp		
Distance to adjacent Ramp		ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway		Ramp		Adjacent Ramp	
Volume, V (vph)	1036		68			vph
Peak-hour factor, PHF	0.94		0.94			
Peak 15-min volume, v15	276		18			v
Trucks and buses	4		3			%
Recreational vehicles	0		0			%
Terrain type:	Level		Level			
Grade		%		%		%
Length		mi		mi		mi
Trucks and buses PCE, ET	1.5		1.5			
Recreational vehicle PCE, ER	1.2		1.2			

```
Heavy vehicle adjustment, fHV          0.980       0.985                        X
Driver population factor, fP           1.00        1.00
Flow rate, vp                          1124        73                    pcph

_________________________Estimation of V12 Merge Areas_________________________

                  L   =             (Equation 13-6 or 13-7)
                   EQ
                  P   =    1.000   Using Equation  0
                   FM
                  v  = v  (P  ) =  1124   pc/h
                   12   F   FM

_______________________________Capacity Checks_________________________________

                           Actual        Maximum         LOS F?
     v                     1197          4700            No
      FO
     v  or v               0    pc/h     (Equation 13-14 or 13-17)
      3     av34
Is   v  or v      > 2700 pc/h?           No
      3     av34
Is   v  or v      > 1.5 v  /2            No
      3     av34         12
If yes, v    = 1124                   (Equation 13-15, 13-16, 13-18, or 13-19)
         12A

________________________Flow Entering Merge Influence Area_____________________
                      Actual        Max Desirable         Violation?
     v                1197          4600                  No
      R12
_________________Level of Service Determination (if not F)_____________________

Density, D = 5.475 + 0.00734 v  + 0.0078 v   - 0.00627 L   =   11.6    pc/mi/ln
          R                    R           12             A
Level of service for ramp-freeway junction areas of influence  B

_____________________________Speed Estimation__________________________________

Intermediate speed variable,                 M  = 0.294
                                              S
Space mean speed in ramp influence area,     S  = 58.2    mph
                                              R
Space mean speed in outer lanes,             S  =  N/A    mph
                                              0
Space mean speed for all vehicles,           S  = 58.2    mph
_______________________________________________________________________________
```

HCS 2010: Freeway Merge and Diverge Segments Release 6.80

X

Phone: Fax:
E-mail:

Merge Analysis

Analyst: Melissa Elian
Agency/Co.: Santa Clara University
Date performed: 11/16/2017
Analysis time period:
Freeway/Dir of Travel: Merge fr Mission Eb to 680S
Junction:
Jurisdiction:
Analysis Year:
Description:

Freeway Data

Type of analysis	Merge	
Number of lanes in freeway	5	
Free-flow speed on freeway	65.0	mph
Volume on freeway	1597	vph

On Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-flow speed on ramp	40.0	mph
Volume on ramp	684	vph
Length of first accel/decel lane	1030	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	No	
Volume on adjacent Ramp		vph
Position of adjacent Ramp		
Type of adjacent Ramp		
Distance to adjacent Ramp		ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	1597	684		vph
Peak-hour factor, PHF	0.94	0.94		
Peak 15-min volume, v15	425	182		v
Trucks and buses	4	4		%
Recreational vehicles	0	0		%
Terrain type:	Level	Level		
Grade	%	%	%	
Length	mi	mi	mi	
Trucks and buses PCE, ET	1.5	1.5		
Recreational vehicle PCE, ER	1.2	1.2		

X

```
Heavy vehicle adjustment, fHV          0.980       0.980
Driver population factor, fP           1.00        1.00
Flow rate, vp                          1733        742                     pcph

_________________________Estimation of V12 Merge Areas_________________________

                  L   =             (Equation 13-6 or 13-7)
                   EQ
                  P   =    0.412   Using Equation  0
                   FM
                  v  = v  (P  ) =  557    pc/h
                   12   F   FM

_______________________________Capacity Checks_________________________________

                           Actual        Maximum         LOS F?
     v                     2094          11752           No
      FO
     v  or v               397  pc/h     (Equation 13-14 or 13-17)
      3     av34
Is   v  or v      > 2700 pc/h?           No
      3     av34
Is   v  or v      > 1.5 v  /2            No
      3     av34         12
If yes, v    = 557                    (Equation 13-15, 13-16, 13-18, or 13-19)
         12A

________________________Flow Entering Merge Influence Area_____________________
                      Actual        Max Desirable         Violation?
     v                1299          4600                  No
      R12
_________________Level of Service Determination (if not F)_____________________

Density, D = 5.475 + 0.00734 v  + 0.0078 v   - 0.00627 L   =   8.8     pc/mi/ln
          R                   R            12             A
Level of service for ramp-freeway junction areas of influence  A

_____________________________Speed Estimation__________________________________

Intermediate speed variable,                 M  = 0.253
                                              S
Space mean speed in ramp influence area,     S  = 59.2    mph
                                              R
Space mean speed in outer lanes,             S  = 65.0    mph
                                              0
Space mean speed for all vehicles,           S  = 61.3    mph
_______________________________________________________________________________
```

x

Phone: Fax:
E-mail:

Merge Analysis

Analyst:
Agency/Co.:
Date performed: 1/26/2018
Analysis time period:
Freeway/Dir of Travel: Merge fr 680S to Mission Eb
Junction:
Jurisdiction:
Analysis Year:
Description:

Freeway Data

Type of analysis	Merge	
Number of lanes in freeway	2	
Free-flow speed on freeway	45.0	mph
Volume on freeway	566	vph

On Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-flow speed on ramp	25.0	mph
Volume on ramp	28	vph
Length of first accel/decel lane	500	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	No	
Volume on adjacent Ramp		vph
Position of adjacent Ramp		
Type of adjacent Ramp		
Distance to adjacent Ramp		ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	566	28		vph
Peak-hour factor, PHF	0.94	0.94		
Peak 15-min volume, v15	151	7		v
Trucks and buses	5	3		%
Recreational vehicles	0	0		%
Terrain type:	Level	Level		
Grade	%	%	%	
Length	mi	mi	mi	
Trucks and buses PCE, ET	1.5	1.5		
Recreational vehicle PCE, ER	1.2	1.2		

Heavy vehicle adjustment, fHV	0.976	0.985	
Driver population factor, fP	1.00	1.00	
Flow rate, vp	617	30	pcph

X

Estimation of V12 Merge Areas

L_{EQ} = (Equation 13-6 or 13-7)

P_{FM} = 1.000 Using Equation 0

$v_{12} = v_F (P_{FM})$ = 617 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	647	1110704128	No
v_3 or v_{av34}	0 pc/h	(Equation 13-14 or 13-17)	
Is v_3 or v_{av34} > 2700 pc/h?		No	
Is v_3 or v_{av34} > 1.5 v_{12}/2		No	

If yes, v_{12A} = 617 (Equation 13-15, 13-16, 13-18, or 13-19)

Flow Entering Merge Influence Area

	Actual	Max Desirable	Violation?
v_{R12}	647	1110704128	No

Level of Service Determination (if not F)

Density, $D_R = 5.475 + 0.00734\, v_R + 0.0078\, v_{12} - 0.00627\, L_A$ = 7.4 pc/mi/ln

Level of service for ramp-freeway junction areas of influence A

Speed Estimation

Intermediate speed variable,	M_S = 0.303	
Space mean speed in ramp influence area,	S_R = 44.1	mph
Space mean speed in outer lanes,	S_0 = N/A	mph
Space mean speed for all vehicles,	S = 44.1	mph

X

HCS 2010: Freeway Merge and Diverge Segments Release 6.80

Phone: Fax:
E-mail:

Merge Analysis

Analyst:
Agency/Co.:
Date performed: 1/26/2018
Analysis time period:
Freeway/Dir of Travel: Merge fr 680N to Mission Wb
Junction:
Jurisdiction:
Analysis Year:
Description:

Freeway Data

Type of analysis	Merge	
Number of lanes in freeway	2	
Free-flow speed on freeway	45.0	mph
Volume on freeway	2361	vph

On Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-flow speed on ramp	25.0	mph
Volume on ramp	590	vph
Length of first accel/decel lane	500	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	No	
Volume on adjacent Ramp		vph
Position of adjacent Ramp		
Type of adjacent Ramp		
Distance to adjacent Ramp		ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway		Ramp		Adjacent Ramp	
Volume, V (vph)	2361		590			vph
Peak-hour factor, PHF	0.94		0.94			
Peak 15-min volume, v15	628		157			v
Trucks and buses	4		5			%
Recreational vehicles	0		0			%
Terrain type:	Level		Grade			
Grade		%	0.00	%		%
Length		mi	0.00	mi		mi
Trucks and buses PCE, ET	1.5		1.5			
Recreational vehicle PCE, ER	1.2		1.2			

```
Heavy vehicle adjustment, fHV          0.980       0.976                          x
Driver population factor, fP           1.00        1.00
Flow rate, vp                          2562        643                    pcph

_________________________Estimation of V12 Merge Areas_________________________

                  L  =            (Equation 13-6 or 13-7)
                   EQ
                  P  =    1.000   Using Equation  0
                   FM
                  v  = v  (P  ) =  2562   pc/h
                   12   F   FM

_______________________________Capacity Checks_________________________________

                           Actual        Maximum        LOS F?
     v                     3205          1110704128     No
      FO
     v  or v               0    pc/h     (Equation 13-14 or 13-17)
      3     av34
Is   v  or v      > 2700 pc/h?           No
      3     av34
Is   v  or v      > 1.5 v  /2            No
      3     av34         12
If yes, v    = 2562                   (Equation 13-15, 13-16, 13-18, or 13-19)
         12A

________________________Flow Entering Merge Influence Area_____________________
                      Actual        Max Desirable        Violation?
     v                3205          1110704128           No
      R12
_________________Level of Service Determination (if not F)_____________________

Density, D = 5.475 + 0.00734 v  + 0.0078 v   - 0.00627 L   =   27.0    pc/mi/ln
          R                   R           12             A
Level of service for ramp-freeway junction areas of influence  C

_____________________________Speed Estimation__________________________________

Intermediate speed variable,                 M  = 0.392
                                              S
Space mean speed in ramp influence area,     S  = 43.8    mph
                                              R
Space mean speed in outer lanes,             S  =  N/A    mph
                                              0
Space mean speed for all vehicles,           S  = 43.8    mph
_______________________________________________________________________________
```

X

HCS 2010: Freeway Merge and Diverge Segments Release 6.80

Phone: Fax:
E-mail:

Merge Analysis

Analyst:
Agency/Co.:
Date performed: 1/26/2018
Analysis time period:
Freeway/Dir of Travel: Merge fr 680N to Mission Eb
Junction:
Jurisdiction:
Analysis Year:
Description:

Freeway Data

Type of analysis	Merge	
Number of lanes in freeway	2	
Free-flow speed on freeway	45.0	mph
Volume on freeway	589	vph

On Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-flow speed on ramp	40.0	mph
Volume on ramp	170	vph
Length of first accel/decel lane	500	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	No	
Volume on adjacent Ramp		vph
Position of adjacent Ramp		
Type of adjacent Ramp		
Distance to adjacent Ramp		ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway		Ramp		Adjacent Ramp	
Volume, V (vph)	589		170			vph
Peak-hour factor, PHF	0.94		0.94			
Peak 15-min volume, v15	157		45			v
Trucks and buses	6		3			%
Recreational vehicles	0		0			%
Terrain type:	Level		Level			
Grade		%		%		%
Length		mi		mi		mi
Trucks and buses PCE, ET	1.5		1.5			
Recreational vehicle PCE, ER	1.2		1.2			

X

```
Heavy vehicle adjustment, fHV           0.971       0.985
Driver population factor, fP            1.00        1.00
Flow rate, vp                           645         184                  pcph

_________________________Estimation of V12 Merge Areas_________________________

                  L   =           (Equation 13-6 or 13-7)
                   EQ
                  P   =    1.000   Using Equation  0
                   FM
                  v   = v  (P  ) =  645    pc/h
                   12    F   FM

_______________________________Capacity Checks_________________________________

                           Actual        Maximum         LOS F?
     v                     829           1110704128      No
      FO
     v  or v               0    pc/h     (Equation 13-14 or 13-17)
      3     av34
Is   v  or v      > 2700 pc/h?           No
      3     av34
Is   v  or v      > 1.5 v  /2            No
      3     av34         12
If yes, v    = 645                    (Equation 13-15, 13-16, 13-18, or 13-19)
         12A

________________________Flow Entering Merge Influence Area_____________________
                      Actual        Max Desirable         Violation?
     v                829           1110704128            No
      R12
_________________Level of Service Determination (if not F)_____________________

Density, D = 5.475 + 0.00734 v  + 0.0078 v   - 0.00627 L   =   8.7     pc/mi/ln
          R                   R           12             A
Level of service for ramp-freeway junction areas of influence  A

_____________________________Speed Estimation__________________________________

Intermediate speed variable,                 M  = 0.290
                                              S
Space mean speed in ramp influence area,     S  = 44.1    mph
                                              R
Space mean speed in outer lanes,             S  =  N/A    mph
                                              0
Space mean speed for all vehicles,           S  = 44.1    mph
_______________________________________________________________________________
```

X

HCS 2010: Freeway Merge and Diverge Segments Release 6.80

Phone: Fax:
E-mail:

Diverge Analysis

Analyst:
Agency/Co.:
Date performed: 1/25/2018
Analysis time period:
Freeway/Dir of Travel: Diverge from 680S to Mission W
Junction:
Jurisdiction:
Analysis Year:
Description:

Freeway Data

Type of analysis	Diverge	
Number of lanes in freeway	2	
Free-flow speed on freeway	65.0	mph
Volume on freeway	1879	vph

Off Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-Flow speed on ramp	35.0	mph
Volume on ramp	1717	vph
Length of first accel/decel lane	500	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	No	
Volume on adjacent ramp		vph
Position of adjacent ramp		
Type of adjacent ramp		
Distance to adjacent ramp		ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway		Ramp		Adjacent Ramp	
Volume, V (vph)	1879		1717			vph
Peak-hour factor, PHF	0.94		0.94			
Peak 15-min volume, v15	500		457			v
Trucks and buses	5		7			%
Recreational vehicles	0		0			%
Terrain type:	Level		Level			
Grade	0.00	%	0.00	%	%	
Length	0.00	mi	0.00	mi	mi	
Trucks and buses PCE, ET	1.5		1.5			
Recreational vehicle PCE, ER	1.2		1.2			

```
Heavy vehicle adjustment, fHV          0.976       0.966                          X
Driver population factor, fP           1.00        1.00
Flow rate, vp                          2049        1891                  pcph

_________________________Estimation of V12 Diverge Areas_______________________

                  L  =           (Equation 13-12 or 13-13)
                   EQ
                  P  =    1.000   Using Equation  0
                   FD
                  v  = v  + (v - v ) P  =  2049   pc/h
                   12   R     F   R   FD

_______________________________Capacity Checks_________________________________

                           Actual        Maximum         LOS F?
     v  = v                2049          4700            No
      Fi   F
     v  = v - v            158           4700            No
      FO   F   R
     v                     1891          2000            No
      R
     v  or v               0    pc/h     (Equation 13-14 or 13-17)
      3     av34
Is   v  or v      > 2700 pc/h?           No
      3     av34
Is   v  or v      > 1.5 v  /2            No
      3     av34         12
If yes, v    = 2049                   (Equation 13-15, 13-16, 13-18, or 13-19)
         12A

______________________Flow Entering Diverge Influence Area_____________________
                      Actual        Max Desirable          Violation?
     v                2049          4400                   No
      12
_________________Level of Service Determination (if not F)_____________________

Density,               D = 4.252 + 0.0086 v  - 0.009  L   =   17.4    pc/mi/ln
                        R                  12          D
Level of service for ramp-freeway junction areas of influence B

_____________________________Speed Estimation__________________________________

Intermediate speed variable,                 D  = 0.598
                                              S
Space mean speed in ramp influence area,     S  = 51.2    mph
                                              R
Space mean speed in outer lanes,             S  =  N/A    mph
                                              0
Space mean speed for all vehicles,           S  = 51.2    mph
_______________________________________________________________________________
```

X

HCS 2010: Freeway Merge and Diverge Segments Release 6.80

Phone: Fax:
E-mail:

Diverge Analysis

Analyst:
Agency/Co.:
Date performed: 1/26/2018
Analysis time period:
Freeway/Dir of Travel: Diverge fr Mission Wb to 680S
Junction:
Jurisdiction:
Analysis Year:
Description:

Freeway Data

Type of analysis	Diverge	
Number of lanes in freeway	2	
Free-flow speed on freeway	45.0	mph
Volume on freeway	810	vph

Off Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-Flow speed on ramp	25.0	mph
Volume on ramp	526	vph
Length of first accel/decel lane	500	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	No	
Volume on adjacent ramp		vph
Position of adjacent ramp		
Type of adjacent ramp		
Distance to adjacent ramp		ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway		Ramp		Adjacent Ramp	
Volume, V (vph)	810		526			vph
Peak-hour factor, PHF	0.94		0.94			
Peak 15-min volume, v15	215		140			v
Trucks and buses	5		4			%
Recreational vehicles	0		0			%
Terrain type:	Level		Level			
Grade	0.00	%	0.00	%	%	
Length	0.00	mi	0.00	mi	mi	
Trucks and buses PCE, ET	1.5		1.5			
Recreational vehicle PCE, ER	1.2		1.2			

```
Heavy vehicle adjustment, fHV          0.976       0.980                        x
Driver population factor, fP           1.00        1.00
Flow rate, vp                          883         571                    pcph

_________________________Estimation of V12 Diverge Areas_______________________

                  L   =           (Equation 13-12 or 13-13)
                   EQ
                  P   =    1.000   Using Equation  0
                   FD
                  v   = v  + (v - v ) P  =  883    pc/h
                   12   R      F   R   FD

_______________________________Capacity Checks_________________________________

                           Actual        Maximum         LOS F?
     v  = v                883           1110704128      No
      Fi   F
     v  = v - v            312           1110704128      No
      FO   F   R
     v                     571           1900            No
      R
     v  or v               0    pc/h     (Equation 13-14 or 13-17)
      3     av34
Is   v  or v      > 2700 pc/h?           No
      3     av34
Is   v  or v      > 1.5 v  /2            No
      3     av34         12
If yes, v    = 883                    (Equation 13-15, 13-16, 13-18, or 13-19)
         12A

______________________Flow Entering Diverge Influence Area______________________
                      Actual        Max Desirable          Violation?
     v                883           1110704128             No
      12
_________________Level of Service Determination (if not F)______________________

Density,               D = 4.252 + 0.0086 v  - 0.009  L   =   7.3     pc/mi/ln
                        R                  12          D
Level of service for ramp-freeway junction areas of influence A

_____________________________Speed Estimation__________________________________

Intermediate speed variable,                D  = 0.609
                                             S
Space mean speed in ramp influence area,    S  = 43.2    mph
                                             R
Space mean speed in outer lanes,            S  =  N/A    mph
                                             0
Space mean speed for all vehicles,          S  = 43.2    mph
_______________________________________________________________________________
```

X

HCS 2010: Freeway Merge and Diverge Segments Release 6.80

Phone: Fax:
E-mail:

Diverge Analysis

Analyst:
Agency/Co.:
Date performed: 1/26/2018
Analysis time period:
Freeway/Dir of Travel: Diverge fr Mission Wb to 680N
Junction:
Jurisdiction:
Analysis Year:
Description:

Freeway Data

Type of analysis	Diverge	
Number of lanes in freeway	2	
Free-flow speed on freeway	45.0	mph
Volume on freeway	1154	vph

Off Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-Flow speed on ramp	40.0	mph
Volume on ramp	68	vph
Length of first accel/decel lane	500	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	No	
Volume on adjacent ramp		vph
Position of adjacent ramp		
Type of adjacent ramp		
Distance to adjacent ramp		ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway		Ramp		Adjacent Ramp	
Volume, V (vph)	1154		68			vph
Peak-hour factor, PHF	0.94		0.94			
Peak 15-min volume, v15	307		18			v
Trucks and buses	5		4			%
Recreational vehicles	0		0			%
Terrain type:	Level		Level			
Grade	0.00	%	0.00	%	%	
Length	0.00	mi	0.00	mi	mi	
Trucks and buses PCE, ET	1.5		1.5			
Recreational vehicle PCE, ER	1.2		1.2			

```
Heavy vehicle adjustment, fHV          0.976       0.980                          x
Driver population factor, fP           1.00        1.00
Flow rate, vp                          1258        74                    pcph

_________________________Estimation of V12 Diverge Areas_______________________

                  L   =            (Equation 13-12 or 13-13)
                   EQ
                  P   =    1.000   Using Equation  0
                   FD
                  v   = v  + (v - v ) P   =  1258   pc/h
                   12   R      F    R   FD

_______________________________Capacity Checks_________________________________

                           Actual        Maximum         LOS F?
     v  = v                1258          1110704128      No
      Fi   F
     v  = v - v            1184          1110704128      No
      FO   F   R
     v                     74            2100            No
      R
     v  or v               0    pc/h     (Equation 13-14 or 13-17)
      3     av34
Is   v  or v       > 2700 pc/h?          No
      3     av34
Is   v  or v       > 1.5 v  /2           No
      3     av34         12
If yes, v    = 1258                   (Equation 13-15, 13-16, 13-18, or 13-19)
         12A

______________________Flow Entering Diverge Influence Area_____________________
                      Actual        Max Desirable        Violation?
     v                1258          1110704128           No
      12
_________________Level of Service Determination (if not F)_____________________

Density,               D = 4.252 + 0.0086 v  - 0.009  L   =   10.6    pc/mi/ln
                        R                  12          D
Level of service for ramp-freeway junction areas of influence B

_____________________________Speed Estimation__________________________________

Intermediate speed variable,                D   = 0.370
                                             S
Space mean speed in ramp influence area,    S   = 43.9    mph
                                             R
Space mean speed in outer lanes,            S   =  N/A    mph
                                             0
Space mean speed for all vehicles,          S   = 43.9    mph
_______________________________________________________________________________
```

X

Phone: Fax:
E-mail:

Diverge Analysis

Analyst:
Agency/Co.:
Date performed: 1/26/2018
Analysis time period:
Freeway/Dir of Travel: Diverge fr Mission Eb to 680 S
Junction:
Jurisdiction:
Analysis Year:
Description:

Freeway Data

Type of analysis	Diverge	
Number of lanes in freeway	2	
Free-flow speed on freeway	45.0	mph
Volume on freeway	1808	vph

Off Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-Flow speed on ramp	40.0	mph
Volume on ramp	684	vph
Length of first accel/decel lane	500	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	No	
Volume on adjacent ramp		vph
Position of adjacent ramp		
Type of adjacent ramp		
Distance to adjacent ramp		ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway		Ramp		Adjacent Ramp	
Volume, V (vph)	1808		684			vph
Peak-hour factor, PHF	0.94		0.94			
Peak 15-min volume, v15	481		182			v
Trucks and buses	4		4			%
Recreational vehicles	0		0			%
Terrain type:	Level		Level			
Grade	0.00	%	0.00	%		%
Length	0.00	mi	0.00	mi		mi
Trucks and buses PCE, ET	1.5		1.5			
Recreational vehicle PCE, ER	1.2		1.2			

```
Heavy vehicle adjustment, fHV           0.980       0.980
Driver population factor, fP            1.00        1.00                              x
Flow rate, vp                           1962        742                   pcph

_________________________Estimation of V12 Diverge Areas_______________________

                  L   =            (Equation 13-12 or 13-13)
                   EQ
                  P   =    1.000   Using Equation  0
                   FD
                  v   = v  + (v - v ) P  =  1962   pc/h
                   12    R      F    R   FD

_______________________________Capacity Checks_________________________________

                           Actual        Maximum          LOS F?
     v   = v               1962          1110704128       No
      Fi    F
     v   = v - v           1220          1110704128       No
      FO    F   R
     v                     742           2100             No
      R
     v  or v               0    pc/h     (Equation 13-14 or 13-17)
      3     av34
Is   v  or v      > 2700 pc/h?           No
      3     av34
Is   v  or v      > 1.5 v  /2            No
      3     av34         12
If yes, v    = 1962                   (Equation 13-15, 13-16, 13-18, or 13-19)
         12A

______________________Flow Entering Diverge Influence Area_____________________
                      Actual        Max Desirable        Violation?
     v                1962          1110704128           No
      12
_________________Level of Service Determination (if not F)_____________________

Density,               D = 4.252 + 0.0086 v  - 0.009  L   =   16.6    pc/mi/ln
                        R                   12           D
Level of service for ramp-freeway junction areas of influence B

_____________________________Speed Estimation__________________________________

Intermediate speed variable,                D   = 0.430
                                             S
Space mean speed in ramp influence area,    S   = 43.7    mph
                                             R
Space mean speed in outer lanes,            S   =  N/A    mph
                                             0
Space mean speed for all vehicles,          S   = 43.7    mph
_______________________________________________________________________________
```

Phone: Fax:
E-mail:

Diverge Analysis

Analyst:	
Agency/Co.:	
Date performed:	1/26/2018
Analysis time period:	
Freeway/Dir of Travel:	Diverge fr Mission Eb to 680N
Junction:	
Jurisdiction:	
Analysis Year:	
Description:	

Freeway Data

Type of analysis	Diverge	
Number of lanes in freeway	2	
Free-flow speed on freeway	45.0	mph
Volume on freeway	1393	vph

Off Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-Flow speed on ramp	25.0	mph
Volume on ramp	682	vph
Length of first accel/decel lane	500	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	No	
Volume on adjacent ramp		vph
Position of adjacent ramp		
Type of adjacent ramp		
Distance to adjacent ramp		ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway		Ramp		Adjacent Ramp	
Volume, V (vph)	1393		682			vph
Peak-hour factor, PHF	0.94		0.94			
Peak 15-min volume, v15	370		181			v
Trucks and buses	4		7			%
Recreational vehicles	0		0			%
Terrain type:	Level		Level			
Grade	0.00	%	0.00	%		%
Length	0.00	mi	0.00	mi		mi
Trucks and buses PCE, ET	1.5		1.5			
Recreational vehicle PCE, ER	1.2		1.2			

Heavy vehicle adjustment, fHV	0.980	0.966		x
Driver population factor, fP	1.00	1.00		
Flow rate, vp	1512	751	pcph	

Estimation of V12 Diverge Areas

L_{EQ} = (Equation 13-12 or 13-13)

P_{FD} = 1.000 Using Equation 0

$v_{12} = v_R + (v_F - v_R) P_{FD}$ = 1512 pc/h

Capacity Checks

	Actual		Maximum	LOS F?
$v_{Fi} = v_F$	1512		1110704128	No
$v_{FO} = v_F - v_R$	761		1110704128	No
v_R	751		1900	No
v_3 or v_{av34}	0	pc/h	(Equation 13-14 or 13-17)	
Is v_3 or v_{av34} > 2700 pc/h?			No	
Is v_3 or v_{av34} > 1.5 v_{12}/2			No	

If yes, v_{12A} = 1512 (Equation 13-15, 13-16, 13-18, or 13-19)

Flow Entering Diverge Influence Area

	Actual	Max Desirable	Violation?
v_{12}	1512	1110704128	No

Level of Service Determination (if not F)

Density, $D_R = 4.252 + 0.0086\, v_{12} - 0.009\, L_D$ = 12.8 pc/mi/ln

Level of service for ramp-freeway junction areas of influence B

Speed Estimation

Intermediate speed variable,	D_S = 0.626		
Space mean speed in ramp influence area,	S_R = 43.1	mph	
Space mean speed in outer lanes,	S_0 = N/A	mph	
Space mean speed for all vehicles,	S = 43.1	mph	

HCS 2010: Freeway Merge and Diverge Segments Release 6.80

Phone: Fax:
E-mail:

Diverge Analysis

Analyst:
Agency/Co.:
Date performed: 1/26/2018
Analysis time period:
Freeway/Dir of Travel: Diverge fr 680N to Mission Wb
Junction:
Jurisdiction:
Analysis Year:
Description:

Freeway Data

Type of analysis	Diverge	
Number of lanes in freeway	2	
Free-flow speed on freeway	65.0	mph
Volume on freeway	1662	vph

Off Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-Flow speed on ramp	25.0	mph
Volume on ramp	746	vph
Length of first accel/decel lane	500	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	No	
Volume on adjacent ramp		vph
Position of adjacent ramp		
Type of adjacent ramp		
Distance to adjacent ramp		ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway		Ramp		Adjacent Ramp	
Volume, V (vph)	1662		746			vph
Peak-hour factor, PHF	0.94		0.94			
Peak 15-min volume, v15	442		198			v
Trucks and buses	4		5			%
Recreational vehicles	0		0			%
Terrain type:	Level		Level			
Grade	0.00	%	0.00	%		%
Length	0.00	mi	0.00	mi		mi
Trucks and buses PCE, ET	1.5		1.5			
Recreational vehicle PCE, ER	1.2		1.2			

X

Heavy vehicle adjustment, fHV	0.980	0.976	
Driver population factor, fP	1.00	1.00	
Flow rate, vp	1803	813	pcph

Estimation of V12 Diverge Areas

L_{EQ} = (Equation 13-12 or 13-13)

P_{FD} = 1.000 Using Equation 0

$v_{12} = v_R + (v_F - v_R) P_{FD}$ = 1803 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{Fi} = v_F$	1803	4700	No
$v_{FO} = v_F - v_R$	990	4700	No
v_R	813	1900	No
v_3 or v_{av34}	0 pc/h	(Equation 13-14 or 13-17)	

Is v_3 or v_{av34} > 2700 pc/h? No

Is v_3 or v_{av34} > 1.5 v_{12}/2 No

If yes, v_{12A} = 1803 (Equation 13-15, 13-16, 13-18, or 13-19)

Flow Entering Diverge Influence Area

	Actual	Max Desirable	Violation?
v_{12}	1803	4400	No

Level of Service Determination (if not F)

Density, $D_R = 4.252 + 0.0086\, v_{12} - 0.009\, L_D$ = 15.3 pc/mi/ln

Level of service for ramp-freeway junction areas of influence B

Speed Estimation

Intermediate speed variable,	D_S = 0.631	
Space mean speed in ramp influence area,	S_R = 50.5	mph
Space mean speed in outer lanes,	S_0 = N/A	mph
Space mean speed for all vehicles,	S = 50.5	mph

X

HCS 2010: Freeway Merge and Diverge Segments Release 6.80

Phone: Fax:
E-mail:

Diverge Analysis

Analyst:
Agency/Co.:
Date performed: 1/26/2018
Analysis time period:
Freeway/Dir of Travel: Diverge fr 680 N to Mission Eb
Junction:
Jurisdiction:
Analysis Year:
Description:

Freeway Data

Type of analysis	Diverge	
Number of lanes in freeway	2	
Free-flow speed on freeway	65.0	mph
Volume on freeway	1112	vph

Off Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-Flow speed on ramp	40.0	mph
Volume on ramp	170	vph
Length of first accel/decel lane	500	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	No	
Volume on adjacent ramp		vph
Position of adjacent ramp		
Type of adjacent ramp		
Distance to adjacent ramp		ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway		Ramp		Adjacent Ramp	
Volume, V (vph)	1112		170			vph
Peak-hour factor, PHF	0.94		0.94			
Peak 15-min volume, v15	296		45			v
Trucks and buses	4		6			%
Recreational vehicles	0		0			%
Terrain type:	Level		Level			
Grade	0.00	%	0.00	%		%
Length	0.00	mi	0.00	mi		mi
Trucks and buses PCE, ET	1.5		1.5			
Recreational vehicle PCE, ER	1.2		1.2			

```
Heavy vehicle adjustment, fHV           0.980       0.971                       X
Driver population factor, fP            1.00        1.00
Flow rate, vp                           1207        186                    pcph

_________________________Estimation of V12 Diverge Areas_______________________

                  L   =             (Equation 13-12 or 13-13)
                   EQ
                  P   =     1.000   Using Equation  0
                   FD
                  v   = v   + (v - v ) P   =  1207   pc/h
                   12    R      F    R    FD

_______________________________Capacity Checks_________________________________

                           Actual        Maximum         LOS F?
     v   = v               1207          4700            No
      Fi    F
     v   = v - v           1021          4700            No
      FO    F   R
     v                     186           2100            No
      R
     v   or v              0    pc/h     (Equation 13-14 or 13-17)
      3      av34
Is   v   or v      > 2700 pc/h?          No
      3      av34
Is   v   or v      > 1.5 v  /2           No
      3      av34         12
If yes, v    = 1207                   (Equation 13-15, 13-16, 13-18, or 13-19)
         12A

______________________Flow Entering Diverge Influence Area_____________________
                      Actual        Max Desirable          Violation?
     v                1207          4400                   No
      12
_________________Level of Service Determination (if not F)_____________________

Density,               D = 4.252 + 0.0086 v  - 0.009  L    =   10.1    pc/mi/ln
                        R                  12          D
Level of service for ramp-freeway junction areas of influence B

_____________________________Speed Estimation__________________________________

Intermediate speed variable,                 D   = 0.380
                                              S
Space mean speed in ramp influence area,     S   = 56.3    mph
                                              R
Space mean speed in outer lanes,             S   =  N/A    mph
                                              0
Space mean speed for all vehicles,           S   = 56.3    mph
_______________________________________________________________________________
```

X

HCS 2010: Basic Freeway Segments Release 6.80

Phone: Fax:
E-mail:

Operational Analysis

Analyst:	
Agency or Company:	
Date Performed:	1/26/2018
Analysis Time Period:	
Freeway/Direction:	680 South
From/To:	
Jurisdiction:	Fremont, CA
Analysis Year:	2017
Description:	

Flow Inputs and Adjustments

Volume, V	7853	veh/h
Peak-hour factor, PHF	0.94	
Peak 15-min volume, v15	2089	v
Trucks and buses	5	%
Recreational vehicles	0	%
Terrain type:	Level	
Grade	-	%
Segment length	-	mi
Trucks and buses PCE, ET	1.5	
Recreational vehicle PCE, ER	1.2	
Heavy vehicle adjustment, fHV	0.976	
Driver population factor, fp	1.00	
Flow rate, vp	2141	pc/h/ln

Speed Inputs and Adjustments

Lane width	-	ft
Right-side lateral clearance	-	ft
Total ramp density, TRD	-	ramps/mi
Number of lanes, N	4	
Free-flow speed:	Measured	
FFS or BFFS	65.0	mi/h
Lane width adjustment, fLW	-	mi/h
Lateral clearance adjustment, fLC	-	mi/h
TRD adjustment	-	mi/h
Free-flow speed, FFS	65.0	mi/h

LOS and Performance Measures

Flow rate, vp	2141	pc/h/ln
Free-flow speed, FFS	65.0	mi/h
Average passenger-car speed, S	57.2	mi/h
Number of lanes, N	4	
Density, D	37.4	pc/mi/ln
Level of service, LOS	E	

Overall results are not computed when free-flow speed is less than 55 mph. X

X

HCS 2010: Basic Freeway Segments Release 6.80

Phone: Fax:
E-mail:

Operational Analysis

Analyst:	
Agency or Company:	
Date Performed:	4/28/2018
Analysis Time Period:	
Freeway/Direction:	680 North
From/To:	
Jurisdiction:	Fremont, Ca
Analysis Year:	
Description:	

Flow Inputs and Adjustments

Volume, V	6464	veh/h
Peak-hour factor, PHF	0.94	
Peak 15-min volume, v15	1719	v
Trucks and buses	4	%
Recreational vehicles	0	%
Terrain type:	Level	
Grade	-	%
Segment length	-	mi
Trucks and buses PCE, ET	1.5	
Recreational vehicle PCE, ER	1.2	
Heavy vehicle adjustment, fHV	0.980	
Driver population factor, fp	1.00	
Flow rate, vp	2338	pc/h/ln

Speed Inputs and Adjustments

Lane width	-	ft
Right-side lateral clearance	-	ft
Total ramp density, TRD	-	ramps/mi
Number of lanes, N	3	
Free-flow speed:	Measured	
FFS or BFFS	65.0	mi/h
Lane width adjustment, fLW	-	mi/h
Lateral clearance adjustment, fLC	-	mi/h
TRD adjustment	-	mi/h
Free-flow speed, FFS	65.0	mi/h

LOS and Performance Measures

Flow rate, vp	2338	pc/h/ln
Free-flow speed, FFS	65.0	mi/h
Average passenger-car speed, S	52.5	mi/h
Number of lanes, N	3	
Density, D	44.5	pc/mi/ln
Level of service, LOS	E	

Overall results are not computed when free-flow speed is less than 55 mph. X

HCS 2010: Freeway Merge and Diverge Segments Release 6.80

X

Phone: Fax:
E-mail:

Merge Analysis

Analyst:	
Agency/Co.:	
Date performed:	1/26/2018
Analysis time period:	
Freeway/Dir of Travel:	Merge from 680S to Mission Wb
Junction:	
Jurisdiction:	
Analysis Year:	
Description:	

Freeway Data

Type of analysis	Merge	
Number of lanes in freeway	2	
Free-flow speed on freeway	45.0	mph
Volume on freeway	3379	vph

On Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-flow speed on ramp	35.0	mph
Volume on ramp	2494	vph
Length of first accel/decel lane	500	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	No	
Volume on adjacent Ramp		vph
Position of adjacent Ramp		
Type of adjacent Ramp		
Distance to adjacent Ramp		ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	3379	2494		vph
Peak-hour factor, PHF	0.94	0.94		
Peak 15-min volume, v15	899	663		v
Trucks and buses	4	5		%
Recreational vehicles	0	0		%
Terrain type:	Level	Level		
Grade	%	%	%	
Length	mi	mi	mi	
Trucks and buses PCE, ET	1.5	1.5		
Recreational vehicle PCE, ER	1.2	1.2		

```
Heavy vehicle adjustment, fHV          0.980       0.976                        X
Driver population factor, fP           1.00        1.00
Flow rate, vp                          3667        2720                 pcph

_________________________Estimation of V12 Merge Areas_________________________

                  L  =            (Equation 13-6 or 13-7)
                   EQ
                  P  =    1.000   Using Equation  0
                   FM
                  v  = v  (P  ) =  3667   pc/h
                   12   F   FM

_______________________________Capacity Checks_______________________________

                           Actual        Maximum         LOS F?
     v                     6387          1110704128      No
      FO
     v  or v               0    pc/h     (Equation 13-14 or 13-17)
      3     av34
Is   v  or v      > 2700 pc/h?           No
      3     av34
Is   v  or v      > 1.5 v  /2            No
      3     av34         12
If yes, v    = 3667                   (Equation 13-15, 13-16, 13-18, or 13-19)
         12A

________________________Flow Entering Merge Influence Area_____________________
                      Actual        Max Desirable          Violation?
     v                6387          1110704128             No
      R12
_________________Level of Service Determination (if not F)_____________________

Density, D = 5.475 + 0.00734 v  + 0.0078 v   - 0.00627 L   =   50.9    pc/mi/ln
         R                    R            12             A
Level of service for ramp-freeway junction areas of influence  E

_____________________________Speed Estimation_________________________________

Intermediate speed variable,                 M  = 2.603
                                              S
Space mean speed in ramp influence area,     S  = 37.2    mph
                                              R
Space mean speed in outer lanes,             S  =  N/A    mph
                                              0
Space mean speed for all vehicles,           S  = 37.2    mph
_______________________________________________________________________________
```

X

HCS 2010: Freeway Merge and Diverge Segments Release 6.80

Phone: Fax:
E-mail:

Merge Analysis

Analyst:
Agency/Co.:
Date performed: 1/26/2018
Analysis time period:
Freeway/Dir of Travel: Merge fr Mission W to 680N
Junction:
Jurisdiction:
Analysis Year:
Description:

Freeway Data

Type of analysis	Merge	
Number of lanes in freeway	2	
Free-flow speed on freeway	65.0	mph
Volume on freeway	1112	vph

On Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-flow speed on ramp	40.0	mph
Volume on ramp	121	vph
Length of first accel/decel lane	500	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	No	
Volume on adjacent Ramp		vph
Position of adjacent Ramp		
Type of adjacent Ramp		
Distance to adjacent Ramp		ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway		Ramp		Adjacent Ramp	
Volume, V (vph)	1112		121			vph
Peak-hour factor, PHF	0.94		0.94			
Peak 15-min volume, v15	296		32			v
Trucks and buses	4		3			%
Recreational vehicles	0		0			%
Terrain type:	Level		Level			
Grade		%		%		%
Length		mi		mi		mi
Trucks and buses PCE, ET	1.5		1.5			
Recreational vehicle PCE, ER	1.2		1.2			

```
Heavy vehicle adjustment, fHV           0.980       0.985                            X
Driver population factor, fP            1.00        1.00
Flow rate, vp                           1207        131                    pcph

_________________________Estimation of V12 Merge Areas_________________________

                  L   =            (Equation 13-6 or 13-7)
                   EQ
                  P   =    1.000   Using Equation  0
                   FM
                  v   = v  (P   ) =  1207   pc/h
                   12   F    FM

_______________________________Capacity Checks_______________________________

                           Actual        Maximum         LOS F?
     v                     1338          4700            No
      FO
     v  or v               0    pc/h     (Equation 13-14 or 13-17)
      3     av34
Is   v  or v      > 2700 pc/h?           No
      3     av34
Is   v  or v      > 1.5 v  /2            No
      3     av34         12
If yes, v    = 1207                   (Equation 13-15, 13-16, 13-18, or 13-19)
         12A

________________________Flow Entering Merge Influence Area_____________________
                      Actual        Max Desirable        Violation?
     v                1338          4600                 No
      R12
_________________Level of Service Determination (if not F)_____________________

Density, D = 5.475 + 0.00734 v  + 0.0078 v   - 0.00627 L   =   12.7    pc/mi/ln
          R                   R           12             A
Level of service for ramp-freeway junction areas of influence  B

_____________________________Speed Estimation________________________________

Intermediate speed variable,                 M  = 0.296
                                              S
Space mean speed in ramp influence area,     S  = 58.2    mph
                                              R
Space mean speed in outer lanes,             S  =  N/A    mph
                                              0
Space mean speed for all vehicles,           S  = 58.2    mph
_______________________________________________________________________________
```

X

HCS 2010: Freeway Merge and Diverge Segments Release 6.80

Phone: Fax:
E-mail:

Merge Analysis

Analyst: Melissa Elian
Agency/Co.: Santa Clara University
Date performed: 11/16/2017
Analysis time period:
Freeway/Dir of Travel: Merge fr Mission Eb to 680S
Junction:
Jurisdiction:
Analysis Year:
Description:

Freeway Data

Type of analysis	Merge	
Number of lanes in freeway	5	
Free-flow speed on freeway	65.0	mph
Volume on freeway	3048	vph

On Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-flow speed on ramp	40.0	mph
Volume on ramp	1425	vph
Length of first accel/decel lane	1030	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	No	
Volume on adjacent Ramp		vph
Position of adjacent Ramp		
Type of adjacent Ramp		
Distance to adjacent Ramp		ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway		Ramp		Adjacent Ramp	
Volume, V (vph)	3048		1425			vph
Peak-hour factor, PHF	0.94		0.94			
Peak 15-min volume, v15	811		379			v
Trucks and buses	4		4			%
Recreational vehicles	0		0			%
Terrain type:	Level		Level			
Grade		%		%		%
Length		mi		mi		mi
Trucks and buses PCE, ET	1.5		1.5			
Recreational vehicle PCE, ER	1.2		1.2			

X

Heavy vehicle adjustment, fHV	0.980	0.980	
Driver population factor, fP	1.00	1.00	
Flow rate, vp	3307	1546	pcph

Estimation of V12 Merge Areas

L_{EQ} = (Equation 13-6 or 13-7)

P_{FM} = 0.312 Using Equation 0

$v_{12} = v_F (P_{FM})$ = 804 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	4126	11752	No
v_3 or v_{av34}	888 pc/h	(Equation 13-14 or 13-17)	
Is v_3 or v_{av34} > 2700 pc/h?		No	
Is v_3 or v_{av34} > 1.5 v_{12}/2		Yes	
If yes, v_{12A} = 1032		(Equation 13-15, 13-16, 13-18, or 13-19)	

Flow Entering Merge Influence Area

	Actual	Max Desirable	Violation?
v_{12A}	2578	4600	No

Level of Service Determination (if not F)

Density, $D_R = 5.475 + 0.00734\, v_R + 0.0078\, v_{12} - 0.00627\, L_A$ = 18.4 pc/mi/ln

Level of service for ramp-freeway junction areas of influence B

Speed Estimation

Intermediate speed variable,	M_S = 0.290	
Space mean speed in ramp influence area,	S_R = 58.3	mph
Space mean speed in outer lanes,	S_0 = 64.0	mph
Space mean speed for all vehicles,	S = 60.3	mph

X

HCS 2010: Freeway Merge and Diverge Segments Release 6.80

Phone: Fax:
E-mail:

Merge Analysis

Analyst:
Agency/Co.:
Date performed: 1/26/2018
Analysis time period:
Freeway/Dir of Travel: Merge fr 680S to Mission Eb
Junction:
Jurisdiction:
Analysis Year:
Description:

Freeway Data

Type of analysis	Merge	
Number of lanes in freeway	2	
Free-flow speed on freeway	45.0	mph
Volume on freeway	566	vph

On Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-flow speed on ramp	25.0	mph
Volume on ramp	28	vph
Length of first accel/decel lane	500	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	No	
Volume on adjacent Ramp		vph
Position of adjacent Ramp		
Type of adjacent Ramp		
Distance to adjacent Ramp		ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	566	28		vph
Peak-hour factor, PHF	0.94	0.94		
Peak 15-min volume, v15	151	7		v
Trucks and buses	5	3		%
Recreational vehicles	0	0		%
Terrain type:	Level	Level		
Grade	%	%	%	
Length	mi	mi	mi	
Trucks and buses PCE, ET	1.5	1.5		
Recreational vehicle PCE, ER	1.2	1.2		

Heavy vehicle adjustment, fHV	0.976	0.985		x
Driver population factor, fP	1.00	1.00		
Flow rate, vp	617	30	pcph	

Estimation of V12 Merge Areas

L_{EQ} = (Equation 13-6 or 13-7)

P_{FM} = 1.000 Using Equation 0

$v_{12} = v_F (P_{FM})$ = 617 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	647	1110704128	No
v_3 or v_{av34}	0 pc/h	(Equation 13-14 or 13-17)	
Is v_3 or v_{av34} > 2700 pc/h?		No	
Is v_3 or v_{av34} > 1.5 v_{12}/2		No	

If yes, v_{12A} = 617 (Equation 13-15, 13-16, 13-18, or 13-19)

Flow Entering Merge Influence Area

	Actual	Max Desirable	Violation?
v_{R12}	647	1110704128	No

Level of Service Determination (if not F)

Density, $D_R = 5.475 + 0.00734\, v_R + 0.0078\, v_{12} - 0.00627\, L_A$ = 7.4 pc/mi/ln

Level of service for ramp-freeway junction areas of influence A

Speed Estimation

Intermediate speed variable,	M_S = 0.303		
Space mean speed in ramp influence area,	S_R = 44.1	mph	
Space mean speed in outer lanes,	S_0 = N/A	mph	
Space mean speed for all vehicles,	S = 44.1	mph	

X

HCS 2010: Freeway Merge and Diverge Segments Release 6.80

Phone: Fax:
E-mail:

Merge Analysis

Analyst:
Agency/Co.:
Date performed: 1/26/2018
Analysis time period:
Freeway/Dir of Travel: Merge fr 680N to Mission Wb
Junction:
Jurisdiction:
Analysis Year:
Description:

Freeway Data

Type of analysis	Merge	
Number of lanes in freeway	2	
Free-flow speed on freeway	45.0	mph
Volume on freeway	2361	vph

On Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-flow speed on ramp	25.0	mph
Volume on ramp	590	vph
Length of first accel/decel lane	500	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	No	
Volume on adjacent Ramp		vph
Position of adjacent Ramp		
Type of adjacent Ramp		
Distance to adjacent Ramp		ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway		Ramp		Adjacent Ramp	
Volume, V (vph)	2361		590			vph
Peak-hour factor, PHF	0.94		0.94			
Peak 15-min volume, v15	628		157			v
Trucks and buses	4		5			%
Recreational vehicles	0		0			%
Terrain type:	Level		Grade			
Grade		%	0.00	%		%
Length		mi	0.00	mi		mi
Trucks and buses PCE, ET	1.5		1.5			
Recreational vehicle PCE, ER	1.2		1.2			

Heavy vehicle adjustment, fHV	0.980	0.976		X
Driver population factor, fP	1.00	1.00		
Flow rate, vp	2562	643	pcph	

Estimation of V12 Merge Areas

L_{EQ} = (Equation 13-6 or 13-7)

P_{FM} = 1.000 Using Equation 0

$v_{12} = v_F (P_{FM})$ = 2562 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	3205	1110704128	No
v_3 or v_{av34}	0 pc/h	(Equation 13-14 or 13-17)	
Is v_3 or v_{av34} > 2700 pc/h?		No	
Is v_3 or v_{av34} > 1.5 v_{12}/2		Yes	
If yes, v_{12A} = 2562		(Equation 13-15, 13-16, 13-18, or 13-19)	

Flow Entering Merge Influence Area

	Actual	Max Desirable	Violation?
v_{12A}	3205	1110704128	No

Level of Service Determination (if not F)

Density, $D_R = 5.475 + 0.00734\, v_R + 0.0078\, v_{12} - 0.00627\, L_A$ = 27.0 pc/mi/ln

Level of service for ramp-freeway junction areas of influence C

Speed Estimation

Intermediate speed variable,	M_S = 0.392		
Space mean speed in ramp influence area,	S_R = 43.8	mph	
Space mean speed in outer lanes,	S_0 = N/A	mph	
Space mean speed for all vehicles,	S = 43.8	mph	

X

HCS 2010: Freeway Merge and Diverge Segments Release 6.80

Phone: Fax:
E-mail:

Merge Analysis

Analyst:
Agency/Co.:
Date performed: 1/26/2018
Analysis time period:
Freeway/Dir of Travel: Merge fr 680N to Mission Eb
Junction:
Jurisdiction:
Analysis Year:
Description:

Freeway Data

Type of analysis	Merge	
Number of lanes in freeway	2	
Free-flow speed on freeway	45.0	mph
Volume on freeway	634	vph

On Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-flow speed on ramp	40.0	mph
Volume on ramp	229	vph
Length of first accel/decel lane	500	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	No	
Volume on adjacent Ramp		vph
Position of adjacent Ramp		
Type of adjacent Ramp		
Distance to adjacent Ramp		ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	634	229		vph
Peak-hour factor, PHF	0.94	0.94		
Peak 15-min volume, v15	169	61		v
Trucks and buses	6	3		%
Recreational vehicles	0	0		%
Terrain type:	Level	Level		
Grade	%	%	%	
Length	mi	mi	mi	
Trucks and buses PCE, ET	1.5	1.5		
Recreational vehicle PCE, ER	1.2	1.2		

```
Heavy vehicle adjustment, fHV           0.971       0.985                                 x
Driver population factor, fP            1.00        1.00
Flow rate, vp                           695         247                       pcph

_________________________Estimation of V12 Merge Areas_________________________

                  L   =             (Equation 13-6 or 13-7)
                   EQ
                  P   =    1.000   Using Equation  0
                   FM
                  v  = v  (P  ) =  695     pc/h
                   12   F   FM

_______________________________Capacity Checks_________________________________

                           Actual        Maximum         LOS F?
     v                     942           1110704128      No
      FO
     v  or v               0    pc/h     (Equation 13-14 or 13-17)
      3     av34
Is   v  or v      > 2700 pc/h?           No
      3     av34
Is   v  or v      > 1.5 v  /2            No
      3     av34         12
If yes, v    = 695                    (Equation 13-15, 13-16, 13-18, or 13-19)
         12A

________________________Flow Entering Merge Influence Area_____________________
                      Actual        Max Desirable        Violation?
     v                942           1110704128           No
      R12
_________________Level of Service Determination (if not F)_____________________

Density, D = 5.475 + 0.00734 v  + 0.0078 v   - 0.00627 L   =   9.6     pc/mi/ln
         R                    R           12              A
Level of service for ramp-freeway junction areas of influence  A

_____________________________Speed Estimation__________________________________

Intermediate speed variable,                 M  = 0.291
                                              S
Space mean speed in ramp influence area,     S  = 44.1    mph
                                              R
Space mean speed in outer lanes,             S  =  N/A    mph
                                              0
Space mean speed for all vehicles,           S  = 44.1    mph
_______________________________________________________________________________
```

HCS 2010: Freeway Merge and Diverge Segments Release 6.80

Phone: Fax:
E-mail:

Diverge Analysis

Analyst:
Agency/Co.:
Date performed: 1/25/2018
Analysis time period:
Freeway/Dir of Travel: Diverge from 680S to Mission W
Junction:
Jurisdiction:
Analysis Year:
Description:

Freeway Data

Type of analysis	Diverge	
Number of lanes in freeway	2	
Free-flow speed on freeway	65.0	mph
Volume on freeway	2859	vph

Off Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-Flow speed on ramp	35.0	mph
Volume on ramp	2494	vph
Length of first accel/decel lane	500	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	No	
Volume on adjacent ramp		vph
Position of adjacent ramp		
Type of adjacent ramp		
Distance to adjacent ramp		ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway		Ramp		Adjacent Ramp	
Volume, V (vph)	2859		2494			vph
Peak-hour factor, PHF	0.94		0.94			
Peak 15-min volume, v15	760		663			v
Trucks and buses	5		7			%
Recreational vehicles	0		0			%
Terrain type:	Level		Level			
Grade	0.00	%	0.00	%	%	
Length	0.00	mi	0.00	mi	mi	
Trucks and buses PCE, ET	1.5		1.5			
Recreational vehicle PCE, ER	1.2		1.2			

Heavy vehicle adjustment, fHV	0.976	0.966		X
Driver population factor, fP	1.00	1.00		
Flow rate, vp	3118	2746	pcph	

Estimation of V12 Diverge Areas

L_{EQ} = (Equation 13-12 or 13-13)

P_{FD} = 1.000 Using Equation 0

$v_{12} = v_R + (v_F - v_R) P_{FD}$ = 3118 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{Fi} = v_F$	3118	4700	No
$v_{FO} = v_F - v_R$	372	4700	No
v_R	2746	2000	Yes
v_3 or v_{av34}	0 pc/h	(Equation 13-14 or 13-17)	

Is v_3 or v_{av34} > 2700 pc/h? No

Is v_3 or v_{av34} > 1.5 v_{12}/2 No

If yes, v_{12A} = 3118 (Equation 13-15, 13-16, 13-18, or 13-19)

Flow Entering Diverge Influence Area

	Actual	Max Desirable	Violation?
v_{12}	3118	4400	No

Level of Service Determination (if not F)

Density, $D_R = 4.252 + 0.0086\, v_{12} - 0.009\, L_D$ = 26.6 pc/mi/ln

Level of service for ramp-freeway junction areas of influence F

Speed Estimation

Intermediate speed variable,	D_S = 0.675	
Space mean speed in ramp influence area,	S_R = 49.5	mph
Space mean speed in outer lanes,	S_0 = N/A	mph
Space mean speed for all vehicles,	S = 49.5	mph

X

HCS 2010: Freeway Merge and Diverge Segments Release 6.80

Phone: Fax:
E-mail:

Diverge Analysis

Analyst:
Agency/Co.:
Date performed: 1/26/2018
Analysis time period:
Freeway/Dir of Travel: Diverge fr Mission Wb to 680S
Junction:
Jurisdiction:
Analysis Year:
Description:

Freeway Data

Type of analysis	Diverge	
Number of lanes in freeway	2	
Free-flow speed on freeway	45.0	mph
Volume on freeway	810	vph

Off Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-Flow speed on ramp	25.0	mph
Volume on ramp	526	vph
Length of first accel/decel lane	500	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	No	
Volume on adjacent ramp		vph
Position of adjacent ramp		
Type of adjacent ramp		
Distance to adjacent ramp		ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway		Ramp		Adjacent Ramp	
Volume, V (vph)	810		526			vph
Peak-hour factor, PHF	0.94		0.94			
Peak 15-min volume, v15	215		140			v
Trucks and buses	5		4			%
Recreational vehicles	0		0			%
Terrain type:	Level		Level			
Grade	0.00	%	0.00	%	%	
Length	0.00	mi	0.00	mi	mi	
Trucks and buses PCE, ET	1.5		1.5			
Recreational vehicle PCE, ER	1.2		1.2			

Heavy vehicle adjustment, fHV	0.976	0.980	
Driver population factor, fP	1.00	1.00	
Flow rate, vp	883	571	pcph

X

Estimation of V12 Diverge Areas

L_{EQ} = (Equation 13-12 or 13-13)

P_{FD} = 1.000 Using Equation 0

$v_{12} = v_R + (v_F - v_R) P_{FD}$ = 883 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{Fi} = v_F$	883	1110704128	No
$v_{FO} = v_F - v_R$	312	1110704128	No
v_R	571	1900	No
v_3 or v_{av34}	0 pc/h	(Equation 13-14 or 13-17)	

Is v_3 or v_{av34} > 2700 pc/h? No

Is v_3 or v_{av34} > 1.5 v_{12}/2 No

If yes, v_{12A} = 883 (Equation 13-15, 13-16, 13-18, or 13-19)

Flow Entering Diverge Influence Area

	Actual	Max Desirable	Violation?
v_{12}	883	1110704128	No

Level of Service Determination (if not F)

Density, $D_R = 4.252 + 0.0086\ v_{12} - 0.009\ L_D$ = 7.3 pc/mi/ln

Level of service for ramp-freeway junction areas of influence A

Speed Estimation

Intermediate speed variable,	D_S = 0.609	
Space mean speed in ramp influence area,	S_R = 43.2	mph
Space mean speed in outer lanes,	S_0 = N/A	mph
Space mean speed for all vehicles,	S = 43.2	mph

X

HCS 2010: Freeway Merge and Diverge Segments Release 6.80

Phone: Fax:
E-mail:

Diverge Analysis

Analyst:
Agency/Co.:
Date performed: 1/26/2018
Analysis time period:
Freeway/Dir of Travel: Diverge fr Mission Wb to 680N
Junction:
Jurisdiction:
Analysis Year:
Description:

Freeway Data

Type of analysis	Diverge	
Number of lanes in freeway	2	
Free-flow speed on freeway	45.0	mph
Volume on freeway	1843	vph

Off Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-Flow speed on ramp	40.0	mph
Volume on ramp	68	vph
Length of first accel/decel lane	500	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	No	
Volume on adjacent ramp		vph
Position of adjacent ramp		
Type of adjacent ramp		
Distance to adjacent ramp		ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway		Ramp		Adjacent Ramp	
Volume, V (vph)	1843		68			vph
Peak-hour factor, PHF	0.94		0.94			
Peak 15-min volume, v15	490		18			v
Trucks and buses	5		4			%
Recreational vehicles	0		0			%
Terrain type:	Level		Level			
Grade	0.00	%	0.00	%		%
Length	0.00	mi	0.00	mi		mi
Trucks and buses PCE, ET	1.5		1.5			
Recreational vehicle PCE, ER	1.2		1.2			

```
Heavy vehicle adjustment, fHV          0.976       0.980                              X
Driver population factor, fP           1.00        1.00
Flow rate, vp                          2010        74                     pcph

_________________________Estimation of V12 Diverge Areas_______________________

                  L   =            (Equation 13-12 or 13-13)
                   EQ
                  P   =    1.000   Using Equation  0
                   FD
                  v   = v  + (v - v ) P  =  2010   pc/h
                   12   R     F   R   FD

_______________________________Capacity Checks_________________________________

                             Actual        Maximum         LOS F?
     v  = v                  2010          1110704128      No
      Fi   F
     v  = v - v              1936          1110704128      No
      FO   F   R
     v                       74            2100            No
      R
     v  or v                 0    pc/h     (Equation 13-14 or 13-17)
      3     av34
Is   v  or v      > 2700 pc/h?             No
      3     av34
Is   v  or v      > 1.5 v  /2              No
      3     av34         12
If yes, v    = 2010                     (Equation 13-15, 13-16, 13-18, or 13-19)
         12A

______________________Flow Entering Diverge Influence Area______________________
                      Actual        Max Desirable          Violation?
     v                2010          1110704128             No
      12
_________________Level of Service Determination (if not F)______________________

Density,               D = 4.252 + 0.0086 v  - 0.009  L   =   17.0    pc/mi/ln
                        R                  12          D
Level of service for ramp-freeway junction areas of influence B

_____________________________Speed Estimation__________________________________

Intermediate speed variable,               D  = 0.370
                                            S
Space mean speed in ramp influence area,   S  = 43.9    mph
                                            R
Space mean speed in outer lanes,           S  =  N/A    mph
                                            0
Space mean speed for all vehicles,         S  = 43.9    mph
_______________________________________________________________________________
```

X

HCS 2010: Freeway Merge and Diverge Segments Release 6.80

Phone: Fax:
E-mail:

Diverge Analysis

Analyst:
Agency/Co.:
Date performed: 1/26/2018
Analysis time period:
Freeway/Dir of Travel: Diverge fr Mission Eb to 680 S
Junction:
Jurisdiction:
Analysis Year:
Description:

Freeway Data

Type of analysis	Diverge	
Number of lanes in freeway	2	
Free-flow speed on freeway	45.0	mph
Volume on freeway	2638	vph

Off Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-Flow speed on ramp	40.0	mph
Volume on ramp	1425	vph
Length of first accel/decel lane	500	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	No	
Volume on adjacent ramp		vph
Position of adjacent ramp		
Type of adjacent ramp		
Distance to adjacent ramp		ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway		Ramp		Adjacent Ramp	
Volume, V (vph)	2638		1425			vph
Peak-hour factor, PHF	0.94		0.94			
Peak 15-min volume, v15	702		379			v
Trucks and buses	4		4			%
Recreational vehicles	0		0			%
Terrain type:	Level		Level			
Grade	0.00	%	0.00	%		%
Length	0.00	mi	0.00	mi		mi
Trucks and buses PCE, ET	1.5		1.5			
Recreational vehicle PCE, ER	1.2		1.2			

```
Heavy vehicle adjustment, fHV          0.980      0.980                           X
Driver population factor, fP           1.00       1.00
Flow rate, vp                          2863       1546                 pcph

_________________________Estimation of V12 Diverge Areas_______________________

                  L  =           (Equation 13-12 or 13-13)
                   EQ
                  P  =    1.000   Using Equation  0
                   FD
                  v  = v  + (v - v ) P  =  2863   pc/h
                   12   R      F   R   FD

_______________________________Capacity Checks_________________________________

                             Actual        Maximum         LOS F?
     v  = v                  2863          1110704128      No
      Fi   F
     v  = v - v              1317          1110704128      No
      FO   F   R
     v                       1546          2100            No
      R
     v  or v                 0    pc/h     (Equation 13-14 or 13-17)
      3     av34
Is   v  or v      > 2700 pc/h?             No
      3     av34
Is   v  or v      > 1.5 v  /2              No
      3     av34         12
If yes, v    = 2863                     (Equation 13-15, 13-16, 13-18, or 13-19)
         12A

______________________Flow Entering Diverge Influence Area_____________________
                      Actual        Max Desirable         Violation?
     v                2863          1110704128            No
      12
_________________Level of Service Determination (if not F)_____________________

Density,               D = 4.252 + 0.0086 v  - 0.009  L   =   24.4    pc/mi/ln
                        R                  12          D
Level of service for ramp-freeway junction areas of influence C

_____________________________Speed Estimation__________________________________

Intermediate speed variable,                 D  = 0.502
                                              S
Space mean speed in ramp influence area,     S  = 43.5    mph
                                              R
Space mean speed in outer lanes,             S  =  N/A    mph
                                              0
Space mean speed for all vehicles,           S  = 43.5    mph
_______________________________________________________________________________
```

X

HCS 2010: Freeway Merge and Diverge Segments Release 6.80

Phone: Fax:
E-mail:

Diverge Analysis

Analyst:
Agency/Co.:
Date performed: 1/26/2018
Analysis time period:
Freeway/Dir of Travel: Diverge fr Mission Eb to 680N
Junction:
Jurisdiction:
Analysis Year:
Description:

Freeway Data

Type of analysis	Diverge	
Number of lanes in freeway	2	
Free-flow speed on freeway	45.0	mph
Volume on freeway	1393	vph

Off Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-Flow speed on ramp	25.0	mph
Volume on ramp	682	vph
Length of first accel/decel lane	500	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	No	
Volume on adjacent ramp		vph
Position of adjacent ramp		
Type of adjacent ramp		
Distance to adjacent ramp		ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway		Ramp		Adjacent Ramp	
Volume, V (vph)	1393		682			vph
Peak-hour factor, PHF	0.94		0.94			
Peak 15-min volume, v15	370		181			v
Trucks and buses	4		7			%
Recreational vehicles	0		0			%
Terrain type:	Level		Level			
Grade	0.00	%	0.00	%	%	
Length	0.00	mi	0.00	mi	mi	
Trucks and buses PCE, ET	1.5		1.5			
Recreational vehicle PCE, ER	1.2		1.2			

```
Heavy vehicle adjustment, fHV          0.980       0.966                             X
Driver population factor, fP           1.00        1.00
Flow rate, vp                          1512        751                  pcph

_________________________Estimation of V12 Diverge Areas_______________________

                  L   =            (Equation 13-12 or 13-13)
                   EQ
                  P   =    1.000   Using Equation  0
                   FD
                  v   = v  + (v - v ) P  =  1512   pc/h
                   12   R      F   R   FD

_______________________________Capacity Checks_________________________________

                             Actual        Maximum         LOS F?
     v  = v                  1512          1110704128      No
      Fi   F
     v  = v - v              761           1110704128      No
      FO   F   R
     v                       751           1900            No
      R
     v  or v                 0    pc/h     (Equation 13-14 or 13-17)
      3     av34
Is   v  or v      > 2700 pc/h?             No
      3     av34
Is   v  or v      > 1.5 v  /2              No
      3     av34         12
If yes, v    = 1512                     (Equation 13-15, 13-16, 13-18, or 13-19)
         12A

______________________Flow Entering Diverge Influence Area_____________________
                      Actual        Max Desirable          Violation?
     v                1512          1110704128             No
      12
_________________Level of Service Determination (if not F)_____________________

Density,               D = 4.252 + 0.0086 v  - 0.009  L   =   12.8    pc/mi/ln
                        R                  12          D
Level of service for ramp-freeway junction areas of influence B

_____________________________Speed Estimation__________________________________

Intermediate speed variable,                D  = 0.626
                                             S
Space mean speed in ramp influence area,    S  = 43.1    mph
                                             R
Space mean speed in outer lanes,            S  =  N/A    mph
                                             0
Space mean speed for all vehicles,          S  = 43.1    mph
_______________________________________________________________________________
```

HCS 2010: Freeway Merge and Diverge Segments Release 6.80

Phone: Fax:
E-mail:

Diverge Analysis

Analyst:
Agency/Co.:
Date performed: 1/26/2018
Analysis time period:
Freeway/Dir of Travel: Diverge fr 680N to Mission Wb
Junction:
Jurisdiction:
Analysis Year:
Description:

Freeway Data

Type of analysis	Diverge	
Number of lanes in freeway	2	
Free-flow speed on freeway	65.0	mph
Volume on freeway	1662	vph

Off Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-Flow speed on ramp	25.0	mph
Volume on ramp	746	vph
Length of first accel/decel lane	500	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	No	
Volume on adjacent ramp		vph
Position of adjacent ramp		
Type of adjacent ramp		
Distance to adjacent ramp		ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway		Ramp		Adjacent Ramp	
Volume, V (vph)	1662		746			vph
Peak-hour factor, PHF	0.94		0.94			
Peak 15-min volume, v15	442		198			v
Trucks and buses	4		5			%
Recreational vehicles	0		0			%
Terrain type:	Level		Level			
Grade	0.00	%	0.00	%		%
Length	0.00	mi	0.00	mi		mi
Trucks and buses PCE, ET	1.5		1.5			
Recreational vehicle PCE, ER	1.2		1.2			

Heavy vehicle adjustment, fHV	0.980	0.976		X
Driver population factor, fP	1.00	1.00		
Flow rate, vp	1803	813	pcph	

Estimation of V12 Diverge Areas

L_{EQ} = (Equation 13-12 or 13-13)

P_{FD} = 1.000 Using Equation 0

$v_{12} = v_R + (v_F - v_R) P_{FD}$ = 1803 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{Fi} = v_F$	1803	4700	No
$v_{FO} = v_F - v_R$	990	4700	No
v_R	813	1900	No
v_3 or v_{av34}	0 pc/h	(Equation 13-14 or 13-17)	
Is v_3 or v_{av34} > 2700 pc/h?		No	
Is v_3 or v_{av34} > 1.5 v_{12}/2		No	

If yes, v_{12A} = 1803 (Equation 13-15, 13-16, 13-18, or 13-19)

Flow Entering Diverge Influence Area

	Actual	Max Desirable	Violation?
v_{12}	1803	4400	No

Level of Service Determination (if not F)

Density, $D_R = 4.252 + 0.0086\ v_{12} - 0.009\ L_D$ = 15.3 pc/mi/ln

Level of service for ramp-freeway junction areas of influence B

Speed Estimation

Intermediate speed variable,	D_S = 0.631	
Space mean speed in ramp influence area,	S_R = 50.5	mph
Space mean speed in outer lanes,	S_0 = N/A	mph
Space mean speed for all vehicles,	S = 50.5	mph

HCS 2010: Freeway Merge and Diverge Segments Release 6.80

Phone: Fax:
E-mail:

Diverge Analysis

Analyst:
Agency/Co.:
Date performed: 1/26/2018
Analysis time period:
Freeway/Dir of Travel: Diverge fr 680 N to Mission Eb
Junction:
Jurisdiction:
Analysis Year:
Description:

Freeway Data

Type of analysis	Diverge	
Number of lanes in freeway	2	
Free-flow speed on freeway	65.0	mph
Volume on freeway	1015	vph

Off Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-Flow speed on ramp	40.0	mph
Volume on ramp	229	vph
Length of first accel/decel lane	500	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	No	
Volume on adjacent ramp		vph
Position of adjacent ramp		
Type of adjacent ramp		
Distance to adjacent ramp		ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway		Ramp		Adjacent Ramp	
Volume, V (vph)	1015		229			vph
Peak-hour factor, PHF	0.94		0.94			
Peak 15-min volume, v15	270		61			v
Trucks and buses	4		6			%
Recreational vehicles	0		0			%
Terrain type:	Level		Level			
Grade	0.00	%	0.00	%		%
Length	0.00	mi	0.00	mi		mi
Trucks and buses PCE, ET	1.5		1.5			
Recreational vehicle PCE, ER	1.2		1.2			

X

```
Heavy vehicle adjustment, fHV          0.980       0.971
Driver population factor, fP           1.00        1.00
Flow rate, vp                          1101        251                    pcph

_________________________Estimation of V12 Diverge Areas_______________________

                  L   =            (Equation 13-12 or 13-13)
                   EQ
                  P   =    1.000   Using Equation  0
                   FD
                  v   = v  + (v - v ) P  =  1101   pc/h
                   12    R      F    R   FD

_______________________________Capacity Checks_________________________________

                           Actual        Maximum         LOS F?
     v  = v                1101          4700            No
      Fi   F
     v  = v - v            850           4700            No
      FO   F   R
     v                     251           2100            No
      R
     v  or v               0    pc/h     (Equation 13-14 or 13-17)
      3     av34
Is   v  or v      > 2700 pc/h?           No
      3     av34
Is   v  or v      > 1.5 v  /2            No
      3     av34         12
If yes, v    = 1101                   (Equation 13-15, 13-16, 13-18, or 13-19)
         12A

______________________Flow Entering Diverge Influence Area_____________________
                      Actual        Max Desirable        Violation?
     v                1101          4400                 No
      12
_________________Level of Service Determination (if not F)_____________________

Density,               D = 4.252 + 0.0086 v  - 0.009  L   =   9.2     pc/mi/ln
                        R                  12          D
Level of service for ramp-freeway junction areas of influence A

_____________________________Speed Estimation__________________________________

Intermediate speed variable,                D  = 0.386
                                             S
Space mean speed in ramp influence area,    S  = 56.1    mph
                                             R
Space mean speed in outer lanes,            S  =  N/A    mph
                                             0
Space mean speed for all vehicles,          S  = 56.1    mph
_______________________________________________________________________________
```

HCS 2010: Basic Freeway Segments Release 6.80

Phone: Fax:
E-mail:

Operational Analysis

Analyst:
Agency or Company:
Date Performed: 1/26/2018
Analysis Time Period:
Freeway/Direction: 680 South
From/To:
Jurisdiction: Fremont, CA
Analysis Year: 2017
Description:

Flow Inputs and Adjustments

Volume, V	9689	veh/h
Peak-hour factor, PHF	0.94	
Peak 15-min volume, v15	2577	v
Trucks and buses	5	%
Recreational vehicles	0	%
Terrain type:	Level	
Grade	-	%
Segment length	-	mi
Trucks and buses PCE, ET	1.5	
Recreational vehicle PCE, ER	1.2	
Heavy vehicle adjustment, fHV	0.976	
Driver population factor, fp	1.00	
Flow rate, vp	2641	pc/h/ln

Speed Inputs and Adjustments

Lane width	-	ft
Right-side lateral clearance	-	ft
Total ramp density, TRD	-	ramps/mi
Number of lanes, N	4	
Free-flow speed:	Measured	
FFS or BFFS	65.0	mi/h
Lane width adjustment, fLW	-	mi/h
Lateral clearance adjustment, fLC	-	mi/h
TRD adjustment	-	mi/h
Free-flow speed, FFS	65.0	mi/h

LOS and Performance Measures

Flow rate, vp	2641	pc/h/ln
Free-flow speed, FFS	65.0	mi/h
Average passenger-car speed, S	43.2	mi/h
Number of lanes, N	4	
Density, D	61.2	pc/mi/ln
Level of service, LOS	F	

Overall results are not computed when free-flow speed is less than 55 mph. X

X

HCS 2010: Basic Freeway Segments Release 6.80

Phone: Fax:
E-mail:

Operational Analysis

Analyst:	
Agency or Company:	
Date Performed:	4/28/2018
Analysis Time Period:	
Freeway/Direction:	680 North
From/To:	
Jurisdiction:	Fremont, Ca
Analysis Year:	
Description:	

Flow Inputs and Adjustments

Volume, V	7485	veh/h
Peak-hour factor, PHF	0.94	
Peak 15-min volume, v15	1991	v
Trucks and buses	4	%
Recreational vehicles	0	%
Terrain type:	Level	
Grade	-	%
Segment length	-	mi
Trucks and buses PCE, ET	1.5	
Recreational vehicle PCE, ER	1.2	
Heavy vehicle adjustment, fHV	0.980	
Driver population factor, fp	1.00	
Flow rate, vp	2707	pc/h/ln

Speed Inputs and Adjustments

Lane width	-	ft
Right-side lateral clearance	-	ft
Total ramp density, TRD	-	ramps/mi
Number of lanes, N	3	
Free-flow speed:	Measured	
FFS or BFFS	65.0	mi/h
Lane width adjustment, fLW	-	mi/h
Lateral clearance adjustment, fLC	-	mi/h
TRD adjustment	-	mi/h
Free-flow speed, FFS	65.0	mi/h

LOS and Performance Measures

Flow rate, vp	2707	pc/h/ln
Free-flow speed, FFS	65.0	mi/h
Average passenger-car speed, S	40.8	mi/h
Number of lanes, N	3	
Density, D	66.4	pc/mi/ln
Level of service, LOS	F	

Overall results are not computed when free-flow speed is less than 55 mph. X

X

Phone: Fax:
E-mail:

Merge Analysis

Analyst:
Agency/Co.:
Date performed: 1/26/2018
Analysis time period:
Freeway/Dir of Travel: Merge from 680S to Mission Wb
Junction:
Jurisdiction:
Analysis Year:
Description:

Freeway Data

Type of analysis	Merge	
Number of lanes in freeway	2	
Free-flow speed on freeway	45.0	mph
Volume on freeway	2185	vph

On Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-flow speed on ramp	30.0	mph
Volume on ramp	1190	vph
Length of first accel/decel lane	500	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	No	
Volume on adjacent Ramp		vph
Position of adjacent Ramp		
Type of adjacent Ramp		
Distance to adjacent Ramp		ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway		Ramp		Adjacent Ramp	
Volume, V (vph)	2185		1190			vph
Peak-hour factor, PHF	0.94		0.94			
Peak 15-min volume, v15	581		316			v
Trucks and buses	4		5			%
Recreational vehicles	0		0			%
Terrain type:	Level		Level			
Grade		%		%		%
Length		mi		mi		mi
Trucks and buses PCE, ET	1.5		1.5			
Recreational vehicle PCE, ER	1.2		1.2			

```
Heavy vehicle adjustment, fHV           0.980       0.976                            X
Driver population factor, fP            1.00        1.00
Flow rate, vp                           2371        1298                  pcph

_________________________Estimation of V12 Merge Areas_________________________

                  L   =            (Equation 13-6 or 13-7)
                   EQ
                  P   =    1.000   Using Equation  0
                   FM
                  v   = v  (P   ) =  2371   pc/h
                   12    F    FM

_______________________________Capacity Checks_________________________________

                           Actual        Maximum         LOS F?
     v                     3669          1110704128      No
      FO
     v  or v               0    pc/h     (Equation 13-14 or 13-17)
      3     av34
Is   v  or v      > 2700 pc/h?           No
      3     av34
Is   v  or v      > 1.5 v  /2            No
      3     av34         12
If yes, v    = 2371                   (Equation 13-15, 13-16, 13-18, or 13-19)
         12A

________________________Flow Entering Merge Influence Area_____________________
                      Actual        Max Desirable        Violation?
     v                3669          1110704128           No
      R12
_________________Level of Service Determination (if not F)_____________________

Density, D = 5.475 + 0.00734 v  + 0.0078 v   - 0.00627 L   =   30.4    pc/mi/ln
         R                    R            12              A
Level of service for ramp-freeway junction areas of influence  D

_____________________________Speed Estimation__________________________________

Intermediate speed variable,                 M  = 0.444
                                              S
Space mean speed in ramp influence area,     S  = 43.7    mph
                                              R
Space mean speed in outer lanes,             S  =  N/A    mph
                                              0
Space mean speed for all vehicles,           S  = 43.7    mph
_______________________________________________________________________________
```

X

HCS 2010: Freeway Merge and Diverge Segments Release 6.80

Phone: Fax:
E-mail:

Merge Analysis

Analyst:
Agency/Co.:
Date performed: 1/26/2018
Analysis time period:
Freeway/Dir of Travel: Merge fr Mission W to 680N
Junction:
Jurisdiction:
Analysis Year:
Description:

Freeway Data

Type of analysis	Merge	
Number of lanes in freeway	2	
Free-flow speed on freeway	65.0	mph
Volume on freeway	1541	vph

On Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-flow speed on ramp	40.0	mph
Volume on ramp	79	vph
Length of first accel/decel lane	500	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	No	
Volume on adjacent Ramp		vph
Position of adjacent Ramp		
Type of adjacent Ramp		
Distance to adjacent Ramp		ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	1541	79		vph
Peak-hour factor, PHF	0.94	0.94		
Peak 15-min volume, v15	410	21		v
Trucks and buses	4	3		%
Recreational vehicles	0	0		%
Terrain type:	Level	Level		
Grade	%	%	%	
Length	mi	mi	mi	
Trucks and buses PCE, ET	1.5	1.5		
Recreational vehicle PCE, ER	1.2	1.2		

Heavy vehicle adjustment, fHV	0.980	0.985		X
Driver population factor, fP	1.00	1.00		
Flow rate, vp	1672	85	pcph	

Estimation of V12 Merge Areas

L_{EQ} = (Equation 13-6 or 13-7)

P_{FM} = 1.000 Using Equation 0

$v_{12} = v_F (P_{FM})$ = 1672 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	1757	4700	No
v_3 or v_{av34}	0 pc/h	(Equation 13-14 or 13-17)	
Is v_3 or v_{av34} > 2700 pc/h?		No	
Is v_3 or v_{av34} > 1.5 v_{12}/2		No	
If yes, v_{12A} = 1672		(Equation 13-15, 13-16, 13-18, or 13-19)	

Flow Entering Merge Influence Area

	Actual	Max Desirable	Violation?
v_{R12}	1757	4600	No

Level of Service Determination (if not F)

Density, $D_R = 5.475 + 0.00734\ v_R + 0.0078\ v_{12} - 0.00627\ L_A$ = 16.0 pc/mi/ln

Level of service for ramp-freeway junction areas of influence B

Speed Estimation

Intermediate speed variable,	M_S = 0.304	
Space mean speed in ramp influence area,	S_R = 58.0	mph
Space mean speed in outer lanes,	S_0 = N/A	mph
Space mean speed for all vehicles,	S = 58.0	mph

X

HCS 2010: Freeway Merge and Diverge Segments Release 6.80

Phone: Fax:
E-mail:

Merge Analysis

Analyst:	Melissa Elian
Agency/Co.:	Santa Clara University
Date performed:	11/16/2017
Analysis time period:	
Freeway/Dir of Travel:	Merge fr Mission Eb to 680S
Junction:	
Jurisdiction:	
Analysis Year:	
Description:	

Freeway Data

Type of analysis	Merge	
Number of lanes in freeway	5	
Free-flow speed on freeway	65.0	mph
Volume on freeway	1307	vph

On Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-flow speed on ramp	40.0	mph
Volume on ramp	1025	vph
Length of first accel/decel lane	1030	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	No	
Volume on adjacent Ramp		vph
Position of adjacent Ramp		
Type of adjacent Ramp		
Distance to adjacent Ramp		ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway		Ramp		Adjacent Ramp	
Volume, V (vph)	1307		1025			vph
Peak-hour factor, PHF	0.94		0.94			
Peak 15-min volume, v15	348		273			v
Trucks and buses	4		4			%
Recreational vehicles	0		0			%
Terrain type:	Level		Level			
Grade		%		%		%
Length		mi		mi		mi
Trucks and buses PCE, ET	1.5		1.5			
Recreational vehicle PCE, ER	1.2		1.2			

X

Heavy vehicle adjustment, fHV	0.980	0.980	
Driver population factor, fP	1.00	1.00	
Flow rate, vp	1418	1112	pcph

Estimation of V12 Merge Areas

L_{EQ} = (Equation 13-6 or 13-7)

P_{FM} = 0.366 Using Equation 0

$v_{12} = v_F (P_{FM})$ = 405 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	2219	11752	No
v_3 or v_{av34}	351 pc/h	(Equation 13-14 or 13-17)	
Is v_3 or v_{av34} > 2700 pc/h?		No	
Is v_3 or v_{av34} > 1.5 v_{12}/2		Yes	

If yes, v_{12A} = 442 (Equation 13-15, 13-16, 13-18, or 13-19)

Flow Entering Merge Influence Area

	Actual	Max Desirable	Violation?
v_{12A}	1554	4600	No

Level of Service Determination (if not F)

Density, $D_R = 5.475 + 0.00734\, v_R + 0.0078\, v_{12} - 0.00627\, L_A$ = 10.6 pc/mi/ln

Level of service for ramp-freeway junction areas of influence B

Speed Estimation

Intermediate speed variable,	M_S = 0.257	
Space mean speed in ramp influence area,	S_R = 59.1	mph
Space mean speed in outer lanes,	S_0 = 65.0	mph
Space mean speed for all vehicles,	S = 60.7	mph

X

HCS 2010: Freeway Merge and Diverge Segments Release 6.80

Phone: Fax:
E-mail:

Merge Analysis

Analyst:
Agency/Co.:
Date performed: 1/26/2018
Analysis time period:
Freeway/Dir of Travel: Merge fr 680S to Mission Eb
Junction:
Jurisdiction:
Analysis Year:
Description:

Freeway Data

Type of analysis	Merge	
Number of lanes in freeway	2	
Free-flow speed on freeway	45.0	mph
Volume on freeway	566	vph

On Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-flow speed on ramp	25.0	mph
Volume on ramp	28	vph
Length of first accel/decel lane	500	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	No	
Volume on adjacent Ramp		vph
Position of adjacent Ramp		
Type of adjacent Ramp		
Distance to adjacent Ramp		ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	566	28		vph
Peak-hour factor, PHF	0.94	0.94		
Peak 15-min volume, v15	151	7		v
Trucks and buses	5	3		%
Recreational vehicles	0	0		%
Terrain type:	Level	Level		
Grade	%	%	%	
Length	mi	mi	mi	
Trucks and buses PCE, ET	1.5	1.5		
Recreational vehicle PCE, ER	1.2	1.2		

```
Heavy vehicle adjustment, fHV          0.976       0.985                     X
Driver population factor, fP           1.00        1.00
Flow rate, vp                          617         30                    pcph

_________________________Estimation of V12 Merge Areas_________________________

                  L  =             (Equation 13-6 or 13-7)
                   EQ
                  P  =    1.000   Using Equation  0
                   FM
                  v  = v  (P  ) =  617    pc/h
                   12   F   FM

_______________________________Capacity Checks_________________________________

                           Actual        Maximum         LOS F?
     v                     647           1110704128      No
      FO
     v  or v               0    pc/h     (Equation 13-14 or 13-17)
      3     av34
Is   v  or v      > 2700 pc/h?           No
      3     av34
Is   v  or v      > 1.5 v  /2            No
      3     av34         12
If yes, v    = 617                    (Equation 13-15, 13-16, 13-18, or 13-19)
         12A

________________________Flow Entering Merge Influence Area_____________________
                      Actual        Max Desirable        Violation?
     v                647           1110704128           No
      R12
_________________Level of Service Determination (if not F)_____________________

Density, D = 5.475 + 0.00734 v  + 0.0078 v   - 0.00627 L   =   7.4     pc/mi/ln
          R                   R           12            A
Level of service for ramp-freeway junction areas of influence  A

______________________________Speed Estimation__________________________________

Intermediate speed variable,                 M  = 0.303
                                              S
Space mean speed in ramp influence area,     S  = 44.1    mph
                                              R
Space mean speed in outer lanes,             S  =  N/A    mph
                                              0
Space mean speed for all vehicles,           S  = 44.1    mph
________________________________________________________________________________
```

X

HCS 2010: Freeway Merge and Diverge Segments Release 6.80

Phone: Fax:
E-mail:

Merge Analysis

Analyst:
Agency/Co.:
Date performed: 1/26/2018
Analysis time period:
Freeway/Dir of Travel: Merge fr 680N to Mission Wb
Junction:
Jurisdiction:
Analysis Year:
Description:

Freeway Data

Type of analysis	Merge	
Number of lanes in freeway	2	
Free-flow speed on freeway	45.0	mph
Volume on freeway	2361	vph

On Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-flow speed on ramp	25.0	mph
Volume on ramp	590	vph
Length of first accel/decel lane	500	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	No	
Volume on adjacent Ramp		vph
Position of adjacent Ramp		
Type of adjacent Ramp		
Distance to adjacent Ramp		ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway		Ramp		Adjacent Ramp	
Volume, V (vph)	2361		590			vph
Peak-hour factor, PHF	0.94		0.94			
Peak 15-min volume, v15	628		157			v
Trucks and buses	4		5			%
Recreational vehicles	0		0			%
Terrain type:	Level		Grade			
Grade		%	0.00	%		%
Length		mi	0.00	mi		mi
Trucks and buses PCE, ET	1.5		1.5			
Recreational vehicle PCE, ER	1.2		1.2			

```
Heavy vehicle adjustment, fHV          0.980       0.976                          X
Driver population factor, fP           1.00        1.00
Flow rate, vp                          2562        643                  pcph

_________________________Estimation of V12 Merge Areas_________________________

                  L  =            (Equation 13-6 or 13-7)
                   EQ
                  P  =    1.000   Using Equation  0
                   FM
                  v  = v  (P  ) =  2562   pc/h
                   12   F   FM

_______________________________Capacity Checks_________________________________

                           Actual        Maximum         LOS F?
     v                     3205          1110704128      No
      FO
     v  or v               0    pc/h     (Equation 13-14 or 13-17)
      3     av34
Is   v  or v      > 2700 pc/h?           No
      3     av34
Is   v  or v      > 1.5 v  /2            No
      3     av34         12
If yes, v    = 2562                   (Equation 13-15, 13-16, 13-18, or 13-19)
         12A

________________________Flow Entering Merge Influence Area_____________________
                      Actual        Max Desirable        Violation?
     v                3205          1110704128           No
      R12
_________________Level of Service Determination (if not F)_____________________

Density, D = 5.475 + 0.00734 v  + 0.0078 v   - 0.00627 L   =   27.0    pc/mi/ln
          R                   R           12            A
Level of service for ramp-freeway junction areas of influence  C

_____________________________Speed Estimation__________________________________

Intermediate speed variable,                 M  = 0.392
                                              S
Space mean speed in ramp influence area,     S  = 43.8    mph
                                              R
Space mean speed in outer lanes,             S  =  N/A    mph
                                              0
Space mean speed for all vehicles,           S  = 43.8    mph
_______________________________________________________________________________
```

HCS 2010: Freeway Merge and Diverge Segments Release 6.80

Phone: Fax:
E-mail:

Merge Analysis

Analyst:
Agency/Co.:
Date performed: 1/26/2018
Analysis time period:
Freeway/Dir of Travel: Merge fr 680N to Mission Eb
Junction:
Jurisdiction:
Analysis Year:
Description:

Freeway Data

Type of analysis	Merge	
Number of lanes in freeway	2	
Free-flow speed on freeway	45.0	mph
Volume on freeway	1201	vph

On Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-flow speed on ramp	40.0	mph
Volume on ramp	794	vph
Length of first accel/decel lane	500	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	No	
Volume on adjacent Ramp		vph
Position of adjacent Ramp		
Type of adjacent Ramp		
Distance to adjacent Ramp		ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway		Ramp		Adjacent Ramp	
Volume, V (vph)	1201		794			vph
Peak-hour factor, PHF	0.94		0.94			
Peak 15-min volume, v15	319		211			v
Trucks and buses	6		3			%
Recreational vehicles	0		0			%
Terrain type:	Level		Level			
Grade		%		%		%
Length		mi		mi		mi
Trucks and buses PCE, ET	1.5		1.5			
Recreational vehicle PCE, ER	1.2		1.2			

```
Heavy vehicle adjustment, fHV           0.971       0.985                     X
Driver population factor, fP            1.00        1.00
Flow rate, vp                           1316        857                  pcph

_________________________Estimation of V12 Merge Areas_________________________

                  L   =             (Equation 13-6 or 13-7)
                   EQ
                  P   =    1.000   Using Equation  0
                   FM
                  v   = v  (P   ) =  1316   pc/h
                   12   F   FM

_______________________________Capacity Checks_______________________________

                           Actual        Maximum         LOS F?
     v                     2173          1110704128      No
      FO
     v  or v               0    pc/h     (Equation 13-14 or 13-17)
      3     av34
Is   v  or v      > 2700 pc/h?           No
      3     av34
Is   v  or v      > 1.5 v  /2            No
      3     av34         12
If yes, v    = 1316                   (Equation 13-15, 13-16, 13-18, or 13-19)
         12A

________________________Flow Entering Merge Influence Area_____________________
                      Actual        Max Desirable         Violation?
     v                2173          1110704128            No
      R12
_________________Level of Service Determination (if not F)_____________________

Density, D = 5.475 + 0.00734 v  + 0.0078 v   - 0.00627 L   =   18.9    pc/mi/ln
          R                   R           12             A
Level of service for ramp-freeway junction areas of influence  B

_____________________________Speed Estimation__________________________________

Intermediate speed variable,                 M  = 0.315
                                              S
Space mean speed in ramp influence area,     S  = 44.1    mph
                                              R
Space mean speed in outer lanes,             S  =  N/A    mph
                                              0
Space mean speed for all vehicles,           S  = 44.1    mph
_______________________________________________________________________________
```

HCS 2010: Freeway Merge and Diverge Segments Release 6.80

Phone: Fax:
E-mail:

Diverge Analysis

Analyst:
Agency/Co.:
Date performed: 1/26/2018
Analysis time period:
Freeway/Dir of Travel: Diverge fr Mission Wb to 680S
Junction:
Jurisdiction:
Analysis Year:
Description:

Freeway Data

Type of analysis	Diverge	
Number of lanes in freeway	2	
Free-flow speed on freeway	45.0	mph
Volume on freeway	810	vph

Off Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-Flow speed on ramp	25.0	mph
Volume on ramp	526	vph
Length of first accel/decel lane	500	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	No	
Volume on adjacent ramp		vph
Position of adjacent ramp		
Type of adjacent ramp		
Distance to adjacent ramp		ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway		Ramp		Adjacent Ramp	
Volume, V (vph)	810		526			vph
Peak-hour factor, PHF	0.94		0.94			
Peak 15-min volume, v15	215		140			v
Trucks and buses	5		4			%
Recreational vehicles	0		0			%
Terrain type:	Level		Level			
Grade	0.00	%	0.00	%	%	
Length	0.00	mi	0.00	mi	mi	
Trucks and buses PCE, ET	1.5		1.5			
Recreational vehicle PCE, ER	1.2		1.2			

```
Heavy vehicle adjustment, fHV          0.976       0.980                        X
Driver population factor, fP           1.00        1.00
Flow rate, vp                          883         571                  pcph

_________________________Estimation of V12 Diverge Areas_______________________

                  L  =            (Equation 13-12 or 13-13)
                   EQ
                  P  =    1.000   Using Equation  0
                   FD
                  v  = v  + (v - v ) P  =  883    pc/h
                   12   R      F   R   FD

_______________________________Capacity Checks_________________________________

                             Actual        Maximum         LOS F?
     v  = v                  883           1110704128      No
      Fi   F
     v  = v - v              312           1110704128      No
      FO   F   R
     v                       571           1900            No
      R
     v  or v                 0    pc/h     (Equation 13-14 or 13-17)
      3     av34
Is   v  or v      > 2700 pc/h?             No
      3     av34
Is   v  or v      > 1.5 v  /2              No
      3     av34         12
If yes, v    = 883                      (Equation 13-15, 13-16, 13-18, or 13-19)
         12A

______________________Flow Entering Diverge Influence Area______________________
                        Actual        Max Desirable        Violation?
     v                  883           1110704128           No
      12
_________________Level of Service Determination (if not F)______________________

Density,                 D = 4.252 + 0.0086 v  - 0.009  L   =   7.3     pc/mi/ln
                          R                  12          D
Level of service for ramp-freeway junction areas of influence A

_____________________________Speed Estimation__________________________________

Intermediate speed variable,                  D  = 0.609
                                               S
Space mean speed in ramp influence area,      S  = 43.2    mph
                                               R
Space mean speed in outer lanes,              S  =  N/A    mph
                                               0
Space mean speed for all vehicles,            S  = 43.2    mph
_______________________________________________________________________________
```

HCS 2010: Freeway Merge and Diverge Segments Release 6.80

Phone: Fax:
E-mail:

Diverge Analysis

Analyst:
Agency/Co.:
Date performed: 1/26/2018
Analysis time period:
Freeway/Dir of Travel: Diverge fr Mission Wb to 680N
Junction:
Jurisdiction:
Analysis Year:
Description:

Freeway Data

Type of analysis	Diverge	
Number of lanes in freeway	2	
Free-flow speed on freeway	45.0	mph
Volume on freeway	622	vph

Off Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-Flow speed on ramp	40.0	mph
Volume on ramp	79	vph
Length of first accel/decel lane	500	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	No	
Volume on adjacent ramp		vph
Position of adjacent ramp		
Type of adjacent ramp		
Distance to adjacent ramp		ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway		Ramp		Adjacent Ramp	
Volume, V (vph)	622		79			vph
Peak-hour factor, PHF	0.94		0.94			
Peak 15-min volume, v15	165		21			v
Trucks and buses	5		4			%
Recreational vehicles	0		0			%
Terrain type:	Level		Level			
Grade	0.00	%	0.00	%		%
Length	0.00	mi	0.00	mi		mi
Trucks and buses PCE, ET	1.5		1.5			
Recreational vehicle PCE, ER	1.2		1.2			

```
Heavy vehicle adjustment, fHV          0.976       0.980                        X
Driver population factor, fP           1.00        1.00
Flow rate, vp                          678         86                    pcph

_________________________Estimation of V12 Diverge Areas_______________________

                  L   =            (Equation 13-12 or 13-13)
                   EQ
                  P   =    1.000   Using Equation  0
                   FD
                  v   = v  + (v - v ) P  =  678    pc/h
                   12   R     F   R   FD

_______________________________Capacity Checks_________________________________

                           Actual        Maximum         LOS F?
     v  = v                678           1110704128      No
      Fi   F
     v  = v - v            592           1110704128      No
      FO   F   R
     v                     86            2100            No
      R
     v  or v               0    pc/h     (Equation 13-14 or 13-17)
      3     av34
Is   v  or v      > 2700 pc/h?           No
      3     av34
Is   v  or v      > 1.5 v  /2            No
      3     av34         12
If yes, v    = 678                    (Equation 13-15, 13-16, 13-18, or 13-19)
         12A

______________________Flow Entering Diverge Influence Area_____________________
                      Actual        Max Desirable          Violation?
     v                678           1110704128             No
      12
_________________Level of Service Determination (if not F)_____________________

Density,               D = 4.252 + 0.0086 v  - 0.009  L   =   5.6     pc/mi/ln
                        R                  12          D
Level of service for ramp-freeway junction areas of influence A

_____________________________Speed Estimation__________________________________

Intermediate speed variable,                D  = 0.371
                                             S
Space mean speed in ramp influence area,    S  = 43.9    mph
                                             R
Space mean speed in outer lanes,            S  =  N/A    mph
                                             0
Space mean speed for all vehicles,          S  = 43.9    mph
_______________________________________________________________________________
```

X

HCS 2010: Freeway Merge and Diverge Segments Release 6.80

Phone: Fax:
E-mail:

Diverge Analysis

Analyst:
Agency/Co.:
Date performed: 1/26/2018
Analysis time period:
Freeway/Dir of Travel: Diverge fr Mission Eb to 680 S
Junction:
Jurisdiction:
Analysis Year:
Description:

Freeway Data

Type of analysis	Diverge	
Number of lanes in freeway	2	
Free-flow speed on freeway	45.0	mph
Volume on freeway	2901	vph

Off Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-Flow speed on ramp	40.0	mph
Volume on ramp	1025	vph
Length of first accel/decel lane	500	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	No	
Volume on adjacent ramp		vph
Position of adjacent ramp		
Type of adjacent ramp		
Distance to adjacent ramp		ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway		Ramp		Adjacent Ramp	
Volume, V (vph)	2901		1025			vph
Peak-hour factor, PHF	0.94		0.94			
Peak 15-min volume, v15	772		273			v
Trucks and buses	4		4			%
Recreational vehicles	0		0			%
Terrain type:	Level		Level			
Grade	0.00	%	0.00	%		%
Length	0.00	mi	0.00	mi		mi
Trucks and buses PCE, ET	1.5		1.5			
Recreational vehicle PCE, ER	1.2		1.2			

Heavy vehicle adjustment, fHV	0.980	0.980		X
Driver population factor, fP	1.00	1.00		
Flow rate, vp	3148	1112	pcph	

Estimation of V12 Diverge Areas

L_{EQ} = (Equation 13-12 or 13-13)

P_{FD} = 1.000 Using Equation 0

$v_{12} = v_R + (v_F - v_R) P_{FD}$ = 3148 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{Fi} = v_F$	3148	1110704128	No
$v_{FO} = v_F - v_R$	2036	1110704128	No
v_R	1112	2100	No
v_3 or v_{av34}	0 pc/h	(Equation 13-14 or 13-17)	

Is v_3 or v_{av34} > 2700 pc/h? No

Is v_3 or v_{av34} > 1.5 v_{12}/2 No

If yes, v_{12A} = 3148 (Equation 13-15, 13-16, 13-18, or 13-19)

Flow Entering Diverge Influence Area

	Actual	Max Desirable	Violation?
v_{12}	3148	1110704128	No

Level of Service Determination (if not F)

Density, $D_R = 4.252 + 0.0086\, v_{12} - 0.009\, L_D$ = 26.8 pc/mi/ln

Level of service for ramp-freeway junction areas of influence C

Speed Estimation

Intermediate speed variable, D_S = 0.463

Space mean speed in ramp influence area, S_R = 43.6 mph

Space mean speed in outer lanes, S_0 = N/A mph

Space mean speed for all vehicles, S = 43.6 mph

X

HCS 2010: Freeway Merge and Diverge Segments Release 6.80

Phone: Fax:
E-mail:

Diverge Analysis

Analyst:
Agency/Co.:
Date performed: 1/26/2018
Analysis time period:
Freeway/Dir of Travel: Diverge fr Mission Eb to 680N
Junction:
Jurisdiction:
Analysis Year:
Description:

Freeway Data

Type of analysis	Diverge	
Number of lanes in freeway	2	
Free-flow speed on freeway	45.0	mph
Volume on freeway	1393	vph

Off Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-Flow speed on ramp	25.0	mph
Volume on ramp	682	vph
Length of first accel/decel lane	500	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	No	
Volume on adjacent ramp		vph
Position of adjacent ramp		
Type of adjacent ramp		
Distance to adjacent ramp		ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway		Ramp		Adjacent Ramp	
Volume, V (vph)	1393		682			vph
Peak-hour factor, PHF	0.94		0.94			
Peak 15-min volume, v15	370		181			v
Trucks and buses	4		7			%
Recreational vehicles	0		0			%
Terrain type:	Level		Level			
Grade	0.00	%	0.00	%	%	
Length	0.00	mi	0.00	mi	mi	
Trucks and buses PCE, ET	1.5		1.5			
Recreational vehicle PCE, ER	1.2		1.2			

Heavy vehicle adjustment, fHV	0.980	0.966	
Driver population factor, fP	1.00	1.00	
Flow rate, vp	1512	751	pcph

X

Estimation of V12 Diverge Areas

L_{EQ} = (Equation 13-12 or 13-13)

P_{FD} = 1.000 Using Equation 0

$v_{12} = v_R + (v_F - v_R) P_{FD}$ = 1512 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{Fi} = v_F$	1512	1110704128	No
$v_{FO} = v_F - v_R$	761	1110704128	No
v_R	751	1900	No
v_3 or v_{av34}	0 pc/h	(Equation 13-14 or 13-17)	

Is v_3 or v_{av34} > 2700 pc/h? No

Is v_3 or v_{av34} > 1.5 v_{12}/2 No

If yes, v_{12A} = 1512 (Equation 13-15, 13-16, 13-18, or 13-19)

Flow Entering Diverge Influence Area

	Actual	Max Desirable	Violation?
v_{12}	1512	1110704128	No

Level of Service Determination (if not F)

Density, $D_R = 4.252 + 0.0086\, v_{12} - 0.009\, L_D$ = 12.8 pc/mi/ln

Level of service for ramp-freeway junction areas of influence B

Speed Estimation

Intermediate speed variable, D_S = 0.626

Space mean speed in ramp influence area, S_R = 43.1 mph

Space mean speed in outer lanes, S_0 = N/A mph

Space mean speed for all vehicles, S = 43.1 mph

HCS 2010: Freeway Merge and Diverge Segments Release 6.80

X

Phone: Fax:
E-mail:

Diverge Analysis

Analyst:
Agency/Co.:
Date performed: 1/26/2018
Analysis time period:
Freeway/Dir of Travel: Diverge fr 680N to Mission Wb
Junction:
Jurisdiction:
Analysis Year:
Description:

Freeway Data

Type of analysis	Diverge	
Number of lanes in freeway	2	
Free-flow speed on freeway	65.0	mph
Volume on freeway	1662	vph

Off Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-Flow speed on ramp	25.0	mph
Volume on ramp	746	vph
Length of first accel/decel lane	500	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	No	
Volume on adjacent ramp		vph
Position of adjacent ramp		
Type of adjacent ramp		
Distance to adjacent ramp		ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway		Ramp		Adjacent Ramp	
Volume, V (vph)	1662		746			vph
Peak-hour factor, PHF	0.94		0.94			
Peak 15-min volume, v15	442		198			v
Trucks and buses	4		5			%
Recreational vehicles	0		0			%
Terrain type:	Level		Level			
Grade	0.00	%	0.00	%		%
Length	0.00	mi	0.00	mi		mi
Trucks and buses PCE, ET	1.5		1.5			
Recreational vehicle PCE, ER	1.2		1.2			

```
Heavy vehicle adjustment, fHV          0.980       0.976                              X
Driver population factor, fP           1.00        1.00
Flow rate, vp                          1803        813                    pcph

_________________________Estimation of V12 Diverge Areas_______________________

                  L   =            (Equation 13-12 or 13-13)
                   EQ
                  P   =    1.000   Using Equation  0
                   FD
                  v   = v  + (v - v ) P  =  1803   pc/h
                   12   R      F   R   FD

_______________________________Capacity Checks_________________________________

                             Actual        Maximum         LOS F?
     v  = v                  1803          4700            No
      Fi   F
     v  = v - v              990           4700            No
      FO   F   R
     v                       813           1900            No
      R
     v  or v                 0    pc/h     (Equation 13-14 or 13-17)
      3     av34
Is   v  or v      > 2700 pc/h?             No
      3     av34
Is   v  or v      > 1.5 v  /2              No
      3     av34         12
If yes, v    = 1803                     (Equation 13-15, 13-16, 13-18, or 13-19)
         12A

______________________Flow Entering Diverge Influence Area____________________
                      Actual        Max Desirable          Violation?
     v                1803          4400                   No
      12
_________________Level of Service Determination (if not F)____________________

Density,               D = 4.252 + 0.0086 v  - 0.009  L   =   15.3    pc/mi/ln
                        R                  12          D
Level of service for ramp-freeway junction areas of influence B

_____________________________Speed Estimation__________________________________

Intermediate speed variable,                 D  = 0.631
                                              S
Space mean speed in ramp influence area,     S  = 50.5    mph
                                              R
Space mean speed in outer lanes,             S  =  N/A    mph
                                              0
Space mean speed for all vehicles,           S  = 50.5    mph
_______________________________________________________________________________
```

X

HCS 2010: Freeway Merge and Diverge Segments Release 6.80

Phone: Fax:
E-mail:

Diverge Analysis

Analyst:
Agency/Co.:
Date performed: 1/26/2018
Analysis time period:
Freeway/Dir of Travel: Diverge fr 680 N to Mission Eb
Junction:
Jurisdiction:
Analysis Year:
Description:

Freeway Data

Type of analysis	Diverge	
Number of lanes in freeway	2	
Free-flow speed on freeway	65.0	mph
Volume on freeway	1482	vph

Off Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-Flow speed on ramp	40.0	mph
Volume on ramp	794	vph
Length of first accel/decel lane	500	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	No	
Volume on adjacent ramp		vph
Position of adjacent ramp		
Type of adjacent ramp		
Distance to adjacent ramp		ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway		Ramp		Adjacent Ramp	
Volume, V (vph)	1482		794			vph
Peak-hour factor, PHF	0.94		0.94			
Peak 15-min volume, v15	394		211			v
Trucks and buses	4		6			%
Recreational vehicles	0		0			%
Terrain type:	Level		Level			
Grade	0.00	%	0.00	%		%
Length	0.00	mi	0.00	mi		mi
Trucks and buses PCE, ET	1.5		1.5			
Recreational vehicle PCE, ER	1.2		1.2			

Heavy vehicle adjustment, fHV	0.980	0.971		X
Driver population factor, fP	1.00	1.00		
Flow rate, vp	1608	870	pcph	

Estimation of V12 Diverge Areas

L_{EQ} = (Equation 13-12 or 13-13)

P_{FD} = 1.000 Using Equation 0

$v_{12} = v_R + (v_F - v_R) P_{FD}$ = 1608 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{Fi} = v_F$	1608	4700	No
$v_{FO} = v_F - v_R$	738	4700	No
v_R	870	2100	No
v_3 or v_{av34}	0 pc/h	(Equation 13-14 or 13-17)	

Is v_3 or v_{av34} > 2700 pc/h? No

Is v_3 or v_{av34} > 1.5 v_{12}/2 No

If yes, v_{12A} = 1608 (Equation 13-15, 13-16, 13-18, or 13-19)

Flow Entering Diverge Influence Area

	Actual	Max Desirable	Violation?
v_{12}	1608	4400	No

Level of Service Determination (if not F)

Density, $D_R = 4.252 + 0.0086\ v_{12} - 0.009\ L_D$ = 13.6 pc/mi/ln

Level of service for ramp-freeway junction areas of influence B

Speed Estimation

Intermediate speed variable,	D_S = 0.441	
Space mean speed in ramp influence area,	S_R = 54.9	mph
Space mean speed in outer lanes,	S_0 = N/A	mph
Space mean speed for all vehicles,	S = 54.9	mph

X

HCS 2010: Basic Freeway Segments Release 6.80

Phone: Fax:
E-mail:

Operational Analysis

Analyst:	
Agency or Company:	
Date Performed:	1/26/2018
Analysis Time Period:	
Freeway/Direction:	680 South
From/To:	
Jurisdiction:	Fremont, CA
Analysis Year:	2017
Description:	

Flow Inputs and Adjustments

Volume, V	5498	veh/h
Peak-hour factor, PHF	0.94	
Peak 15-min volume, v15	1462	v
Trucks and buses	5	%
Recreational vehicles	0	%
Terrain type:	Level	
Grade	-	%
Segment length	-	mi
Trucks and buses PCE, ET	1.5	
Recreational vehicle PCE, ER	1.2	
Heavy vehicle adjustment, fHV	0.976	
Driver population factor, fp	1.00	
Flow rate, vp	1499	pc/h/ln

Speed Inputs and Adjustments

Lane width	-	ft
Right-side lateral clearance	-	ft
Total ramp density, TRD	-	ramps/mi
Number of lanes, N	4	
Free-flow speed:	Measured	
FFS or BFFS	65.0	mi/h
Lane width adjustment, fLW	-	mi/h
Lateral clearance adjustment, fLC	-	mi/h
TRD adjustment	-	mi/h
Free-flow speed, FFS	65.0	mi/h

LOS and Performance Measures

Flow rate, vp	1499	pc/h/ln
Free-flow speed, FFS	65.0	mi/h
Average passenger-car speed, S	64.9	mi/h
Number of lanes, N	4	
Density, D	23.1	pc/mi/ln
Level of service, LOS	C	

Overall results are not computed when free-flow speed is less than 55 mph. X

HCS 2010: Basic Freeway Segments Release 6.80

X

Phone: Fax:
E-mail:

Operational Analysis

Analyst:	
Agency or Company:	
Date Performed:	4/28/2018
Analysis Time Period:	
Freeway/Direction:	680 North
From/To:	
Jurisdiction:	Fremont, Ca
Analysis Year:	
Description:	

Flow Inputs and Adjustments

Volume, V	7699	veh/h
Peak-hour factor, PHF	0.94	
Peak 15-min volume, v15	2048	v
Trucks and buses	4	%
Recreational vehicles	0	%
Terrain type:	Level	
Grade	-	%
Segment length	-	mi
Trucks and buses PCE, ET	1.5	
Recreational vehicle PCE, ER	1.2	
Heavy vehicle adjustment, fHV	0.980	
Driver population factor, fp	1.00	
Flow rate, vp	2785	pc/h/ln

Speed Inputs and Adjustments

Lane width	-	ft
Right-side lateral clearance	-	ft
Total ramp density, TRD	-	ramps/mi
Number of lanes, N	3	
Free-flow speed:	Measured	
FFS or BFFS	65.0	mi/h
Lane width adjustment, fLW	-	mi/h
Lateral clearance adjustment, fLC	-	mi/h
TRD adjustment	-	mi/h
Free-flow speed, FFS	65.0	mi/h

LOS and Performance Measures

Flow rate, vp	2785	pc/h/ln
Free-flow speed, FFS	65.0	mi/h
Average passenger-car speed, S	37.8	mi/h
Number of lanes, N	3	
Density, D	73.7	pc/mi/ln
Level of service, LOS	F	

Overall results are not computed when free-flow speed is less than 55 mph. X

Phone: Fax:
E-mail:

Merge Analysis

Analyst:
Agency/Co.:
Date performed: 1/26/2018
Analysis time period:
Freeway/Dir of Travel: Merge from 680S to Mission Wb
Junction:
Jurisdiction:
Analysis Year:
Description:

Freeway Data

Type of analysis	Merge	
Number of lanes in freeway	2	
Free-flow speed on freeway	45.0	mph
Volume on freeway	2842	vph

On Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-flow speed on ramp	30.0	mph
Volume on ramp	1592	vph
Length of first accel/decel lane	1000	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	No	
Volume on adjacent Ramp		vph
Position of adjacent Ramp		
Type of adjacent Ramp		
Distance to adjacent Ramp		ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	2842	1592		vph
Peak-hour factor, PHF	0.94	0.94		
Peak 15-min volume, v15	756	423		v
Trucks and buses	4	5		%
Recreational vehicles	0	0		%
Terrain type:	Level	Level		
Grade	%	%	%	
Length	mi	mi	mi	
Trucks and buses PCE, ET	1.5	1.5		
Recreational vehicle PCE, ER	1.2	1.2		

X

```
Heavy vehicle adjustment, fHV          0.980       0.976
Driver population factor, fP           1.00        1.00
Flow rate, vp                          3084        1736                  pcph

_________________________Estimation of V12 Merge Areas_________________________

                  L   =             (Equation 13-6 or 13-7)
                   EQ
                  P   =    1.000   Using Equation  0
                   FM
                  v  = v  (P   ) =  3084   pc/h
                   12   F    FM

_______________________________Capacity Checks_______________________________

                           Actual        Maximum         LOS F?
     v                     4820          1110704128      No
      FO
     v  or v               0    pc/h     (Equation 13-14 or 13-17)
      3     av34
Is   v  or v      > 2700 pc/h?           No
      3     av34
Is   v  or v      > 1.5 v  /2            No
      3     av34        12
If yes, v    = 3084                   (Equation 13-15, 13-16, 13-18, or 13-19)
         12A

________________________Flow Entering Merge Influence Area_____________________
                      Actual        Max Desirable        Violation?
     v                4820          1110704128           No
      R12
_________________Level of Service Determination (if not F)_____________________

Density, D = 5.475 + 0.00734 v  + 0.0078 v   - 0.00627 L   =   36.0    pc/mi/ln
          R                   R           12             A
Level of service for ramp-freeway junction areas of influence  E

_____________________________Speed Estimation__________________________________

Intermediate speed variable,                 M  = 0.744
                                              S
Space mean speed in ramp influence area,     S  = 42.8    mph
                                              R
Space mean speed in outer lanes,             S  =  N/A    mph
                                              0
Space mean speed for all vehicles,           S  = 42.8    mph
_______________________________________________________________________________
```

X

HCS 2010: Freeway Merge and Diverge Segments Release 6.80

Phone: Fax:
E-mail:

Merge Analysis

Analyst:
Agency/Co.:
Date performed: 1/26/2018
Analysis time period:
Freeway/Dir of Travel: Merge fr Mission W to 680N
Junction:
Jurisdiction:
Analysis Year:
Description:

Freeway Data

Type of analysis	Merge	
Number of lanes in freeway	2	
Free-flow speed on freeway	65.0	mph
Volume on freeway	2820	vph

On Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-flow speed on ramp	40.0	mph
Volume on ramp	208	vph
Length of first accel/decel lane	500	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	No	
Volume on adjacent Ramp		vph
Position of adjacent Ramp		
Type of adjacent Ramp		
Distance to adjacent Ramp		ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	2820	208		vph
Peak-hour factor, PHF	0.94	0.94		
Peak 15-min volume, v15	750	55		v
Trucks and buses	4	3		%
Recreational vehicles	0	0		%
Terrain type:	Level	Level		
Grade	%	%	%	
Length	mi	mi	mi	
Trucks and buses PCE, ET	1.5	1.5		
Recreational vehicle PCE, ER	1.2	1.2		

```
Heavy vehicle adjustment, fHV          0.980       0.985                          x
Driver population factor, fP           1.00        1.00
Flow rate, vp                          3060        225                     pcph

_________________________Estimation of V12 Merge Areas_________________________

                  L  =            (Equation 13-6 or 13-7)
                   EQ
                  P  =    1.000   Using Equation  0
                   FM
                  v  = v  (P  ) =  3060   pc/h
                   12   F   FM

_______________________________Capacity Checks_________________________________

                           Actual        Maximum         LOS F?
     v                     3285          4700            No
      FO
     v  or v               0    pc/h     (Equation 13-14 or 13-17)
      3     av34
Is   v  or v      > 2700 pc/h?           No
      3     av34
Is   v  or v      > 1.5 v  /2            No
      3     av34         12
If yes, v    = 3060                   (Equation 13-15, 13-16, 13-18, or 13-19)
         12A

________________________Flow Entering Merge Influence Area_____________________
                      Actual        Max Desirable         Violation?
     v                3285          4600                  No
      R12
_________________Level of Service Determination (if not F)_____________________

Density, D = 5.475 + 0.00734 v  + 0.0078 v   - 0.00627 L   =   27.9    pc/mi/ln
          R                   R           12             A
Level of service for ramp-freeway junction areas of influence  C

_____________________________Speed Estimation__________________________________

Intermediate speed variable,                 M  = 0.385
                                              S
Space mean speed in ramp influence area,     S  = 56.1    mph
                                              R
Space mean speed in outer lanes,             S  =  N/A    mph
                                              0
Space mean speed for all vehicles,           S  = 56.1    mph
_______________________________________________________________________________
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HCS 2010: Freeway Merge and Diverge Segments Release 6.80

Phone: Fax:
E-mail:

Merge Analysis

Analyst: Melissa Elian
Agency/Co.: Santa Clara University
Date performed: 11/16/2017
Analysis time period:
Freeway/Dir of Travel: Merge fr Mission Eb to 680S
Junction:
Jurisdiction:
Analysis Year:
Description:

Freeway Data

Type of analysis	Merge	
Number of lanes in freeway	5	
Free-flow speed on freeway	65.0	mph
Volume on freeway	1605	vph

On Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-flow speed on ramp	40.0	mph
Volume on ramp	1143	vph
Length of first accel/decel lane	1030	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	No	
Volume on adjacent Ramp		vph
Position of adjacent Ramp		
Type of adjacent Ramp		
Distance to adjacent Ramp		ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway		Ramp		Adjacent Ramp	
Volume, V (vph)	1605		1143			vph
Peak-hour factor, PHF	0.94		0.94			
Peak 15-min volume, v15	427		304			v
Trucks and buses	4		4			%
Recreational vehicles	0		0			%
Terrain type:	Level		Level			
Grade		%		%		%
Length		mi		mi		mi
Trucks and buses PCE, ET	1.5		1.5			
Recreational vehicle PCE, ER	1.2		1.2			

```
Heavy vehicle adjustment, fHV          0.980       0.980                                 X
Driver population factor, fP           1.00        1.00
Flow rate, vp                          1742        1240                 pcph

_________________________Estimation of V12 Merge Areas_________________________

                  L  =             (Equation 13-6 or 13-7)
                   EQ
                  P  =    0.350   Using Equation  0
                   FM
                  v  = v  (P  ) =  476    pc/h
                   12   F   FM

_______________________________Capacity Checks_________________________________

                           Actual        Maximum         LOS F?
     v                     2599          11752           No
      FO
     v  or v               441  pc/h     (Equation 13-14 or 13-17)
      3     av34
Is   v  or v      > 2700 pc/h?           No
      3     av34
Is   v  or v      > 1.5 v  /2            Yes
      3     av34         12
If yes, v    = 543                    (Equation 13-15, 13-16, 13-18, or 13-19)
         12A

________________________Flow Entering Merge Influence Area_____________________
                      Actual        Max Desirable         Violation?
     v                1783          4600                  No
      12A
_________________Level of Service Determination (if not F)_____________________

Density, D = 5.475 + 0.00734 v  + 0.0078 v   - 0.00627 L   =   12.4    pc/mi/ln
          R                   R           12             A
Level of service for ramp-freeway junction areas of influence  B

_____________________________Speed Estimation__________________________________

Intermediate speed variable,                 M  = 0.262
                                              S
Space mean speed in ramp influence area,     S  = 59.0    mph
                                              R
Space mean speed in outer lanes,             S  = 65.0    mph
                                              0
Space mean speed for all vehicles,           S  = 60.7    mph
_______________________________________________________________________________
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HCS 2010: Freeway Merge and Diverge Segments Release 6.80

Phone: Fax:
E-mail:

Merge Analysis

Analyst:
Agency/Co.:
Date performed: 1/26/2018
Analysis time period:
Freeway/Dir of Travel: Merge fr 680S to Mission Eb
Junction:
Jurisdiction:
Analysis Year:
Description:

Freeway Data

Type of analysis	Merge	
Number of lanes in freeway	2	
Free-flow speed on freeway	45.0	mph
Volume on freeway	566	vph

On Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-flow speed on ramp	25.0	mph
Volume on ramp	28	vph
Length of first accel/decel lane	500	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	No	
Volume on adjacent Ramp		vph
Position of adjacent Ramp		
Type of adjacent Ramp		
Distance to adjacent Ramp		ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	566	28		vph
Peak-hour factor, PHF	0.94	0.94		
Peak 15-min volume, v15	151	7		v
Trucks and buses	5	3		%
Recreational vehicles	0	0		%
Terrain type:	Level	Level		
Grade	%	%	%	
Length	mi	mi	mi	
Trucks and buses PCE, ET	1.5	1.5		
Recreational vehicle PCE, ER	1.2	1.2		

```
Heavy vehicle adjustment, fHV          0.976       0.985                        x
Driver population factor, fP           1.00        1.00
Flow rate, vp                          617         30                     pcph

_________________________Estimation of V12 Merge Areas_________________________

                  L  =             (Equation 13-6 or 13-7)
                   EQ
                  P  =    1.000   Using Equation  0
                   FM
                  v  = v  (P  ) =  617    pc/h
                   12   F   FM

_______________________________Capacity Checks_______________________________

                           Actual        Maximum         LOS F?
     v                     647           1110704128      No
      FO
     v  or v               0    pc/h     (Equation 13-14 or 13-17)
      3     av34
Is   v  or v      > 2700 pc/h?           No
      3     av34
Is   v  or v      > 1.5 v  /2            No
      3     av34         12
If yes, v    = 617                    (Equation 13-15, 13-16, 13-18, or 13-19)
         12A

________________________Flow Entering Merge Influence Area_____________________
                      Actual        Max Desirable         Violation?
     v                647           1110704128            No
      R12
_________________Level of Service Determination (if not F)_____________________

Density, D = 5.475 + 0.00734 v  + 0.0078 v   - 0.00627 L   =   7.4     pc/mi/ln
          R                   R           12            A
Level of service for ramp-freeway junction areas of influence  A

_____________________________Speed Estimation__________________________________

Intermediate speed variable,                 M  = 0.303
                                              S
Space mean speed in ramp influence area,     S  = 44.1    mph
                                              R
Space mean speed in outer lanes,             S  =  N/A    mph
                                              0
Space mean speed for all vehicles,           S  = 44.1    mph
_______________________________________________________________________________
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HCS 2010: Freeway Merge and Diverge Segments Release 6.80

Phone: Fax:
E-mail:

Merge Analysis

Analyst:
Agency/Co.:
Date performed: 1/26/2018
Analysis time period:
Freeway/Dir of Travel: Merge fr 680N to Mission Wb
Junction:
Jurisdiction:
Analysis Year:
Description:

Freeway Data

Type of analysis	Merge	
Number of lanes in freeway	2	
Free-flow speed on freeway	45.0	mph
Volume on freeway	2361	vph

On Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-flow speed on ramp	25.0	mph
Volume on ramp	590	vph
Length of first accel/decel lane	500	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	No	
Volume on adjacent Ramp		vph
Position of adjacent Ramp		
Type of adjacent Ramp		
Distance to adjacent Ramp		ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway		Ramp		Adjacent Ramp	
Volume, V (vph)	2361		590			vph
Peak-hour factor, PHF	0.94		0.94			
Peak 15-min volume, v15	628		157			v
Trucks and buses	4		5			%
Recreational vehicles	0		0			%
Terrain type:	Level		Grade			
Grade		%	0.00	%		%
Length		mi	0.00	mi		mi
Trucks and buses PCE, ET	1.5		1.5			
Recreational vehicle PCE, ER	1.2		1.2			

```
Heavy vehicle adjustment, fHV          0.980      0.976                        X
Driver population factor, fP           1.00       1.00
Flow rate, vp                          2562       643                    pcph

_________________________Estimation of V12 Merge Areas_________________________

                  L  =             (Equation 13-6 or 13-7)
                   EQ
                  P  =    1.000   Using Equation  0
                   FM
                  v  = v  (P  ) =  2562   pc/h
                   12   F   FM

______________________________Capacity Checks__________________________________

                           Actual        Maximum        LOS F?
     v                     3205          1110704128     No
      FO
     v  or v               0    pc/h     (Equation 13-14 or 13-17)
      3     av34
Is   v  or v      > 2700 pc/h?           No
      3     av34
Is   v  or v      > 1.5 v  /2            No
      3     av34         12
If yes, v    = 2562                   (Equation 13-15, 13-16, 13-18, or 13-19)
         12A

________________________Flow Entering Merge Influence Area_____________________
                      Actual        Max Desirable        Violation?
     v                3205          1110704128           No
      R12
_________________Level of Service Determination (if not F)_____________________

Density, D = 5.475 + 0.00734 v  + 0.0078 v   - 0.00627 L   =   27.0    pc/mi/ln
          R                   R           12             A
Level of service for ramp-freeway junction areas of influence  C

_____________________________Speed Estimation__________________________________

Intermediate speed variable,                 M  = 0.392
                                              S
Space mean speed in ramp influence area,     S  = 43.8    mph
                                              R
Space mean speed in outer lanes,             S  =  N/A    mph
                                              0
Space mean speed for all vehicles,           S  = 43.8    mph
_______________________________________________________________________________
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HCS 2010: Freeway Merge and Diverge Segments Release 6.80

Phone: Fax:
E-mail:

Merge Analysis

Analyst:
Agency/Co.:
Date performed: 1/26/2018
Analysis time period:
Freeway/Dir of Travel: Merge fr 680N to Mission Eb
Junction:
Jurisdiction:
Analysis Year:
Description:

Freeway Data

Type of analysis	Merge	
Number of lanes in freeway	2	
Free-flow speed on freeway	45.0	mph
Volume on freeway	1254	vph

On Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-flow speed on ramp	40.0	mph
Volume on ramp	1098	vph
Length of first accel/decel lane	500	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	No	
Volume on adjacent Ramp		vph
Position of adjacent Ramp		
Type of adjacent Ramp		
Distance to adjacent Ramp		ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway		Ramp		Adjacent Ramp	
Volume, V (vph)	1254		1098			vph
Peak-hour factor, PHF	0.94		0.94			
Peak 15-min volume, v15	334		292			v
Trucks and buses	6		3			%
Recreational vehicles	0		0			%
Terrain type:	Level		Level			
Grade		%		%		%
Length		mi		mi		mi
Trucks and buses PCE, ET	1.5		1.5			
Recreational vehicle PCE, ER	1.2		1.2			

X

```
Heavy vehicle adjustment, fHV          0.971       0.985
Driver population factor, fP           1.00        1.00
Flow rate, vp                          1374        1186                 pcph

_________________________Estimation of V12 Merge Areas_________________________

                  L   =             (Equation 13-6 or 13-7)
                   EQ
                  P   =    1.000   Using Equation  0
                   FM
                  v  = v  (P   ) =  1374   pc/h
                   12   F    FM

_______________________________Capacity Checks_______________________________

                           Actual        Maximum         LOS F?
     v                     2560          1110704128      No
      FO
     v  or v               0    pc/h     (Equation 13-14 or 13-17)
      3     av34
Is   v  or v      > 2700 pc/h?           No
      3     av34
Is   v  or v      > 1.5 v  /2            No
      3     av34         12
If yes, v    = 1374                   (Equation 13-15, 13-16, 13-18, or 13-19)
         12A

________________________Flow Entering Merge Influence Area_____________________
                      Actual        Max Desirable        Violation?
     v                2560          1110704128           No
      R12
_________________Level of Service Determination (if not F)_____________________

Density, D = 5.475 + 0.00734 v  + 0.0078 v   - 0.00627 L   =   21.8    pc/mi/ln
          R                   R           12             A
Level of service for ramp-freeway junction areas of influence  C

_____________________________Speed Estimation__________________________________

Intermediate speed variable,                 M  = 0.331
                                              S
Space mean speed in ramp influence area,     S  = 44.0    mph
                                              R
Space mean speed in outer lanes,             S  =  N/A    mph
                                              0
Space mean speed for all vehicles,           S  = 44.0    mph
_______________________________________________________________________________
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HCS 2010: Freeway Merge and Diverge Segments Release 6.80

Phone: Fax:
E-mail:

Diverge Analysis

Analyst:
Agency/Co.:
Date performed: 1/25/2018
Analysis time period:
Freeway/Dir of Travel: Diverge from 680S to Mission W
Junction:
Jurisdiction:
Analysis Year:
Description:

Freeway Data

Type of analysis	Diverge	
Number of lanes in freeway	2	
Free-flow speed on freeway	65.0	mph
Volume on freeway	1639	vph

Off Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-Flow speed on ramp	35.0	mph
Volume on ramp	1592	vph
Length of first accel/decel lane	500	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	No	
Volume on adjacent ramp		vph
Position of adjacent ramp		
Type of adjacent ramp		
Distance to adjacent ramp		ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway		Ramp		Adjacent Ramp	
Volume, V (vph)	1639		1592			vph
Peak-hour factor, PHF	0.94		0.94			
Peak 15-min volume, v15	436		423			v
Trucks and buses	5		7			%
Recreational vehicles	0		0			%
Terrain type:	Level		Level			
Grade	0.00	%	0.00	%		%
Length	0.00	mi	0.00	mi		mi
Trucks and buses PCE, ET	1.5		1.5			
Recreational vehicle PCE, ER	1.2		1.2			

```
Heavy vehicle adjustment, fHV           0.976       0.966                              X
Driver population factor, fP            1.00        1.00
Flow rate, vp                           1787        1753                 pcph

_________________________Estimation of V12 Diverge Areas_______________________

                  L   =            (Equation 13-12 or 13-13)
                   EQ
                  P   =    1.000   Using Equation  0
                   FD
                  v   = v  + (v - v ) P  =  1787   pc/h
                   12    R      F    R   FD

_______________________________Capacity Checks_________________________________

                             Actual        Maximum         LOS F?
     v  = v                  1787          4700            No
      Fi   F
     v  = v - v              34            4700            No
      FO   F   R
     v                       1753          2000            No
      R
     v  or v                 0    pc/h     (Equation 13-14 or 13-17)
      3     av34
Is   v  or v      > 2700 pc/h?             No
      3     av34
Is   v  or v      > 1.5 v  /2              No
      3     av34         12
If yes, v    = 1787                     (Equation 13-15, 13-16, 13-18, or 13-19)
         12A

______________________Flow Entering Diverge Influence Area_____________________
                      Actual        Max Desirable         Violation?
     v                1787          4400                  No
      12
_________________Level of Service Determination (if not F)_____________________

Density,               D = 4.252 + 0.0086 v  - 0.009  L   =   15.1    pc/mi/ln
                        R                  12          D
Level of service for ramp-freeway junction areas of influence B

_____________________________Speed Estimation__________________________________

Intermediate speed variable,                 D  = 0.586
                                              S
Space mean speed in ramp influence area,     S  = 51.5    mph
                                              R
Space mean speed in outer lanes,             S  =  N/A    mph
                                              0
Space mean speed for all vehicles,           S  = 51.5    mph
_______________________________________________________________________________
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X

HCS 2010: Freeway Merge and Diverge Segments Release 6.80

Phone: Fax:
E-mail:

Diverge Analysis

Analyst:
Agency/Co.:
Date performed: 1/26/2018
Analysis time period:
Freeway/Dir of Travel: Diverge fr Mission Wb to 680S
Junction:
Jurisdiction:
Analysis Year:
Description:

Freeway Data

Type of analysis	Diverge	
Number of lanes in freeway	2	
Free-flow speed on freeway	45.0	mph
Volume on freeway	810	vph

Off Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-Flow speed on ramp	25.0	mph
Volume on ramp	526	vph
Length of first accel/decel lane	500	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	No	
Volume on adjacent ramp		vph
Position of adjacent ramp		
Type of adjacent ramp		
Distance to adjacent ramp		ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway		Ramp		Adjacent Ramp	
Volume, V (vph)	810		526			vph
Peak-hour factor, PHF	0.94		0.94			
Peak 15-min volume, v15	215		140			v
Trucks and buses	5		4			%
Recreational vehicles	0		0			%
Terrain type:	Level		Level			
Grade	0.00	%	0.00	%	%	
Length	0.00	mi	0.00	mi	mi	
Trucks and buses PCE, ET	1.5		1.5			
Recreational vehicle PCE, ER	1.2		1.2			

```
Heavy vehicle adjustment, fHV           0.976       0.980                    X
Driver population factor, fP            1.00        1.00
Flow rate, vp                           883         571                 pcph

_________________________Estimation of V12 Diverge Areas_______________________

                  L   =             (Equation 13-12 or 13-13)
                   EQ
                  P   =    1.000   Using Equation  0
                   FD
                  v   = v  + (v - v ) P  =  883    pc/h
                   12    R      F    R   FD

_______________________________Capacity Checks_________________________________

                             Actual        Maximum         LOS F?
     v  = v                  883           1110704128      No
      Fi   F
     v  = v - v              312           1110704128      No
      FO   F   R
     v                       571           1900            No
      R
     v  or v                 0    pc/h     (Equation 13-14 or 13-17)
      3     av34
Is   v  or v      > 2700 pc/h?             No
      3     av34
Is   v  or v      > 1.5 v  /2              No
      3     av34         12
If yes, v    = 883                      (Equation 13-15, 13-16, 13-18, or 13-19)
         12A

______________________Flow Entering Diverge Influence Area_____________________
                        Actual        Max Desirable         Violation?
     v                  883           1110704128            No
      12
_________________Level of Service Determination (if not F)_____________________

Density,                 D = 4.252 + 0.0086 v  - 0.009  L   =   7.3     pc/mi/ln
                          R                   12           D
Level of service for ramp-freeway junction areas of influence A

_____________________________Speed Estimation__________________________________

Intermediate speed variable,                 D  = 0.609
                                              S
Space mean speed in ramp influence area,     S  = 43.2    mph
                                              R
Space mean speed in outer lanes,             S  =  N/A    mph
                                              0
Space mean speed for all vehicles,           S  = 43.2    mph
_______________________________________________________________________________
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X

HCS 2010: Freeway Merge and Diverge Segments Release 6.80

Phone: Fax:
E-mail:

Diverge Analysis

Analyst:
Agency/Co.:
Date performed: 1/26/2018
Analysis time period:
Freeway/Dir of Travel: Diverge fr Mission Wb to 680N
Junction:
Jurisdiction:
Analysis Year:
Description:

Freeway Data

Type of analysis	Diverge	
Number of lanes in freeway	2	
Free-flow speed on freeway	45.0	mph
Volume on freeway	887	vph

Off Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-Flow speed on ramp	40.0	mph
Volume on ramp	208	vph
Length of first accel/decel lane	500	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	No	
Volume on adjacent ramp		vph
Position of adjacent ramp		
Type of adjacent ramp		
Distance to adjacent ramp		ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway		Ramp		Adjacent Ramp	
Volume, V (vph)	887		208			vph
Peak-hour factor, PHF	0.94		0.94			
Peak 15-min volume, v15	236		55			v
Trucks and buses	5		4			%
Recreational vehicles	0		0			%
Terrain type:	Level		Level			
Grade	0.00	%	0.00	%		%
Length	0.00	mi	0.00	mi		mi
Trucks and buses PCE, ET	1.5		1.5			
Recreational vehicle PCE, ER	1.2		1.2			

```
Heavy vehicle adjustment, fHV           0.976       0.980                          X
Driver population factor, fP            1.00        1.00
Flow rate, vp                           967         226                  pcph

_________________________Estimation of V12 Diverge Areas_______________________

                  L  =            (Equation 13-12 or 13-13)
                   EQ
                  P  =    1.000   Using Equation  0
                   FD
                  v  = v  + (v - v ) P  =  967    pc/h
                   12   R      F   R   FD

_______________________________Capacity Checks_________________________________

                           Actual        Maximum         LOS F?
     v  = v                967           1110704128      No
      Fi   F
     v  = v - v            741           1110704128      No
      FO   F   R
     v                     226           2100            No
      R
     v  or v               0    pc/h     (Equation 13-14 or 13-17)
      3     av34
Is   v  or v      > 2700 pc/h?           No
      3     av34
Is   v  or v      > 1.5 v  /2            No
      3     av34         12
If yes, v    = 967                    (Equation 13-15, 13-16, 13-18, or 13-19)
         12A

______________________Flow Entering Diverge Influence Area_____________________
                        Actual        Max Desirable         Violation?
     v                  967           1110704128            No
      12
_________________Level of Service Determination (if not F)_____________________

Density,                 D = 4.252 + 0.0086 v  - 0.009  L   =   8.1     pc/mi/ln
                          R                  12          D
Level of service for ramp-freeway junction areas of influence A

_____________________________Speed Estimation__________________________________

Intermediate speed variable,                D  = 0.383
                                             S
Space mean speed in ramp influence area,    S  = 43.8    mph
                                             R
Space mean speed in outer lanes,            S  =  N/A    mph
                                             0
Space mean speed for all vehicles,          S  = 43.8    mph
_______________________________________________________________________________
```

X

HCS 2010: Freeway Merge and Diverge Segments Release 6.80

Phone: Fax:
E-mail:

Diverge Analysis

Analyst:
Agency/Co.:
Date performed: 1/26/2018
Analysis time period:
Freeway/Dir of Travel: Diverge fr Mission Eb to 680 S
Junction:
Jurisdiction:
Analysis Year:
Description:

Freeway Data

Type of analysis	Diverge	
Number of lanes in freeway	2	
Free-flow speed on freeway	45.0	mph
Volume on freeway	3864	vph

Off Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-Flow speed on ramp	40.0	mph
Volume on ramp	1143	vph
Length of first accel/decel lane	500	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	No	
Volume on adjacent ramp		vph
Position of adjacent ramp		
Type of adjacent ramp		
Distance to adjacent ramp		ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway		Ramp		Adjacent Ramp	
Volume, V (vph)	3864		1143			vph
Peak-hour factor, PHF	0.94		0.94			
Peak 15-min volume, v15	1028		304			v
Trucks and buses	4		4			%
Recreational vehicles	0		0			%
Terrain type:	Level		Level			
Grade	0.00	%	0.00	%	%	
Length	0.00	mi	0.00	mi	mi	
Trucks and buses PCE, ET	1.5		1.5			
Recreational vehicle PCE, ER	1.2		1.2			

X

Heavy vehicle adjustment, fHV	0.980	0.980	
Driver population factor, fP	1.00	1.00	
Flow rate, vp	4193	1240	pcph

Estimation of V12 Diverge Areas

L_{EQ} = (Equation 13-12 or 13-13)

P_{FD} = 1.000 Using Equation 0

$v_{12} = v_R + (v_F - v_R) P_{FD}$ = 4193 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{Fi} = v_F$	4193	1110704128	No
$v_{FO} = v_F - v_R$	2953	1110704128	No
v_R	1240	2100	No
v_3 or v_{av34}	0 pc/h	(Equation 13-14 or 13-17)	

Is v_3 or v_{av34} > 2700 pc/h? No

Is v_3 or v_{av34} > 1.5 v_{12}/2 No

If yes, v_{12A} = 4193 (Equation 13-15, 13-16, 13-18, or 13-19)

Flow Entering Diverge Influence Area

	Actual	Max Desirable	Violation?
v_{12}	4193	1110704128	No

Level of Service Determination (if not F)

Density, $D_R = 4.252 + 0.0086\ v_{12} - 0.009\ L_D$ = 35.8 pc/mi/ln

Level of service for ramp-freeway junction areas of influence E

Speed Estimation

Intermediate speed variable,	D_S = 0.475	
Space mean speed in ramp influence area,	S_R = 43.6	mph
Space mean speed in outer lanes,	S_0 = N/A	mph
Space mean speed for all vehicles,	S = 43.6	mph

X

Phone: Fax:
E-mail:

Diverge Analysis

Analyst:
Agency/Co.:
Date performed: 1/26/2018
Analysis time period:
Freeway/Dir of Travel: Diverge fr Mission Eb to 680N
Junction:
Jurisdiction:
Analysis Year:
Description:

Freeway Data

Type of analysis	Diverge	
Number of lanes in freeway	2	
Free-flow speed on freeway	45.0	mph
Volume on freeway	1393	vph

Off Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-Flow speed on ramp	25.0	mph
Volume on ramp	682	vph
Length of first accel/decel lane	500	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	No	
Volume on adjacent ramp		vph
Position of adjacent ramp		
Type of adjacent ramp		
Distance to adjacent ramp		ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway		Ramp		Adjacent Ramp	
Volume, V (vph)	1393		682			vph
Peak-hour factor, PHF	0.94		0.94			
Peak 15-min volume, v15	370		181			v
Trucks and buses	4		7			%
Recreational vehicles	0		0			%
Terrain type:	Level		Level			
Grade	0.00	%	0.00	%		%
Length	0.00	mi	0.00	mi		mi
Trucks and buses PCE, ET	1.5		1.5			
Recreational vehicle PCE, ER	1.2		1.2			

```
Heavy vehicle adjustment, fHV          0.980       0.966                          X
Driver population factor, fP           1.00        1.00
Flow rate, vp                          1512        751                  pcph

_________________________Estimation of V12 Diverge Areas_______________________

                  L  =            (Equation 13-12 or 13-13)
                   EQ
                  P  =    1.000   Using Equation  0
                   FD
                  v  = v  + (v - v ) P  =  1512   pc/h
                   12   R     F   R   FD

_______________________________Capacity Checks_________________________________

                             Actual        Maximum         LOS F?
     v  = v                  1512          1110704128      No
      Fi   F
     v  = v - v              761           1110704128      No
      FO   F   R
     v                       751           1900            No
      R
     v  or v                 0    pc/h     (Equation 13-14 or 13-17)
      3     av34
Is   v  or v      > 2700 pc/h?             No
      3     av34
Is   v  or v      > 1.5 v  /2              No
      3     av34         12
If yes, v    = 1512                     (Equation 13-15, 13-16, 13-18, or 13-19)
         12A

______________________Flow Entering Diverge Influence Area_____________________
                      Actual        Max Desirable         Violation?
     v                1512          1110704128            No
      12
_________________Level of Service Determination (if not F)_____________________

Density,               D = 4.252 + 0.0086 v  - 0.009  L   =   12.8    pc/mi/ln
                        R                  12          D
Level of service for ramp-freeway junction areas of influence B

_____________________________Speed Estimation__________________________________

Intermediate speed variable,                 D  = 0.626
                                              S
Space mean speed in ramp influence area,     S  = 43.1    mph
                                              R
Space mean speed in outer lanes,             S  =  N/A    mph
                                              0
Space mean speed for all vehicles,           S  = 43.1    mph
_______________________________________________________________________________
```

HCS 2010: Freeway Merge and Diverge Segments Release 6.80

X

Phone: Fax:
E-mail:

Diverge Analysis

Analyst:
Agency/Co.:
Date performed: 1/26/2018
Analysis time period:
Freeway/Dir of Travel: Diverge fr 680N to Mission Wb
Junction:
Jurisdiction:
Analysis Year:
Description:

Freeway Data

Type of analysis	Diverge	
Number of lanes in freeway	2	
Free-flow speed on freeway	65.0	mph
Volume on freeway	1662	vph

Off Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-Flow speed on ramp	25.0	mph
Volume on ramp	746	vph
Length of first accel/decel lane	500	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	No	
Volume on adjacent ramp		vph
Position of adjacent ramp		
Type of adjacent ramp		
Distance to adjacent ramp		ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway		Ramp		Adjacent Ramp	
Volume, V (vph)	1662		746			vph
Peak-hour factor, PHF	0.94		0.94			
Peak 15-min volume, v15	442		198			v
Trucks and buses	4		5			%
Recreational vehicles	0		0			%
Terrain type:	Level		Level			
Grade	0.00	%	0.00	%		%
Length	0.00	mi	0.00	mi		mi
Trucks and buses PCE, ET	1.5		1.5			
Recreational vehicle PCE, ER	1.2		1.2			

Heavy vehicle adjustment, fHV	0.980	0.976	
Driver population factor, fP	1.00	1.00	
Flow rate, vp	1803	813	pcph

X

Estimation of V12 Diverge Areas

L_{EQ} = (Equation 13-12 or 13-13)

P_{FD} = 1.000 Using Equation 0

$v_{12} = v_R + (v_F - v_R) P_{FD}$ = 1803 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
$v_{Fi} = v_F$	1803	4700	No
$v_{FO} = v_F - v_R$	990	4700	No
v_R	813	1900	No
v_3 or v_{av34}	0 pc/h	(Equation 13-14 or 13-17)	
Is v_3 or v_{av34} > 2700 pc/h?		No	
Is v_3 or v_{av34} > 1.5 v_{12}/2		No	

If yes, v_{12A} = 1803 (Equation 13-15, 13-16, 13-18, or 13-19)

Flow Entering Diverge Influence Area

	Actual	Max Desirable	Violation?
v_{12}	1803	4400	No

Level of Service Determination (if not F)

Density, $D_R = 4.252 + 0.0086\ v_{12} - 0.009\ L_D$ = 15.3 pc/mi/ln

Level of service for ramp-freeway junction areas of influence B

Speed Estimation

Intermediate speed variable,	D_S = 0.631	
Space mean speed in ramp influence area,	S_R = 50.5	mph
Space mean speed in outer lanes,	S_0 = N/A	mph
Space mean speed for all vehicles,	S = 50.5	mph

X

HCS 2010: Freeway Merge and Diverge Segments Release 6.80

Phone: Fax:
E-mail:

Diverge Analysis

Analyst:
Agency/Co.:
Date performed: 1/26/2018
Analysis time period:
Freeway/Dir of Travel: Diverge fr 680 N to Mission Eb
Junction:
Jurisdiction:
Analysis Year:
Description:

Freeway Data

Type of analysis	Diverge	
Number of lanes in freeway	2	
Free-flow speed on freeway	65.0	mph
Volume on freeway	2131	vph

Off Ramp Data

Side of freeway	Right	
Number of lanes in ramp	1	
Free-Flow speed on ramp	40.0	mph
Volume on ramp	1098	vph
Length of first accel/decel lane	500	ft
Length of second accel/decel lane		ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	No	
Volume on adjacent ramp		vph
Position of adjacent ramp		
Type of adjacent ramp		
Distance to adjacent ramp		ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway		Ramp		Adjacent Ramp	
Volume, V (vph)	2131		1098			vph
Peak-hour factor, PHF	0.94		0.94			
Peak 15-min volume, v15	567		292			v
Trucks and buses	4		6			%
Recreational vehicles	0		0			%
Terrain type:	Level		Level			
Grade	0.00	%	0.00	%		%
Length	0.00	mi	0.00	mi		mi
Trucks and buses PCE, ET	1.5		1.5			
Recreational vehicle PCE, ER	1.2		1.2			

```
Heavy vehicle adjustment, fHV          0.980       0.971                        X
Driver population factor, fP           1.00        1.00
Flow rate, vp                          2312        1203                 pcph

_________________________Estimation of V12 Diverge Areas_______________________

                  L   =            (Equation 13-12 or 13-13)
                   EQ
                  P   =    1.000   Using Equation  0
                   FD
                  v   = v  + (v - v ) P  =  2312   pc/h
                   12   R     F   R   FD

_______________________________Capacity Checks_________________________________

                             Actual        Maximum          LOS F?
     v  = v                  2312          4700             No
      Fi   F
     v  = v - v              1109          4700             No
      FO   F   R
     v                       1203          2100             No
      R
     v  or v                 0    pc/h     (Equation 13-14 or 13-17)
      3     av34
Is   v  or v      > 2700 pc/h?             No
      3     av34
Is   v  or v      > 1.5 v  /2              No
      3     av34         12
If yes, v    = 2312                  (Equation 13-15, 13-16, 13-18, or 13-19)
         12A

______________________Flow Entering Diverge Influence Area_____________________
                      Actual        Max Desirable         Violation?
     v                2312          4400                  No
      12
_________________Level of Service Determination (if not F)_____________________

Density,               D = 4.252 + 0.0086 v  - 0.009  L   =   19.6    pc/mi/ln
                        R                   12          D
Level of service for ramp-freeway junction areas of influence B

_____________________________Speed Estimation__________________________________

Intermediate speed variable,                 D  = 0.471
                                              S
Space mean speed in ramp influence area,     S  = 54.2    mph
                                              R
Space mean speed in outer lanes,             S  =  N/A    mph
                                              0
Space mean speed for all vehicles,           S  = 54.2    mph
_______________________________________________________________________________
```

X

HCS 2010: Basic Freeway Segments Release 6.80

Phone: Fax:
E-mail:

Operational Analysis

Analyst:	
Agency or Company:	
Date Performed:	1/26/2018
Analysis Time Period:	
Freeway/Direction:	680 South
From/To:	
Jurisdiction:	Fremont, CA
Analysis Year:	2017
Description:	

Flow Inputs and Adjustments

Volume, V	7296	veh/h
Peak-hour factor, PHF	0.94	
Peak 15-min volume, v15	1940	v
Trucks and buses	5	%
Recreational vehicles	0	%
Terrain type:	Level	
Grade	-	%
Segment length	-	mi
Trucks and buses PCE, ET	1.5	
Recreational vehicle PCE, ER	1.2	
Heavy vehicle adjustment, fHV	0.976	
Driver population factor, fp	1.00	
Flow rate, vp	1989	pc/h/ln

Speed Inputs and Adjustments

Lane width	-	ft
Right-side lateral clearance	-	ft
Total ramp density, TRD	-	ramps/mi
Number of lanes, N	4	
Free-flow speed:	Measured	
FFS or BFFS	65.0	mi/h
Lane width adjustment, fLW	-	mi/h
Lateral clearance adjustment, fLC	-	mi/h
TRD adjustment	-	mi/h
Free-flow speed, FFS	65.0	mi/h

LOS and Performance Measures

Flow rate, vp	1989	pc/h/ln
Free-flow speed, FFS	65.0	mi/h
Average passenger-car speed, S	60.1	mi/h
Number of lanes, N	4	
Density, D	33.1	pc/mi/ln
Level of service, LOS	D	

Overall results are not computed when free-flow speed is less than 55 mph. X

X

HCS 2010: Basic Freeway Segments Release 6.80

Phone: Fax:
E-mail:

Operational Analysis

Analyst:	
Agency or Company:	
Date Performed:	4/28/2018
Analysis Time Period:	
Freeway/Direction:	680 North
From/To:	
Jurisdiction:	Fremont, Ca
Analysis Year:	
Description:	

Flow Inputs and Adjustments

Volume, V	9800	veh/h
Peak-hour factor, PHF	0.94	
Peak 15-min volume, v15	2606	v
Trucks and buses	4	%
Recreational vehicles	0	%
Terrain type:	Level	
Grade	-	%
Segment length	-	mi
Trucks and buses PCE, ET	1.5	
Recreational vehicle PCE, ER	1.2	
Heavy vehicle adjustment, fHV	0.980	
Driver population factor, fp	1.00	
Flow rate, vp	3545	pc/h/ln

Speed Inputs and Adjustments

Lane width	-	ft
Right-side lateral clearance	-	ft
Total ramp density, TRD	-	ramps/mi
Number of lanes, N	3	
Free-flow speed:	Measured	
FFS or BFFS	65.0	mi/h
Lane width adjustment, fLW	-	mi/h
Lateral clearance adjustment, fLC	-	mi/h
TRD adjustment	-	mi/h
Free-flow speed, FFS	65.0	mi/h

LOS and Performance Measures

Flow rate, vp	3545	pc/h/ln
Free-flow speed, FFS	65.0	mi/h
Average passenger-car speed, S		mi/h
Number of lanes, N	3	
Density, D		pc/mi/ln
Level of service, LOS	F	

Overall results are not computed when free-flow speed is less than 55 mph. X

HCS 2010: Freeway Merge and Diverge Segments Release 6.80

Phone: Fax:
E-mail:

Merge Analysis

Analyst:
Agency/Co.:
Date performed: 1/26/2018
Analysis time period:
Freeway/Dir of Travel: Merge from 680S to Mission Wb
Junction:
Jurisdiction:
Analysis Year:
Description:

Freeway Data

Type of analysis	Merge	
Number of lanes in freeway	2	
Free-flow speed on freeway	45.0	mph
Volume on freeway	2842	vph

On Ramp Data

Side of freeway	Right	
Number of lanes in ramp	2	
Free-flow speed on ramp	30.0	mph
Volume on ramp	1592	vph
Length of first accel/decel lane	1000	ft
Length of second accel/decel lane	1000	ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	No	
Volume on adjacent Ramp		vph
Position of adjacent Ramp		
Type of adjacent Ramp		
Distance to adjacent Ramp		ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway		Ramp		Adjacent Ramp	
Volume, V (vph)	2842		1592			vph
Peak-hour factor, PHF	0.94		0.94			
Peak 15-min volume, v15	756		423			v
Trucks and buses	4		5			%
Recreational vehicles	0		0			%
Terrain type:	Level		Level			
Grade		%		%		%
Length		mi		mi		mi
Trucks and buses PCE, ET	1.5		1.5			
Recreational vehicle PCE, ER	1.2		1.2			

Heavy vehicle adjustment, fHV	0.980	0.976	
Driver population factor, fP	1.00	1.00	
Flow rate, vp	3084	1736	pcph

Estimation of V12 Merge Areas

L_{EQ} = (Equation 13-6 or 13-7)

P_{FM} = 1.000 Using Equation 0

$v_{12} = v_F (P_{FM})$ = 3084 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	4820	1110704128	No
v_3 or v_{av34}	0 pc/h	(Equation 13-14 or 13-17)	
Is v_3 or v_{av34} > 2700 pc/h?		No	
Is v_3 or v_{av34} > 1.5 v_{12}/2		No	

If yes, v_{12A} = 3084 (Equation 13-15, 13-16, 13-18, or 13-19)

Flow Entering Merge Influence Area

	Actual	Max Desirable	Violation?
v_{R12}	4820	1110704128	No

Level of Service Determination (if not F)

Density, $D_R = 5.475 + 0.00734\, v_R + 0.0078\, v_{12} - 0.00627\, L_A$ = 23.5 pc/mi/ln

Level of service for ramp-freeway junction areas of influence C

Speed Estimation

Intermediate speed variable,	M_S = 0.624		
Space mean speed in ramp influence area,	S_R = 43.1	mph	
Space mean speed in outer lanes,	S_0 = N/A	mph	
Space mean speed for all vehicles,	S = 43.1	mph	

HCS 2010: Freeway Merge and Diverge Segments Release 6.80

Phone: Fax:
E-mail:

Merge Analysis

Analyst:
Agency/Co.:
Date performed: 1/26/2018
Analysis time period:
Freeway/Dir of Travel: Merge from 680S to Mission Wb
Junction:
Jurisdiction:
Analysis Year: PM 2017
Description:

Freeway Data

Type of analysis	Merge	
Number of lanes in freeway	2	
Free-flow speed on freeway	45.0	mph
Volume on freeway	2185	vph

On Ramp Data

Side of freeway	Right	
Number of lanes in ramp	2	
Free-flow speed on ramp	30.0	mph
Volume on ramp	1190	vph
Length of first accel/decel lane	1000	ft
Length of second accel/decel lane	1000	ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	No	
Volume on adjacent Ramp		vph
Position of adjacent Ramp		
Type of adjacent Ramp		
Distance to adjacent Ramp		ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp
Volume, V (vph)	2185	1190	vph
Peak-hour factor, PHF	0.94	0.94	
Peak 15-min volume, v15	581	316	v
Trucks and buses	4	5	%
Recreational vehicles	0	0	%
Terrain type:	Level	Level	
Grade	%	%	%
Length	mi	mi	mi
Trucks and buses PCE, ET	1.5	1.5	
Recreational vehicle PCE, ER	1.2	1.2	

```
Heavy vehicle adjustment, fHV          0.980       0.976
Driver population factor, fP           1.00        1.00
Flow rate, vp                          2371        1298                 pcph

_________________________Estimation of V12 Merge Areas_________________________

                  L  =            (Equation 13-6 or 13-7)
                   EQ
                  P  =    1.000   Using Equation  0
                   FM
                  v  = v  (P  ) =  2371   pc/h
                   12   F   FM

_______________________________Capacity Checks_________________________________

                           Actual        Maximum         LOS F?
     v                     3669          1110704128      No
      FO
     v  or v               0    pc/h     (Equation 13-14 or 13-17)
      3     av34
Is   v  or v      > 2700 pc/h?           No
      3     av34
Is   v  or v      > 1.5 v  /2            No
      3     av34         12
If yes, v    = 2371                   (Equation 13-15, 13-16, 13-18, or 13-19)
         12A

________________________Flow Entering Merge Influence Area_____________________
                      Actual        Max Desirable         Violation?
     v                3669          1110704128            No
      R12
_________________Level of Service Determination (if not F)_____________________

Density, D = 5.475 + 0.00734 v  + 0.0078 v   - 0.00627 L   =   14.7    pc/mi/ln
          R                   R           12             A
Level of service for ramp-freeway junction areas of influence  B

_____________________________Speed Estimation__________________________________

Intermediate speed variable,                 M  = 0.294
                                              S
Space mean speed in ramp influence area,     S  = 44.1    mph
                                              R
Space mean speed in outer lanes,             S  =  N/A    mph
                                              0
Space mean speed for all vehicles,           S  = 44.1    mph
_______________________________________________________________________________
```

HCS 2010: Freeway Merge and Diverge Segments Release 6.80

Phone: Fax:
E-mail:

Merge Analysis

Analyst:
Agency/Co.:
Date performed: 1/26/2018
Analysis time period:
Freeway/Dir of Travel: Merge from 680S to Mission Wb
Junction:
Jurisdiction:
Analysis Year:
Description:

Freeway Data

Type of analysis	Merge	
Number of lanes in freeway	2	
Free-flow speed on freeway	45.0	mph
Volume on freeway	3379	vph

On Ramp Data

Side of freeway	Right	
Number of lanes in ramp	2	
Free-flow speed on ramp	30.0	mph
Volume on ramp	2494	vph
Length of first accel/decel lane	1000	ft
Length of second accel/decel lane	1000	ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	No	
Volume on adjacent Ramp		vph
Position of adjacent Ramp		
Type of adjacent Ramp		
Distance to adjacent Ramp		ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	3379	2494		vph
Peak-hour factor, PHF	0.94	0.94		
Peak 15-min volume, v15	899	663		v
Trucks and buses	4	5		%
Recreational vehicles	0	0		%
Terrain type:	Level	Level		
Grade	%	%	%	
Length	mi	mi	mi	
Trucks and buses PCE, ET	1.5	1.5		
Recreational vehicle PCE, ER	1.2	1.2		

```
Heavy vehicle adjustment, fHV          0.980       0.976
Driver population factor, fP           1.00        1.00
Flow rate, vp                          3667        2720                  pcph

_________________________Estimation of V12 Merge Areas_________________________

                  L   =            (Equation 13-6 or 13-7)
                   EQ
                  P   =    1.000   Using Equation  0
                   FM
                  v  = v  (P  ) =  3667   pc/h
                   12   F   FM

_______________________________Capacity Checks_________________________________

                           Actual        Maximum         LOS F?
     v                     6387          1110704128      No
      FO
     v  or v               0    pc/h     (Equation 13-14 or 13-17)
      3     av34
Is   v  or v      > 2700 pc/h?           No
      3     av34
Is   v  or v      > 1.5 v  /2            No
      3     av34         12
If yes, v    = 3667                   (Equation 13-15, 13-16, 13-18, or 13-19)
         12A

________________________Flow Entering Merge Influence Area_____________________
                      Actual        Max Desirable        Violation?
     v                6387          1110704128           No
      R12
_________________Level of Service Determination (if not F)_____________________

Density, D = 5.475 + 0.00734 v  + 0.0078 v   - 0.00627 L   =   35.2    pc/mi/ln
          R                   R           12             A
Level of service for ramp-freeway junction areas of influence  E

_____________________________Speed Estimation__________________________________

Intermediate speed variable,                 M  = 2.458
                                              S
Space mean speed in ramp influence area,     S  = 37.6    mph
                                              R
Space mean speed in outer lanes,             S  =  N/A    mph
                                              0
Space mean speed for all vehicles,           S  = 37.6    mph
_______________________________________________________________________________
```

HCS 2010: Freeway Merge and Diverge Segments Release 6.80

Phone: Fax:
E-mail:

Merge Analysis

Analyst:
Agency/Co.:
Date performed: 1/26/2018
Analysis time period:
Freeway/Dir of Travel: Merge from 680S to Mission Wb
Junction:
Jurisdiction:
Analysis Year: AM 2018
Description:

Freeway Data

Type of analysis	Merge	
Number of lanes in freeway	2	
Free-flow speed on freeway	45.0	mph
Volume on freeway	2700	vph

On Ramp Data

Side of freeway	Right	
Number of lanes in ramp	2	
Free-flow speed on ramp	30.0	mph
Volume on ramp	1717	vph
Length of first accel/decel lane	1000	ft
Length of second accel/decel lane	1000	ft

Adjacent Ramp Data (if one exists)

Does adjacent ramp exist?	No	
Volume on adjacent Ramp		vph
Position of adjacent Ramp		
Type of adjacent Ramp		
Distance to adjacent Ramp		ft

Conversion to pc/h Under Base Conditions

Junction Components	Freeway	Ramp	Adjacent Ramp	
Volume, V (vph)	2700	1717		vph
Peak-hour factor, PHF	0.94	0.94		
Peak 15-min volume, v15	718	457		v
Trucks and buses	4	5		%
Recreational vehicles	0	0		%
Terrain type:	Level	Level		
Grade	%	%	%	
Length	mi	mi	mi	
Trucks and buses PCE, ET	1.5	1.5		
Recreational vehicle PCE, ER	1.2	1.2		

Heavy vehicle adjustment, fHV	0.980	0.976	
Driver population factor, fP	1.00	1.00	
Flow rate, vp	2930	1872	pcph

Estimation of V12 Merge Areas

L_{EQ} = (Equation 13-6 or 13-7)

P_{FM} = 1.000 Using Equation 0

$v_{12} = v_F (P_{FM})$ = 2930 pc/h

Capacity Checks

	Actual	Maximum	LOS F?
v_{FO}	4802	1110704128	No
v_3 or v_{av34}	0 pc/h	(Equation 13-14 or 13-17)	
Is v_3 or v_{av34} > 2700 pc/h?		No	
Is v_3 or v_{av34} > 1.5 v_{12}/2		No	

If yes, v_{12A} = 2930 (Equation 13-15, 13-16, 13-18, or 13-19)

Flow Entering Merge Influence Area

	Actual	Max Desirable	Violation?
v_{R12}	4802	1110704128	No

Level of Service Determination (if not F)

Density, $D_R = 5.475 + 0.00734\, v_R + 0.0078\, v_{12} - 0.00627\, L_A$ = 23.3 pc/mi/ln

Level of service for ramp-freeway junction areas of influence C

Speed Estimation

Intermediate speed variable,	M_S = 0.616	
Space mean speed in ramp influence area,	S_R = 43.2	mph
Space mean speed in outer lanes,	S_0 = N/A	mph
Space mean speed for all vehicles,	S = 43.2	mph

Appendix E: ASTM C109 standard

Designation: C109/C109M – 13

Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or [50-mm] Cube Specimens)[1]

This standard is issued under the fixed designation C109/C109M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope*

1.1 This test method covers determination of the compressive strength of hydraulic cement mortars, using 2-in. or [50-mm] cube specimens.

NOTE 1—Test Method C349 provides an alternative procedure for this determination (not to be used for acceptance tests).

1.2 This test method covers the application of the test using either inch-pound or SI units. The values stated in either SI units or inch-pound units are to be regarded separately as standard. Within the text, the SI units are shown in brackets. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in nonconformance with the standard.

1.3 Values in SI units shall be obtained by measurement in SI units or by appropriate conversion, using the Rules for Conversion and Rounding given in IEEE/ASTM SI-10, of measurements made in other units.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* (**Warning**—*Fresh hydraulic cementitious mixtures are caustic and may cause chemical burns to skin and tissue upon prolonged exposure.*[2])

2. Referenced Documents

2.1 *ASTM Standards:*[3]

C91 Specification for Masonry Cement
C114 Test Methods for Chemical Analysis of Hydraulic Cement
C150 Specification for Portland Cement
C230/C230M Specification for Flow Table for Use in Tests of Hydraulic Cement
C305 Practice for Mechanical Mixing of Hydraulic Cement Pastes and Mortars of Plastic Consistency
C349 Test Method for Compressive Strength of Hydraulic-Cement Mortars (Using Portions of Prisms Broken in Flexure)
C511 Specification for Mixing Rooms, Moist Cabinets, Moist Rooms, and Water Storage Tanks Used in the Testing of Hydraulic Cements and Concretes
C595 Specification for Blended Hydraulic Cements
C618 Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
C670 Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials
C778 Specification for Sand
C989 Specification for Slag Cement for Use in Concrete and Mortars
C1005 Specification for Reference Masses and Devices for Determining Mass and Volume for Use in the Physical Testing of Hydraulic Cements
C1157 Performance Specification for Hydraulic Cement
C1328 Specification for Plastic (Stucco) Cement
C1329 Specification for Mortar Cement
C1437 Test Method for Flow of Hydraulic Cement Mortar
E4 Practices for Force Verification of Testing Machines

2.2 *IEEE/ASTM Standard:*[3]

IEEE/ASTM SI-10 Standard for Use of the International System of Units (SI): The Modern Metric System

3. Summary of Test Method

3.1 The mortar used consists of 1 part cement and 2.75 parts of sand proportioned by mass. Portland or air-entraining portland cements are mixed at specified water/cement ratios. Water content for other cements is that sufficient to obtain a flow of 110 ± 5 in 25 drops of the flow table. Two-inch or [50-mm] test cubes are compacted by tamping in two layers.

[1] This test method is under the jurisdiction of ASTM Committee C01 on Cement and is the direct responsibility of Subcommittee C01.27 on Strength.

Current edition approved Oct. 1, 2013. Published November 2013. Originally approved in 1934. Last previous edition approved in 2012 as C109/C109M – 12. DOI: 10.1520/C0109_C0109M-13.

[2] See the section on Safety, Manual of Cement Testing, *Annual Book of ASTM Standards*, Vol 04.01.

[3] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

***A Summary of Changes section appears at the end of this standard**

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The cubes are cured one day in the molds and stripped and immersed in lime water until tested.

4. Significance and Use

4.1 This test method provides a means of determining the compressive strength of hydraulic cement and other mortars and results may be used to determine compliance with specifications. Further, this test method is referenced by numerous other specifications and test methods. Caution must be exercised in using the results of this test method to predict the strength of concretes.

5. Apparatus

5.1 *Weights and Weighing Devices,* shall conform to the requirements of Specification C1005. The weighing device shall be evaluated for precision and accuracy at a total load of 2000 g.

5.2 *Glass Graduates,* of suitable capacities (preferably large enough to measure the mixing water in a single operation) to deliver the indicated volume at 20 °C. The permissible variation shall be ±2 mL. These graduates shall be subdivided to at least 5 mL, except that the graduation lines may be omitted for the lowest 10 mL for a 250-mL graduate and for the lowest 25 mL of a 500-mL graduate. The main graduation lines shall be circles and shall be numbered. The least graduations shall extend at least one seventh of the way around, and intermediate graduations shall extend at least one fifth of the way around.

5.3 *Specimen Molds,* for the 2-in. or [50-mm] cube specimens shall be tight fitting. The molds shall have not more than three cube compartments and shall be separable into not more than two parts. The parts of the molds when assembled shall be positively held together. The molds shall be made of hard metal not attacked by the cement mortar. For new molds the Rockwell hardness number of the metal shall be not less than 55 HRB. The sides of the molds shall be sufficiently rigid to prevent spreading or warping. The interior faces of the molds shall be plane surfaces and shall conform to the tolerances of Table 1.

5.3.1 Cube molds shall be checked for conformance to the design and dimensional requirements of this test method at least every 2½ years.

5.4 *Mixer, Bowl and Paddle,* an electrically driven mechanical mixer of the type equipped with paddle and mixing bowl, as specified in Practice C305.

5.5 *Flow Table and Flow Mold,* conforming to the requirements of Specification C230/C230M.

5.6 *Tamper,* a nonabsorptive, nonabrasive, nonbrittle material such as a rubber compound having a Shore A durometer hardness of 80 ± 10 or seasoned oak wood rendered nonabsorptive by immersion for 15 min in paraffin at approximately 392 °F or [200 °C], shall have a cross section of about ½ by 1 in. or [13 by 25 mm] and a convenient length of about 5 to 6 in. or [120 to 150 mm]. The tamping face shall be flat and at right angles to the length of the tamper.

5.6.1 Tampers shall be checked for conformance to the design and dimensional requirements of this test method at least every 2½ years.

5.7 *Trowel,* having a steel blade 4 to 6 in. [100 to 150 mm] in length, with straight edges.

5.8 *Moist Cabinet or Room,* conforming to the requirements of Specification C511.

5.9 *Testing Machine,* either the hydraulic or the screw type, with sufficient opening between the upper bearing surface and the lower bearing surface of the machine to permit the use of verifying apparatus. The load applied to the test specimen shall be indicated with an accuracy of ±1.0 %. If the load applied by the compression machine is registered on a dial, the dial shall be provided with a graduated scale that can be read to at least the nearest 0.1 % of the full scale load (Note 2). The dial shall be readable within 1 % of the indicated load at any given load level within the loading range. In no case shall the loading range of a dial be considered to include loads below the value that is 100 times the smallest change of load that can be read on the scale. The scale shall be provided with a graduation line equal to zero and so numbered. The dial pointer shall be of sufficient length to reach the graduation marks; the width of the end of the pointer shall not exceed the clear distance between the smallest graduations. Each dial shall be equipped with a zero adjustment that is easily accessible from the outside of the dial case, and with a suitable device that at all times until reset, will indicate to within 1 % accuracy the maximum load applied to the specimen.

5.9.1 If the testing machine load is indicated in digital form, the numerical display must be large enough to be easily read. The numerical increment must be equal to or less than 0.10 % of the full scale load of a given loading range. In no case shall the verified loading range include loads less than the minimum numerical increment multiplied by 100. The accuracy of the indicated load must be within 1.0 % for any value displayed within the verified loading range. Provision must be made for adjusting to indicate true zero at zero load. There shall be provided a maximum load indicator that at all times until reset

TABLE 1 Permissible Variations of Specimen Molds

Parameter	2-in. Cube Molds		[50-mm] Cube Molds	
	New	In Use	New	In Use
Planeness of sides	<0.001 in.	<0.002 in.	[<0.025 mm]	[<0.05 mm]
Distance between opposite sides	2 in. ± 0.005	2 in. ± 0.02	[50 mm ± 0.13 mm]	[50 mm ± 0.50 mm]
Height of each compartment	2 in. + 0.01 in. to – 0.005 in.	2 in. + 0.01 in. to – 0.015 in.	[50 mm + 0.25 mm to – 0.13 mm]	[50 mm + 0.25 mm to – 0.38 mm]
Angle between adjacent faces[A]	90 ± 0.5°	90 ± 0.5°	90 ± 0.5°	90 ± 0.5°

[A] Measured at points slightly removed from the intersection. Measured separately for each compartment between all the interior faces and the adjacent face and between interior faces and top and bottom planes of the mold.

will indicate within 1 % system accuracy the maximum load applied to the specimen.

5.9.2 Compression machines shall be verified in accordance with Practices E4 at least annually to determine if indicated loads, with and without the maximum load indicator (when so equipped), are accurate to ±1.0 %.

NOTE 2—As close as can be read is considered 1/50 in. or [0.5 mm] along the arc described by the end of the pointer. Also, one half of the scale interval is about as close as can reasonably be read when the spacing on the load indicating mechanism is between 1/25 in. or [1 mm] and 1/16 in. or [1.6 mm]. When the spacing is between 1/16 in. or [1.6 mm] and 1/8 in. or [3.2 mm], one third of the scale interval can be read with reasonable certainty. When the spacing is 1/8 in. or [3.2 mm] or more, one fourth of the scale interval can be read with reasonable certainty.

5.9.3 The upper bearing assembly shall be a spherically seated, hardened metal block firmly attached at the center of the upper head of the machine. The center of the sphere shall coincide with the surface of the bearing face within a tolerance of ±5 % of the radius of the sphere. Unless otherwise specified by the manufacturer, the spherical portion of the bearing block and the seat that holds this portion shall be cleaned and lubricated with a petroleum type oil such as motor oil at least every six months. The block shall be closely held in its spherical seat, but shall be free to tilt in any direction. A hardened metal bearing block shall be used beneath the specimen to minimize wear of the lower platen of the machine. To facilitate accurate centering of the test specimen in the compression machine, one of the two surfaces of the bearing blocks shall have a diameter or diagonal of between 2.83 in. [70.7 mm] (See Note 3) and 2.9 in. [73.7 mm]. When the upper block bearing surface meets this requirement, the lower block bearing surface shall be greater than 2.83 in. [70.7 mm]. When the lower block bearing surface meets this requirement, the diameter or diagonal of upper block bearing surface shall be between 2.83 and 3⅛ in. [70.7 and 79.4 mm]. When the lower block is the only block with a diameter or diagonal between 2.83 and 2.9 in. [70.7 and 73.7 mm], the lower block shall be used to center the test specimen. In that case, the lower block shall be centered with respect to the upper bearing block and held in position by suitable means. The bearing block surfaces intended for contact with the specimen shall have a Rockwell harness number not less than 60 HRC. These surfaces shall not depart from plane surfaces by more than 0.0005 in. [0.013 mm] when the blocks are new and shall be maintained within a permissible variation of 0.001 in. or [0.025 mm].

5.9.3.1 Compression machine bearing blocks shall be checked for planeness in accordance with this test method at least annually using a straightedge and feeler stock and shall be refinished if found to be out of tolerance.

NOTE 3—The diagonal of a 2 in. [50 mm] cube is 2.83 in. [70.7 mm].

6. Materials

6.1 *Graded Standard Sand:*

6.1.1 The sand (Note 4) used for making test specimens shall be natural silica sand conforming to the requirements for graded standard sand in Specification C778.

NOTE 4—*Segregation of Graded Sand*—The graded standard sand should be handled in such a manner as to prevent segregation, since variations in the grading of the sand cause variations in the consistency of the mortar. In emptying bins or sacks, care should be exercised to prevent the formation of mounds of sand or craters in the sand, down the slopes of which the coarser particles will roll. Bins should be of sufficient size to permit these precautions. Devices for drawing the sand from bins by gravity should not be used.

7. Temperature and Humidity

7.1 *Temperature*—The temperature of the air in the vicinity of the mixing slab, the dry materials, molds, base plates, and mixing bowl, shall be maintained between 73.5 ± 5.5 °F or [23.0 ± 3.0 °C]. The temperature of the mixing water, moist closet or moist room, and water in the storage tank shall be set at 73.5 ± 3.5 °F or [23 ± 2 °C].

7.2 *Humidity*—The relative humidity of the laboratory shall be not less than 50 %. The moist closet or moist room shall conform to the requirements of Specification C511.

8. Test Specimens

8.1 Make two or three specimens from a batch of mortar for each period of test or test age.

9. Preparation of Specimen Molds

9.1 Apply a thin coating of release agent to the interior faces of the mold and non-absorptive base plates. Apply oils and greases using an impregnated cloth or other suitable means. Wipe the mold faces and the base plate with a cloth as necessary to remove any excess release agent and to achieve a thin, even coating on the interior surfaces. When using an aerosol lubricant, spray the release agent directly onto the mold faces and base plate from a distance of 6 to 8 in. or [150 to 200 mm] to achieve complete coverage. After spraying, wipe the surface with a cloth as necessary to remove any excess aerosol lubricant. The residue coating should be just sufficient to allow a distinct finger print to remain following light finger pressure (Note 5).

9.2 Seal the surfaces where the halves of the mold join by applying a coating of light cup grease such as petrolatum. The amount should be sufficient to extrude slightly when the two halves are tightened together. Remove any excess grease with a cloth.

9.3 Seal molds to their base plates with a watertight sealant. Use microcrystalline wax or a mixture of three parts paraffin to five parts rosin by mass. Paraffin wax is permitted as a sealant with molds that clamp to the base plate. Liquefy the wax by heating it to a temperature of between 230 and 248 °F or [110 and 120 °C]. Effect a watertight seal by applying the liquefied sealant at the outside contact lines between the mold and its base plate (Note 6).

9.4 Optionally, a watertight sealant of petroleum jelly is permitted for clamped molds. Apply a small amount of petroleum jelly to the entire surface of the face of the mold that will be contacting the base plate. Clamp the mold to the base plate and wipe any excess sealant from the interior of the mold and base plate.

NOTE 5—Because aerosol lubricants evaporate, molds should be checked for a sufficient coating of lubricant immediately prior to use. If an extended period of time has elapsed since treatment, retreatment may be necessary.

NOTE 6—*Watertight Molds*—The mixture of paraffin and rosin specified for sealing the joints between molds and base plates may be found difficult to remove when molds are being cleaned. Use of straight paraffin is permissible if a watertight joint is secured, but due to the low strength of paraffin it should be used only when the mold is not held to the base plate by the paraffin alone. When securing clamped molds with paraffin, an improved seal can be obtained by slightly warming the mold and base plate prior to applying the wax. Molds so treated should be allowed to return to room temperature before use.

10. Procedure

10.1 *Composition of Mortars:*

10.1.1 The proportions of materials for the standard mortar shall be one part of cement to 2.75 parts of graded standard sand by weight. Use a water-cement ratio of 0.485 for all portland cements and 0.460 for all air-entraining portland cements. The amount of mixing water for other than portland and air-entraining portland cements shall be such as to produce a flow of 110 ± 5 as determined in accordance with 10.3 and shall be expressed as weight percent of cement.

10.1.2 The quantities of materials to be mixed at one time in the batch of mortar for making six, nine, and twelve test specimens shall be as follows:

Number of Specimens	6	9	12
Cement, g	500	740	1060
Sand, g	1375	2035	2915
Water, mL			
Portland (0.485)	242	359	514
Air-entraining portland (0.460)	230	340	488
Other (to flow of 110 ± 5)	...	...	...

10.2 *Preparation of Mortar:*

10.2.1 Mechanically mix in accordance with the procedure given in Practice C305.

10.3 *Determination of Flow:*

10.3.1 Determine flow in accordance with procedure given in Test Method C1437.

10.3.2 For portland and air-entraining portland cements, merely record the flow.

10.3.3 In the case of cements other than portland or air-entraining portland cements, make trial mortars with varying percentages of water until the specified flow is obtained. Make each trial with fresh mortar.

10.3.4 Immediately following completion of the flow test, return the mortar from the flow table to the mixing bowl. Quickly scrape the bowl sides and transfer into the batch the mortar that may have collected on the side of the bowl and then remix the entire batch 15 s at medium speed. Upon completion of mixing, the mixing paddle shall be shaken to remove excess mortar into the mixing bowl.

10.3.5 When a duplicate batch is to be made immediately for additional specimens, the flow test may be omitted and the mortar allowed to stand in the mixing bowl 90 s without covering. During the last 15 s of this interval, quickly scrape the bowl sides and transfer into the batch the mortar that may have collected on the side of the bowl. Then remix for 15 s at medium speed.

10.4 *Molding Test Specimens:*

10.4.1 Complete the consolidation of the mortar in the molds either by hand tamping or by a qualified alternative method. Alternative methods include but are not limited to the use of a vibrating table or mechanical devices.

10.4.2 *Hand Tamping*—Start molding the specimens within a total elapsed time of not more than 2 min and 30 s after completion of the original mixing of the mortar batch. Place a layer of mortar about 1 in. or [25 mm] (approximately one half of the depth of the mold) in all of the cube compartments. Tamp the mortar in each cube compartment 32 times in about 10 s in 4 rounds, each round to be at right angles to the other and consisting of eight adjoining strokes over the surface of the specimen, as illustrated in Fig. 1. The tamping pressure shall be just sufficient to ensure uniform filling of the molds. The 4 rounds of tamping (32 strokes) of the mortar shall be completed in one cube before going to the next. When the tamping of the first layer in all of the cube compartments is completed, fill the compartments with the remaining mortar and then tamp as specified for the first layer. During tamping of the second layer, bring in the mortar forced out onto the tops of the molds after each round of tamping by means of the gloved fingers and the tamper upon completion of each round and before starting the next round of tamping. On completion of the tamping, the tops of all cubes should extend slightly above the tops of the molds. Bring in the mortar that has been forced out onto the tops of the molds with a trowel and smooth off the cubes by drawing the flat side of the trowel (with the leading edge slightly raised) once across the top of each cube at right angles to the length of the mold. Then, for the purpose of leveling the mortar and making the mortar that protrudes above the top of the mold of more uniform thickness, draw the flat side of the trowel (with the leading edge slightly raised) lightly once along the length of the mold. Cut off the mortar to a plane surface flush with the top of the mold by drawing the straight edge of the trowel (held nearly perpendicular to the mold) with a sawing motion over the length of the mold.

10.4.3 *Alternative Methods*—Any consolidation method may be used that meets the qualification requirements of this section. The consolidation method consists of a specific procedure, equipment and consolidation device, as selected and used in a consistent manner by a specific laboratory. The mortar batch size of the method may be modified to accommodate the apparatus, provided the proportions maintain the same ratios as given in 10.1.2.

10.4.3.1 Separate qualifications are required for the following classifications:

Class A, *Non-air entrained cements*—for use in concrete, such as sold under Specifications C150, C595, and C1157.

Class B, *Air-entrained cements*—for use in concrete, such as sold under Specifications C150, C595, and C1157.

Class C, *Masonry, Mortar and Stucco Cements*—such as sold under Specifications C91, C1328, and C1329.

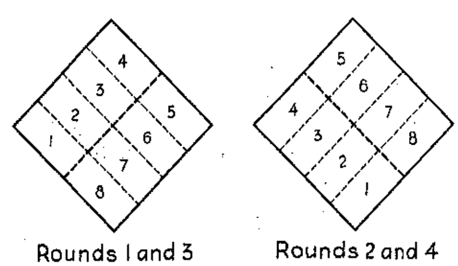

FIG. 1 Order of Tamping in Molding of Test Specimens

10.4.3.2 An alternative method may only be used to test the cement types as given in 10.4.3.1 above, for which it has been qualified.

10.4.3.3 It can also be used for Strength Activity Index determinations for fly ash and slag, such as sold under Specifications C618 and C989, provided the alternative method has qualified for both Class A and Class C cements.

10.4.4 *Qualification Procedure*—Contact CCRL to purchase cement samples that have been used in the Proficiency Sample Program (PSP). Four samples (5 Kg each) of the class to be qualified will be required to complete a single qualification (See Note 7).

10.4.4.1 In one day, prepare replicate 6-cube or 9-cube batches using one of the cements and cast a minimum of 36 cubes. Complete one round of tests on each cement on different days. Store and test all specimens as prescribed in the sections below. Test all cubes at the age of 7-days.

10.4.4.2 Tabulate the compressive strength data and complete the mathematical analyses as instructed in Annex A1.

10.4.5 *Requalification of the Alternate Compaction Method:*

10.4.5.1 Requalification of the method shall be required if any of the following occur:

(1) Evidence that the method may not be providing data in accordance with the requirements of Table 2.

(2) Results that differ from the reported final average of a CCRL-PSP sample with a rating of 3 or less.

(3) Results that differ from the accepted value of a known reference sample with established strength values by more than twice the multi-laboratory 1s % values of Table 2.

Before starting the requalification procedure, evaluate all aspects of cube fabrication and testing process to determine if the offending result is due to some systematic error or just an occasional random event.

10.4.5.2 If the compaction equipment is replaced, significantly modified, repaired, or has been recalibrated, requalify the equipment in accordance with 10.4.4.

NOTE 7—It is recommended that a large homogenous sample of cement be prepared at the time of qualification for use as a secondary standard and for method evaluation. Frequent testing of this sample will give early warning of any changes in the performance of the apparatus.

10.5 *Storage of Test Specimens*—Immediately upon completion of molding, place the test specimens in the moist closet or moist room. Keep all test specimens, immediately after molding, in the molds on the base plates in the moist closet or moist room from 20 to 72 h with their upper surfaces exposed to the moist air but protected from dripping water. If the specimens are removed from the molds before 24 h, keep them on the shelves of the moist closet or moist room until they are 24-h old, and then immerse the specimens, except those for the 24-h test, in saturated lime water in storage tanks constructed of noncorroding materials. Keep the storage water clean by changing as required.

TABLE 2 Precision

	Test Age, days	Coefficient of Variation, 1s %[A]	Acceptable Range of Test Results, d2s %[A]
Portland Cements			
Constant water-cement ratio:			
Single laboratory	1	3.1	8.7
	3	3.9	10.9
	7	3.9	10.9
	28	3.8	10.6
Average	...	3.7	10.4
Multiple laboratories	1	7.3	20.4
	3	6.8	19.0
	7	6.6	18.5
	28	6.5	18.2
Average	...	6.6	18.5
Blended Cements			
Constant flow mortar:			
Single laboratory	3	4.0	11.3
	7	3.8	10.7
	28	3.4	9.6
Average	...	3.8	10.7
Multiple laboratories	3	7.8	22.1
	7	7.6	21.5
	28	7.4	20.9
Average	...	7.6	21.5
Masonry Cements			
Constant flow mortar:			
Single laboratory	7	7.9	22.3
	28	7.5	21.2
Average	...	7.7	21.8
Multiple laboratories	7	11.8	33.4
	28	12.0	33.9
Average	...	11.9	33.7

[A] These numbers represent, respectively, the (1*s* %) and (*d*2*s* %) limits as described in Practice C670.

10.6 *Determination of Compressive Strength:*

10.6.1 Test the specimens immediately after their removal from the moist closet in the case of 24-h specimens, and from storage water in the case of all other specimens. All test specimens for a given test age shall be broken within the permissible tolerance prescribed as follows:

Test Age	Permissible Tolerance
24 h	±½ h
3 days	±1 h
7 days	±3 h
28 days	±12 h

If more than one specimen at a time is removed from the moist closet for the 24-h tests, keep these specimens covered with a damp cloth until time of testing. If more than one specimen at a time is removed from the storage water for testing, keep these specimens in water at a temperature of 73.5 ± 3.5 °F or [23 ± 2 °C] and of sufficient depth to completely immerse each specimen until time of testing.

10.6.2 Wipe each specimen to a surface-dry condition, and remove any loose sand grains or incrustations from the faces that will be in contact with the bearing blocks of the testing machine. Check these faces by applying a straightedge (Note 8). If there is appreciable curvature, grind the face or faces to plane surfaces or discard the specimen. A periodic check of the cross-sectional area of the specimens should be made.

NOTE 8—*Specimen Faces*—Results much lower than the true strength will be obtained by loading faces of the cube specimen that are not truly plane surfaces. Therefore, it is essential that specimen molds be kept scrupulously clean, as otherwise, large irregularities in the surfaces will occur. Instruments for cleaning molds should always be softer than the metal in the molds to prevent wear. In case grinding specimen faces is necessary, it can be accomplished best by rubbing the specimen on a sheet of fine emery paper or cloth glued to a plane surface, using only a moderate pressure. Such grinding is tedious for more than a few thousandths of an inch (hundredths of a millimetre); where more than this is found necessary, it is recommended that the specimen be discarded.

10.6.3 Apply the load to specimen faces that were in contact with the true plane surfaces of the mold. Carefully place the specimen in the testing machine below the center of the upper bearing block. Prior to the testing of each cube, it shall be ascertained that the spherically seated block is free to tilt. Use no cushioning or bedding materials. Bring the spherically seated block into uniform contact with the surface of the specimen. Apply the load rate at a relative rate of movement between the upper and lower platens corresponding to a loading on the specimen with the range of 200 to 400 lbs/s [900 to 1800 N/s]. Obtain this designated rate of movement of the platen during the first half of the anticipated maximum load and make no adjustment in the rate of movement of the platen in the latter half of the loading especially while the cube is yielding before failure.

NOTE 9—It is advisable to apply only a very light coating of a good quality, light mineral oil to the spherical seat of the upper platen.

11. Calculation

11.1 Record the total maximum load indicated by the testing machine, and calculate the compressive strength as follows:

$$fm = P/A \quad (1)$$

where:

fm = compressive strength in psi or [MPa],
P = total maximum load in lbf or [N], and
A = area of loaded surface in^2 or [mm^2].

Either 2-in. or [50-mm] cube specimens may be used for the determination of compressive strength, whether inch-pound or SI units are used. However, consistent units for load and area must be used to calculate strength in the units selected. If the cross-sectional area of a specimen varies more than 1.5 % from the nominal, use the actual area for the calculation of the compressive strength. The compressive strength of all acceptable test specimens (see Section 12) made from the same sample and tested at the same period shall be averaged and reported to the nearest 10 psi [0.1 MPa].

12. Report

12.1 Report the flow to the nearest 1 % and the water used to the nearest 0.1 %. Average compressive strength of all specimens from the same sample shall be reported to the nearest 10 psi [0.1 MPa].

13. Faulty Specimens and Retests

13.1 In determining the compressive strength, do not consider specimens that are manifestly faulty.

13.2 The maximum permissible range between specimens from the same mortar batch, at the same test age is 8.7 % of the average when three cubes represent a test age and 7.6 % when two cubes represent a test age (Note 10).

NOTE 10—The probability of exceeding these ranges is 1 in 100 when the within-batch coefficient of variation is 2.1 %. The 2.1 % is an average for laboratories participating in the portland cement and masonry cement reference sample programs of the Cement and Concrete Reference Laboratory.

13.3 If the range of three specimens exceeds the maximum in 13.2, discard the result which differs most from the average and check the range of the remaining two specimens. Make a retest of the sample if less than two specimens remain after disgarding faulty specimens or disgarding tests that fail to comply with the maximum permissible range of two specimens.

NOTE 11—Reliable strength results depend upon careful observance of all of the specified requirements and procedures. Erratic results at a given test period indicate that some of the requirements and procedures have not been carefully observed; for example, those covering the testing of the specimens as prescribed in 10.6.2 and 10.6.3. Improper centering of specimens resulting in oblique fractures or lateral movement of one of the heads of the testing machine during loading will cause lower strength results.

14. Precision and Bias

14.1 *Precision*[4]—The precision statements for this test method are listed in Table 2 and are based on results from the Cement and Concrete Reference Laboratory Reference Sample Program (see Note 12). They are developed from data where a test result is the average of compressive strength tests of three

[4] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:C01-1011.

cubes molded from a single batch of mortar and tested at the same age (see Note 13).

NOTE 12—Only the precision values for constant water-cement ratio portland cements were revised in this version of Test Method C109/C109M. The precision values for blended cements and masonry cements are unchanged from the previous version.

NOTE 13—A significant change in precision would not be anticipated when a test result is the average of two cubes rather than three.

14.2 These precision statements are applicable to mortars made with cements mixed and tested at the ages as noted (see Note 14).

NOTE 14—The appropriate limits are likely somewhat larger for tests at younger ages and slightly smaller for tests at older ages.

14.3 *Bias*—The procedure in this test method has no bias because the value of compressive strength is defined in terms of the test method.

15. Keywords

15.1 compressive strength; hydraulic cement mortar; hydraulic cement strength; mortar strength; strength

ANNEX

(Mandatory Information)

A1. ANALYSES OF TEST RESULTS FOR QUALIFICATION OF ALTERNATE COMPACTION METHODS

A1.1 *Calculation of Average Within-Batch Standard Deviation and Elimination of Outliers*—Tabulate the results for each cement sample (or round) in separate spreadsheets. In the spreadsheet, list results of each batch in columns and complete the calculations as shown in Table A1.1.

A1.1.1 Eliminate any outliers from the test data and repeat the calculations until none of the values lie outside the normal range.

A1.1.2 Tabulate the cube strengths with all the outliers eliminated and complete the calculations as shown in Table A1.2.

A1.2 *Summary of Results*—Compile the results of the four rounds and complete the calculations as shown in Table A1.3. The number of outliers shall not exceed 5 % of the total number of tests when rounded to the nearest whole number (for example, 4 rounds × 4 batches × 9 cubes = 144 tests × (5%/100) = 7.2 or 7).

A1.3 *Precision Qualification* —Calculate the relative within batch error (RWBE %) as shown in Table A1.3. This value must be less than 2.1 % to comply with the limit established in Note 10 of this specification.

A1.4 *Bias Qualification*—The test results compiled in Table A1.3 are evaluated against three limits to demonstrate an acceptable qualification. The limits have been established statistically from analyses of historical CCRL data and are given in Table A1.4.

A1.5 *Rationale for the Limits Given in* A1.4:

A1.5.1 The multi-laboratory precision (1s%) for the average of n batches is given by:

$$s\%_{ML,n} = \sqrt{s\%_{ML}^2 - \left(1 - \frac{1}{n}\right)s\%_{SO}^2}$$

A1.5.2 The limit for deviation of the individual rounds (no failures being allowed when 4 rounds are performed) is 1.2 $s\%_{ML,n}$, as used in Test Methods C114.

A1.5.3 The multi-laboratory precision (1s%) for the mean of 4 rounds is 0.5 $s\%_{ML,n}$.

A1.5.4 The limit for deviation of the mean of 4 rounds (95 % confidence) is 1.96 times this, or 0.98 $s\%_{ML,n}$.

A1.5.5 The values for $s\%_{ML}$ and $s\%_{SO}$ for Cement Classes A and C (non-air-entrained cements for concrete and cements for mortar respectively) are the 7-day values in the current precision statement of Test Method C109/C109M. There appears to be no data for Cement Class B (air-entrained cements for concrete). Working on the assumption that the value of this quantity is related to the air content, the values adopted for Class B are the mean of the A- and C-values.

A1.5.6 For the applicable conditions, the equations above give the following:

Derivation of Limits for Table A1.4						
Cement Class	A	B	C	A	B	C
Batches per Round (n)	6	6	6	4	4	4
Single Operator s% (single batch)	3.6	5.75	7.9	3.6	5.75	7.9
Multi-Laboratory s% (single batch)	6.4	9.1	11.8	6.4	9.1	11.8
Multi-Laboratory s% (n batches)	5.5	7.4	9.3	5.6	7.6	9.6
Limit for deviation of a single round %	6.6	8.9	11.2	6.7	9.1	11.5
Limit for deviation of mean of four rounds %	5.4	7.3	9.2	5.5	7.5	9.4

TABLE A1.1 Example Using 9 Cube Batch

Round – 2
CCRL Sample # 140 Industry Average Strength, X_I = 32.923
Cast Date – 00/00/00

	7-Day Strengths, MPa			
A	B	C	D	E
Batch No.	1	2	3	4
Cube 1	33.0	34.3	34.4	33.2
Cube 2	33.9	32.5	34.0	34.0
Cube 3	33.4	34.0	34.1	33.8
Cube 4	33.1	33.8	34.0	33.8
Cube 5	33.0	33.4	34.2	34.0
Cube 6	32.8	33.7	31.8	33.1
Cube 7	33.6	32.6	33.9	32.8
Cube 8	31.5	32.1	33.0	33.3
Cube 9	33.6	34.3	33.4	34.4
Average, X_b	33.10	33.42	33.65	33.60
SD_b	0.70	0.82	0.81	0.52
N_b	9	9	9	9
$(N_b-1)SD_b^2$	3.936	5.432	5.265	2.145
			N_r	36
			X_r	33.44
			SD_r	0.692
			MND	1.703
Normal Range				
Max	34.81	35.12	35.35	35.30
Min	31.40	31.71	32.95	31.89
Outliers	None	None	Cube 6	None

where:

X_I = industry average strength (CCRL),
X_b = average of tests values in a single batch,
SD_b = standard deviation of a single batch

$$= \sqrt{\frac{\sum_{Cube} (X - X_b)^2}{N_b - 1}}$$

N_b = number of tests per batch,
$(N_b-1)SD_b^2$ = an intermediate calculation,
N_r = total number of tests per round,
X_r = grand average of tests values obtained per round, MPa,
SD_r = mean standard deviation of round

$$= \sqrt{\frac{\sum_{Batch} [(N_b - 1)SD_b^2]}{N_r - 1}}$$

MND = maximum normal deviation: use Excel® function "=norminv(1−0.25/N_r,0,SD_r)" or equivalent, or use statistical tables to find the inverse integrated normal distribution for an integral value of (1−0.25/n_r) in a normal distribution with $\sigma = SD_r$.

Normal Range:
Maximum = (X_b + MND).
Minimum = (X_b – MND).
Outlier = any test value falling outside the calculated normal range.

TABLE A1.2 Test Data After the Elimination of Outliers (Example Using 9 Cube Batch)

Round – 2
CCRL Sample # 140 Industry Average Strength, X_I = 32.923
Cast Date – 00/00/00 Raw Cube Data:

	7-Day Strengths, MPa			
A	B	C	D	E
Batch No.	1	2	3	4
Cube 1	33.0	34.3	34.4	33.2
Cube 2	33.9	32.5	34.0	34.0
Cube 3	33.4	34.0	34.1	33.8
Cube 4	33.1	33.8	34.0	33.8
Cube 5	33.0	33.4	34.2	34.0
Cube 6	32.8	33.7		33.1
Cube 7	33.6	32.6	33.9	32.8
Cube 8		32.1	33.0	33.3
Cube 9	33.6	34.3	33.4	34.4
Average, X_{bv}	33.29	33.42	33.89	33.60
SD_{bv}	0.39	0.82	0.46	0.52
N_{bv}	8	9	8	9
$(N_{bv}-1)SD_{bv}^2$	1.092	5.348	1.462	2.159
			N_{rv}	34
			X_{rv}	33.55
			X_I	32.92
			SD_{rv}	0.55
			E_r, MPa	0.63
			RE_r, %	1.91

where:

X_{bv} = average of valid test values obtained per batch, MPa,
X_I = industry average strength (CCRL), MPa,
SD_{bv} =

$$\sqrt{\frac{\sum_{ValidCube} (X - X_{bv})^2}{N_{bv} - 1}}$$

N_{bv} = number of valid tests per batch,
$(N_{bv}-1)SD_{bv}^2$ = an intermediate calculation,
N_{rv} = total number of valid tests of the round,
X_{rv} = grand average of valid tests for the round, MPa,
SD_{rv} = mean standard deviation of the round

$$= \sqrt{\frac{\sum_{Batch} [(N_{bv} - 1)SD_{bv}^2]}{N_{rv} - 1}}$$

E_r = error = ($X_I - X_{rv}$), MPa, and
RE_r = relative error for the round, % = 100(E_r/X_{rv}).

TABLE A1.3 Summary of Results

A	B CCRL #	C Day	D X_i, MPa	E X_{rv}, MPa	F RE_r, %	G N_{rv}	H SD_r	I $(N_r-1)SD_r^2$
Round 1	139	1	28.47	30.42	6.85	36	0.97	32.93
Round 2	140	2	32.92	33.55	1.91	34	0.55	9.98
Round 3	141	3	32.64	33.14	1.53	34	0.47	7.29
Round 4	142	4	32.24	33.01	2.39	36	0.51	9.10
						Max, RE_r, %		6.85
						Mean, RE_r, %		3.17
						GMWBE, MPa		0.65
						RWBE, %		2.01
						Max RWBE, %[A]		2.1
						Precision Test		Pass

where:

X_r = industry average strength, MPa,

X_{rv} = grand mean value of the valid tests of a round,

RE_{rv}, % = relative error = $100(X_i - X_{rv})$,

N_{rv} = total number of valid tests of the round,

SD_{rv} = mean standard deviation of a round

$$= \sqrt{\frac{\sum_{Batch}[(N_{bv}-1)SD_{rv}^2]}{N_{rv}-1}}$$

$(N_r-1)SD_r^2$ = intermediate calculation,

X_g = grand mean value of all valid tests (4 rounds),

N_g = total number of valid tests in 4 rounds,

$GMWBE$ = grand mean within-batch error, MPa

$$= \sqrt{\frac{\sum_{Round}[(N_{rv}-1)SD_{rv}^2]}{N_g-1}}$$

$RWBE$ = relative within batch error, % = $100(GMWBE / X_g)$, and

$Max\ RWBE$ = maximum allowed RWBE = 2.10 % (See Note 10).

[A] See Note 9.

TABLE A1.4 Bias Qualification Requirements

	6 Cube Batches (Min 6 Batches per Round)			9 Cube Batches (Min 4 Batches per Round)		
Cement Classification (see 10.4.3.1)	A	B	C	A	B	C
Max allowable relative error any 4 or 6 batches, MAREr %	6.6	8.9	11.2	6.7	9.1	11.5
Max allowable relative error mean of 4 rounds of 4 or 6 batches <5 % failures, GRE%	5.4	7.3	9.2	5.5	7.5	9.4
Minimum allowable confidence limit, % MACL %	95	95	95	95	95	95

TABLE A1.5 Bias Tests
(Example Using 9-Cube Batches, Class A Cement)

MREr %, the maximum relative error value of the four rounds	6.85
MAREr %, max allowable MREr from Table A1.4	6.7
	Fails
GRE %, the average REr % of the four rounds	3.13
Maximum limit of MGREg % from Table A1.4	5.5
	Pass
Bias confidence limit, CL %	96.99
Minimum allowable confidence limit, MACL % (from Table A1.4)	95
	Pass
The above results indicate the data fails to show compliance.	

where:

MREr, % = the maximum relative error, % obtained for any round (from values in column F, Table A1.3),
MAREr, % = the maximum allowable relative error, % of any Round (Table A1.4),
GRE, % = the grand average of the REr, % values of the four rounds,
MAREg, % = maximum allowed GRE, % value (average of column F, Table A1.3), and
CL, % = bias confidence limit, %; the confidence with which it can be stated that the error of the mean of 4 rounds is non-zero. Calculate this by use of Excel® function "=ttest(<range of industry means>,<range of values obtained>,1,1)" or equivalent, or use statistical tables to find the confidence in a one-tailed, paired-value t-test on the set of round errors.

NOTE 1—The qualification method fails for bias if *(1)* the MREr exceeds the MAREr, % limit; or if *(2)* the GRE, % exceeds the MGREg limit and the CL, % exceeds 95 %.

SUMMARY OF CHANGES

Committee C01 has identified the location of selected changes to this standard since the last issue (C109/C109M – 12) that may impact the use of this standard. (Approved Oct. 1, 2013)

(1) Revised 10.1.2 to include requirements for twelve test specimens.

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