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TNW2002-03

Research Project Agreement No. 922927, Task 1, 2000-2001
Adaptations for Workshops NW Training Alliance

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Adaptation of Workshops for TransNow, OSU and TRANSPEED

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by
Katharine Hunter-Zaworski

and

Robert D. Layton
Transportation Research Institute
Oregon State University

Report prepared for:

Transportation Northwest (TransNow)

Department of Civil Engineering

129 More Hall

University of Washington, Box 352700

Seattle, WA 98195-2700

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16. ABSTRACT

The overall goal of this project is to develop Web-based learning materials in transportation engineering for graduate, undergraduate, and life-long learning environments. These materials enhance and augment workshop and course materials that are currently taught by Oregon State University and TRANSPEED. The workshops, training, and education programs include materials that are specific to standards and practices for states in the Northwest. The specific objective includes developing web-based materials to supplement courses and workshops on the new Highway Capacity Manual 2000.

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Introduction

The overall goal of this project is to develop Web based learning materials in transportation engineering for graduate, undergraduate and life long learning environments. These materials enhance and augment workshop and course materials that are currently taught by Oregon State University and TRANSPEED. The workshops, training and education programs include materials that are specific to standards and practices for states in the Northwest. The specific objective includes developing web-based materials to supplement courses and workshops on the new Highway Capacity Manual 2000.

There is a need for participants of workshops and short courses to have an opportunity to preview, synthesize, apply and integrate the knowledge. Typically the workshops and short courses provide intensive learning experiences that may not be conducive for long term retention or application of the materials and knowledge presented. The use of additional web based enhancements of the course materials provides an opportunity to help the workshop participants gain full advantage of learning. Web based teaching (WBT) allows life long learners to study at their own pace, and at remote locations. The convenience for a larger base of students counter balances the costs involved in developing and delivering these educational resources. The availability of knowledge that is packaged electronically is likely to increase the number of participants in life long learning opportunities. Life long learners are able to participate in courses at their own pace, at remote locations and on their own schedule. In addition, most WBT tools provide on line assistance, and feedback that also enhances learning. Some of the guiding principles in the design of the web-based materials are summarized in the statement below.

"Web-based learning tasks should require students to construct meaning rather than repeat information they have read or heard. The instructor must assume the role of facilitator or coach and develop activities with advanced organizers, hyperlinks, and appropriate scaffolding to help students in their knowledge construction. This constructivist approach to teaching and learning, when applied in Web-based learning environments connects "content (knowledge), form (documents and activities), and thought processes (cognitive progressions and assistance)" (Giroux, Hotte, and Dao 1997, p. 3)." [1]

In web based learning the instructor becomes a facilitator to assist the learner in the understanding and synthesis of the information. In the psychological realm, this is referred to as a second order process. First order processing is simply memorization. The key in web based enhancements are to help the learner "construct meaning" and a deeper understanding of the concepts.

A review of the adult learning literature as it pertains to WBT indicates that there are many learning styles. The use of web based enhancements of materials presented in traditional workshop and short courses adapts to the variety of adult learning styles.

Report Organization

The report provides background material on the Highway Capacity Manual and the selection of this short course for the development of web-based teaching materials. There is a short discussion of the project activities, conclusions and recommendations.

Background

[1] Brown, B.L. ERIC Digest No. 218, Web Based Training, October 2000

The Highway Capacity Manual (HCM) is the recognized set of standard procedures used by transportation engineers and planners throughout the United States and the world to evaluate the capacity and level of service of highway facilities. Since the publication of the first HCM in 1950, the scope of the manual has broadened from freeways and signalized intersections to include multi-lane highways, unsignalized intersections, and public transportation. The Committee on Highway Capacity and Quality of Service (HCQS), the Transportation Research Board committee responsible for the development and maintenance of the manual, has also been responsive to the user community by increasing the depth and sophistication of the HCM, developing procedures that can evaluate more complex traffic operational problems and conditions. The HCM procedures can now account for such factors as:

- actuated control at signalized intersections,
- over-saturated conditions, requiring the use of demand profiles over multiple time periods and consideration of initial queues,
- the effect of two stage gap acceptance and flared right turn approaches at Two Way Stop Controlled (TWSC) intersections,
- more complex descriptions of platoon dispersion and vehicle arrival patterns at intersections,
- vehicle interactions at All Way Stop Controlled (AWSC) intersections using iterative computational procedures, and
- the need to apply HCM procedures to special conditions such as problems of access management.

While the inclusion of these computational procedures expands the breadth of problems that can be addressed by the HCM, the training requirements for and level of sophistication required of the user is greatly increased. The time needed in workshops to present this material continues to grow, due to its complexity and sophistication. Once a three day workshop was sufficient to cover the Highway Capacity Manual in depth. Today six days of workshop instruction leave gaps in concepts and procedures, assumptions and accepted practice.

Practicing engineers know the importance of continuing education and training in maintaining the high level of competence required to design, operate, and manage today's transportation systems. The HCM itself is not a training manual, but it does an excellent job in providing important background information for each facility chapter as well as computational examples through the use of sample problems. The HCM analysis has the broadest application in transportation spanning the spectrum from planning and policy to design and operations. The users of HCM methodologies and analysis involve many disciplines. Many of the people who use the Manual do not have a background in engineering, mathematics or traffic flow.

The Highway Capacity Software (HCS), available since the release of the 1985 HCM, greatly assists in the computations, but does not lessen the need for a trained user. It can in fact be argued that while the software simplifies the computations, it requires a greater degree of understanding of the procedures to ensure that they are applied and interpreted accurately. The Software provides a faithful reproduction of the methodologies in the HCM, however, the validity of assumptions, the quality of the inputs, the nature of inputs and the comprehension of the meaning of the outputs rests with the user. The software can be run very easily, and the required inputs introduced very readily. In fact, the simplicity of use of the HCS software misleads users into thinking that they are achieving sound analysis. The subtleties and

complexities of the methodology are not fully realized by many users because the software makes the analysis methodology appear straightforward consequently many users do not study the HCM in depth.

An example of the lack of comprehensive information or subtleties that exist in both the Highway Capacity Manual and the H.C. Software is the determination of composite grade effect. The passenger car equivalent for trucks is based on the speed of a "moving block" up a grade that is either a simple or composite grade. Therefore, the critical point on the grade is the location that gives the minimum speed, based on twelve speed –distance profiles from research. The percent grade and grade length with the same speed is the equivalent grade, and the basis of the passenger car equivalent. If these are positive or flat grades that allow the truck to accelerate back to 55 MPH or higher, the critical composite grade analysis is interrupted, and the previous grade location with the minimum speed is the critical point. Neither the Highway Capacity Manual nor the Highways Capacity Software discusses this anomaly, and they do not tell the user how to approach this situation.

There has been a major change in the HCM structure that treats concepts and methodologies in separate chapters. This tends to lead users into the "methodologies" chapters, without referring to the "concepts" chapters. Overall understanding is consequently diminished. The web based aids must provide the integration and comprehensive understanding that is lost by the separation of concepts and methodologies. In summary, there is clearly a need to develop education and training materials that are based on a rigorous understanding and faithful implementation of the HCM procedures.

While there were 15 and 20 years, respectively, between the first, second, and third editions of the HCM, there were two updates in 1994 and 1997. This increased frequency of revision reflects both the extent of recent highway capacity research and the loose-leaf nature of the 1985 edition. Results from NCHRP 3-55 indicate that with the publication of the HCM 2000, major changes can be expected every five years with minor annual updates. Clearly, the pace of change is not expected to decrease.

The sample problems, provided at the end of each facility chapter, are designed to illustrate various aspects of the computational procedures contained in the chapter. While the sample problems provide an important element of education and training, they are neither comprehensive nor are they designed with an underlying pedagogic foundation. Desirably, the problems should build from a basic understanding to the integration of more complex concepts and issues. In addition, discussions at the January 1997 meeting of the HCQS Committee illustrated the difficulty in maintaining the accuracy and content of the sample problems. Substantial time is required to determine the kinds of problems that should be included, the topics that should be covered, the aspects of the computational procedures that require illustration and discussion, and completion and checking of the sample problems themselves.

The development of training materials requires assumptions regarding users of the HCM, the purpose of the training materials, and the technology to be integrated into the materials. These assumptions, listed below, provide an important context for this project.

1. The HCM procedures are complex, in response to the needs of the user community.

2. Profiles developed from user surveys conducted through NCHRP 3-46, 3-55, 3-55(2) and 3-55(4) show that the typical user needs effective instruction in order to apply the procedures more accurately, with care, and in an appropriate manner.
3. Computer and video technologies are now widely available. The developers of the HCM 2000 assume that users will have access to computers with multimedia technology.
4. Instruction must not only describe the basics of how the procedures work, but must both illustrate the details of the procedures and give students the opportunity to apply them to specific case studies. Only through study of details and the chance to apply the procedures will users become effective in the application of the procedures.
5. Users must be given the opportunity to work through problems using the HCS while working through guided instruction.
6. Software modules developed for this guided instruction must be designed for easy modification and efficient maintainability, as technology and procedures are updated.
7. Materials must be designed so that instructors during on-site workshops or in the classroom can use them.
8. Live video of actual intersection operations and animation should be included to illustrate key points.

Project Discussion:

It has become very clear that the work initiated as part of the TransNow Project on the Adaptation of Workshop Materials is the first part of ongoing and continual efforts to develop and update web based materials that enhance workshops taught as part of a number of life long learning enterprises. It is also very apparent from the workshop agenda that the HCM workshop

class is very fast paced and many students have difficulty understanding, comprehending, and retaining the information. Clearly the more students are involved with the concepts and the procedures, the greater their level of understanding. Also, slowing the pace of presentation and working with the materials will allow the knowledge of the concepts and procedures to sink in. However, there is an extensive amount of material that needs to be presented, and this makes it difficult to slow down the pace of presentation. Pre-workshop preparation assists with comprehension and retention of materials. The supporting web based enhancements assist students to integrate and synthesize the course materials after the workshop as well. The work undertaken in this project has focused on the pre–short course preparation. The instructors for the HCM workshops offered by The University of Washington's TRANSPEED and the Oregon Transportation Research Institute have observed that many students retake the course several times. The students have indicated that they needed to retake the course in order to understand the material. In addition, the instructors have recommended that the students prepare for the workshops ahead of time, in order to improve their understanding of the material. A worthwhile and sufficient goal for a web based orientation program would be to bring all students forward to the same level of knowledge and background prior to starting a "live" workshop. There is a significant loss in time and effectiveness in attempting to instruct classes to students with disparate levels of background and understanding.

Several activities have been undertaken to address the pre-workshop preparation by students. A short course website has been developed and is hosted by TRANSPEED. Some of the material from the website is attached in Appendix A. This material includes course information and a schedule for the three day workshop. In addition, the introduction to a self assessment quiz and post quiz assignment that includes preparatory readings is also included.

Experience by providers of distance education have observed that one of the keys to successful distance education is a continuing relationship with the instructors, and this is even better if the instructor and student has had an opportunity for a face to face meeting. The instructors of the TRANSPEED HCM class have observed that they receive many questions after the course by e-mail and phone from participants in their workshops. (R.D. Layton, 2002).

Developments are underway to integrate a number of post course modules. These modules include worked examples and structured problems and are funded by a different program. In addition, links to materials that are being developed by others such as Dr. Michael Kyte at the National Institute for Advanced Transportation Technology (NIATT) at the University of Idaho will also be included.

The project is producing a set of web based enhancement materials that can be used to train transportation engineers and planners to apply the procedures of the HCM successfully. The primary assumption that guides the development of the web based materials except for the introductory module, self assessment quiz and post –quiz assignment is that the user will have previously attended a workshop, and will also have a complete set of the workshop notes and access to the current edition of the HCM. The web based materials are designed to assist with the understanding, retention, integration, and synthesis of the knowledge. The participants work independently at their own pace, on their own time and spatially distant from an instructor, however the instructors are available by email and phone to answer questions. The instructional materials provide the opportunity for the student to increase their understanding of the materials at his or her own pace. Sample problems, with complete descriptions, step-by-step solutions, and detailed explanations, in a consistent format illustrate each component of the methodology.

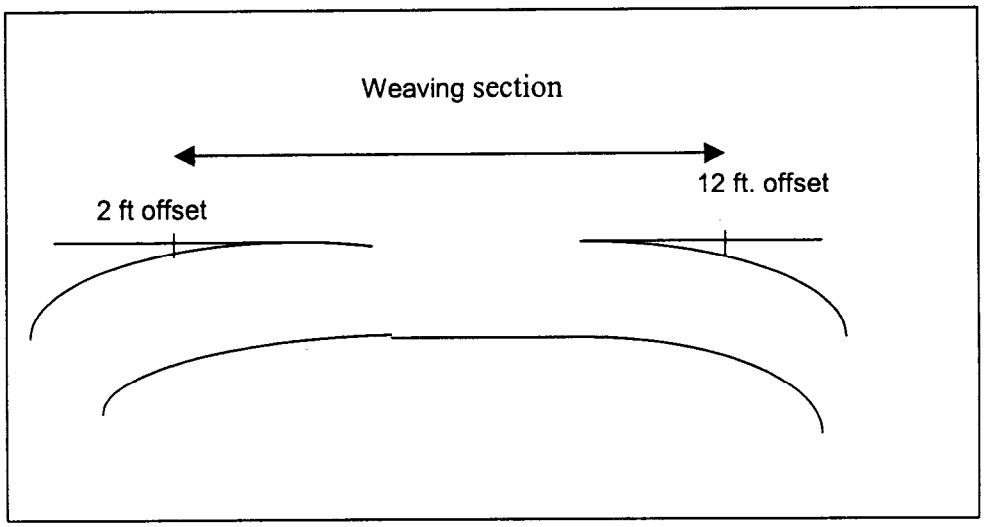
Web based problem sets and classroom problem sets are very different. In general the web based problems are very closed or deterministic unlike the classroom type problems that tend to be more open ended. In general, web based problems are decomposed into small solution steps with feedback provided at each step of the way. These problem sets are very labor intensive to prepare for a web based environment. Many of the post workshop problem sets and modules are being developed as part of another project and there fore have not been completed. These problem sets include an explanation of the procedure, and use graphics to illustrate the purpose and scope of the computational procedure, key computational elements, and output and results. Static graphics are used to illustrate key points. Video clips are also used to illustrate key points. The annotated problems with explanations of the proper procedure are an important part of the materials, but they also can demonstrate the proper approach and teach understanding by having "wrong" answers trigger additional explanations.

Sample problems that illustrate basic elements of the computational procedures have been developed. Methods to enter data that correspond with the HCM methodology including a summary of what data are needed are also included.

Video Clips

Weaving Sections have very complex operations with subtle interactions between driver behavior and geometrics. One video clip shows a short freeway weaving section that is operating at capacity. The operation at this site shows how the level of service (LOS) criteria that is based on density represents this condition very adequately. It also shows what happens in a weaving section as it breaks down, with vehicles attempting to "stretch" the weaving section by entering

early or exiting late. Severe conflicts, near "misses" and over saturated flow is observed in the lanes adjacent to the weaving section.



Video #2

A two lane two way section of highway of about one mile in length is shown with the platooning generated by a few large trucks. The average speed on the facility is about 50 MPH with a few 45 MPH stretches and about fifty percent of the roadway permitting safe passing. The roadway appears to operate at a high level of service with a number of long gaps. However, on evaluation of the number of vehicles in platoon and the speeds of operations, the calculated level of service of "E" being experienced can be readily recognized. The visual representations of the level of service concepts through this video are very useful in presenting what governs the level of service of two-lane two- way highways. The large gaps and low traffic volumes do not necessarily mean that a good level of performance exists, if those conditions are accompanied by

excessive platooning and low average speeds. The video clip shows this clearly, with the students being able to take some analytical measurements to determine the level of service present.

Conclusions:

The project includes the development of pre-workshop materials and post workshop problems. The pre-workshop materials address the need to develop materials for improving long term learning and retention of information presented at the workshops. The workshop instructors have identified the need for improvements in participant preparation before workshops as a key to improving understanding of workshop materials. The number of participants who retake the workshop has demonstrated the need for these enhancement materials. The pre-workshop assessment provides an indication to the participant of their readiness for the workshop and, in addition, suggests recommended readings prior to the workshop.

The second part of the project includes the development of the post workshop problem sets. These problem sets include illustrated sample problems as well as problems that are decomposed into small steps that provide continual feedback. In addition, all the web based enhancements include the opportunity for continual involvement with the course instructors. Much of the determination of effectiveness of these materials will come with time as they are used. Also, joint use of the web-based materials with the short course presentations will help guide further developments and enhancements.

As mentioned previously, web based problem sets are closed ended or deterministic rather than the more open ended or indeterminate type of problems encountered in live classroom

environment. The main reason is that web based instruction relies heavily on self directed and self motivated learning.

Recommendations

The project is part of an ongoing effort to develop web-based enhancements for short courses and workshops that provide support for increased understanding and retention of the presented material. There is a need for additional development and enhancements, that are living documents and adaptable to change. It is recommended that testing and evaluation of the enhancement materials be undertaken, to insure that the web-based materials are effective in improving the understanding and retention of the material that is presented. This work will be funded by other research and development projects.

An "outcomes assessment" of pre-course materials is needed. It is recommended that this be incorporated into the HCM workshops and shortcourses. The results of the self evaluation by short course participants will be used to modify the current web content. In addition, it is recommended that short course participants be engaged in helping to develop problems for use in post-short course problem sets.

References:

Brown, Bettina Lankard, "Web-Based Training. ERIC Digest No. 218. , October 2000

Giroux, S.; Hotte, R.; and Dao, K. "Adaptive and Agile Interactive Learning Environments on the WWW." In WEBNET 97 WORLD CONFERENCE OF THE WWW, INTERNET AND

INTRANET PROCEEDINGS, edited by S. Lobodzinski and I. Tomek. Charlottesville, VA: Association for the Advancement of Computing in Education, 1997. (ED 429 535)

Kruse Kevin, "Information is not Instruction", Learning Circuits, American Society for Training and Development, February 2000

Highway Capacity Manual, Special Report 209, Fourth Edition, Transportation Research Council, Washington, D.C., 2000

Highway Capacity Software, McTrans, University of Florida

Appendix A: Material Currently posted to Website

HCA021

Basic Highway Capacity Analysis

Home Page

View Announcements | How to use this website

Instructors' Information

ROBERT LAYTON

e-mail: robert.layton@orst.edu

Phone: (541) 737-4980

WAYNE KITTELSON

e-mail: wkittelson@kittelson.com

Phone: (503) 228-5230

Course Schedule

CLASS MEETING DATES:

HCA021: January 23-25, 2002 (Wednesday-Friday)

HCA022: June 11-13, 2002 (Tuesday-Thursday)

DAY ONE:

8:00 Introduction-Course Overview

9:15 Traffic Stream Characteristics

10:15 Break

10:30 Traffic Stream Characteristics (cont)

11:15 Introduction to Highway Capacity and Level of Service Concepts

11:45 Lunch

1:00 Basic Freeway Segments

2:15 Multi-Lane Highways

2:30 Break

2:45 Problem Set: Basic Freeway and Multi-Lane Segments

3:45 Unsignalized Intersection Capacity

4:45 Adjourn

DAY TWO:

8:00 Problems: Unsignalized Intersections

9:30 Break

9:45 Capacity of Two-Lane Two-Way Highways

10:45 Problems: Two Lane Two Way Highways

11:45 Lunch

1:00 Capacity for Ramp Junctions

2:00 Break

2:15 Problems: Ramp Junctions

3:00 Capacity of Signalized Intersections-Overview

3:45 Signalized Intersections-Planning Applications

4:45 Adjourn

DAY THREE:

8:00 Problems: Planning Applications

9:00 Critical Movement Analysis

9:45 Break

10:00 Problems: Critical Movement Analysis

10:45 Capacity of Arterial Streets

11:45 Lunch

1:00 Problems: Arterial Streets

2:00 Break

2:15 Capacity of Weaving Areas

3:30 Problems: Weaving Capacity

4:30 Evaluation and Adjourn

How to use this website

Purpose of this website

The multiple purposes of this website are:

- to provide introductory course information;
- to inform you of assignments to be completed PRIOR to the first class meeting;
- to provide a tool for you to assess your current knowledge of the topics to be covered in the course;
- to provide additional references to assist you in preparing for this course; and
- to provide a location for announcements pertaining to this course.

You may wish to "bookmark" this page until you have completed the course. Remember that you need a password to access this website. Note also that you do not have unlimited access to this site; the passwords are changed one week after the course ends.

Sidebar Navigation

You will access the web pages through the links on the "sidebar" (the left-hand column of this page). The following is a brief overview of those links.

HOME

You are at the Home page now. The word is highlighted in yellow in the sidebar and the cursor does not change when you move it over the word. It is not an active link while it is the current page. Go to ANNOUNCEMENTS at the bottom of this page to read any new developments concerning this course.

INTRODUCTORY MODULE

This link takes you to the page providing:

- the course description
- the course topics
- the learning expectations
- workplace applications of the knowledge learned
- and additional references

SELF-ASSESSMENT QUIZ

This link takes you to the page enabling you to assess your current knowledge. By working through the problems in the self-assessment quiz and comparing your answers to the solutions provided, you can evaluate which topics you already know and which topics you need to learn. Additional references are provided with the solutions to give you a headstart with the topics you still need to learn.

POST-QUIZ ASSIGNMENT

This link takes you to the page listing the assignments you should complete prior to the first class meeting.

COURSE EVALUATION

This link takes you to the page that allows you to evaluate the course content and instructor. We appreciate your taking the time to give us your evaluation. However, please do not submit your evaluation until after the course has finished.

EPP HOME PAGE

This link takes you to the Engineering Professional Programs home page.

TRANSPEED HOME PAGE

This link takes you to the TRANSPEED home page.

UW HOME PAGE

This link takes you to the University of Washington home page

Announcements

Course Announcements

There are no new announcements at this time

TRANSPEED Program Announcements

Introductory Module

Course Description

2.1 CEUs

This is the first of two courses in the TRANSPEED highway capacity series that combine to provide comprehensive insights into all aspects of capacity and level-of-service analyses for highway, transit, pedestrian, and bicycle facilities.

The purpose of this three-day course is to provide participants with a basic understanding of fundamental concepts underlying the analysis methods contained in the 2000 edition of the Highway Capacity Manual. Upon completion of the course, participants should be able to successfully undertake basic facility evaluations, and should also be able to appropriately review and interpret the results of analyses conducted by others. Each participant will work in a team to solve sample problems and will discuss solutions in a classroom setting. The course has been completely updated to reflect the contents of HCM2000, which is the most recent edition of the Highway Capacity Manual.

Who Should Attend

This course is appropriate for transportation planners, designers, administrators, policy makers and traffic engineering personnel who have not been formally introduced to highway capacity analysis techniques. It will also serve as a useful refresher to those who only apply highway capacity analysis techniques on an occasional basis. Those attending this course will benefit from the thorough review of fundamentals, information on the newest revisions to the Highway Capacity Manual, and the team problem solving workshop format.

Course Topics (Basic Knowledge to be Gained)

1. Traffic stream characteristics

2. Traffic flow theory
3. Traffic operations and level-of-service concepts
4. Basic freeway segments capacity analysis
5. Ramp junctions
6. Weaving sections
7. Multilane highway capacity analysis
8. Two-lane two-way highways
9. Transit facilities
10. Pedestrian and bicycle facilities
11. Urban streets
12. Signalized and unsignalized intersections

Learning Expectations

The participant will gain an understanding of traffic operations and methods to analyze highway capacity and operations. Specifically, the participant will be able to:

1. apply basic models of traffic operations;
2. analyze and evaluate capacity and level of service of freeway segments and multi-lane highways;
3. analyze operations and evaluate level of service of two-way stop controlled intersections, all-way stop controlled intersections and roundabouts;
4. analyze and evaluate levels of service and operations of two-lane two-way highways, including passing lanes and climbing lanes
5. analyze performance and evaluate level of service of signalized intersections;
6. analyze operations and quality of service at ramps and weaving sections;
7. evaluate level of service of urban streets.

Applications of Course Knowledge in the Workforce/Workplace/Practice

Highway capacity analysis is used to:

1. evaluate the level of service and operations of highway facilities;

2. analyze the nature of traffic control and to specify cycle time, green splits and phasing;
3. determine costs and benefits of highway improvements;
4. plan future highway facilities;
5. determine the design geometrics of highway facilities.

Examples of How/Where Course Knowledge is Applied in Practice

With this knowledge we can:

1. determine the number of lanes on a highway facility by direction to accommodate a given demand volume;
2. determine the impact that a quantity of trucks has on highway performance;
3. evaluate the effect of lane width, lateral clearance and/or grades on operations and level of service;
4. determine the signal timing of a signalized intersection;
5. determine the level of service and the expected queues that occur at unsignalized intersections;
6. determine the lane configuration and geometrics of a weaving section;
7. determine the number of lanes and ramp terminal configuration at on-ramp and off-ramp locations;
8. analyze the operations of two-way two-lane facilities to determine the level of service of an existing condition or the design geometrics for an improvement;
9. determine the justification and geometrics of a passing lane or climbing lane.

Pre-Test Questions

Highway Capacity

1. A traffic stream is carrying 4500 veh/hr in three lanes in one direction. What is the average headway per lane?

2. With the 4500 veh/hr in three lanes;
   a. What is the density per lane if the operating speed is 60 mi/hr?
   b. What is the spacing between vehicles in each lane for these conditions?

3. What is the capacity of a 4-lane freeway in one direction if the density at capacity is 45 veh/mi/lane, and the speed at capacity is 53 mi/hr?

4. A multi-lane highway is operating in a high mountain valley on a typical grade of about 1%, or grades representing level terrain conditions. It is carrying 10% trucks. The passenger car equivalent is 1.5 for level terrain, and 2.5 for rolling terrain and 4.0 for mountainous terrain. What is the heavy vehicle factor, f_{HV}, for this location?

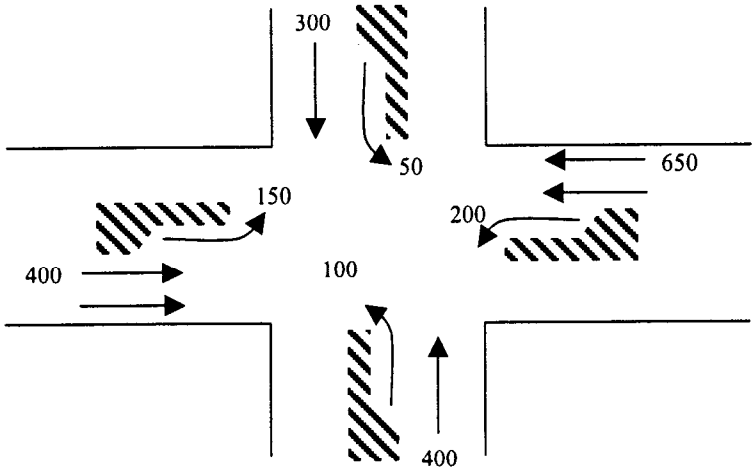
5. For a 6-lane freeway the operating speed is 57 mph and the demand volume is 4800 vph with a peak hour factor of 0.9. Assuming this is for the peak period on a commuter route when no trucks are present, what is the level of service based on the following criteria?

Level of Service	Density, $\frac{\text{pass. cars}}{\text{mile/lane}}$
A	10
B	18
C	25
D	35
E	≤45
F	>45

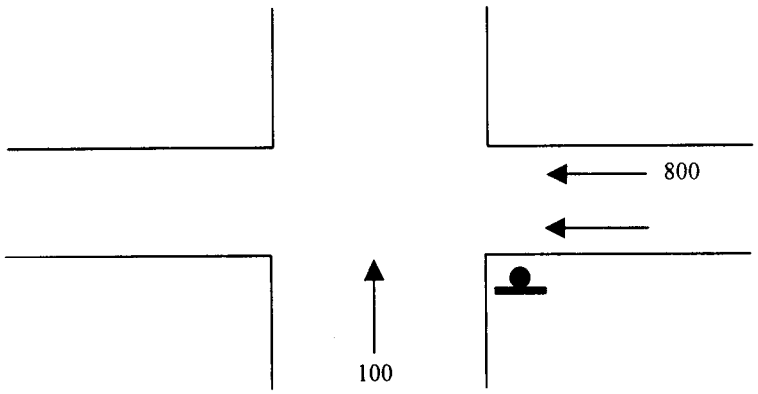
6. For the intersection shown below;

   a. What is the sum of the critical movements?

   b. Are those volumes likely to exceed the capacity of a signalized intersection?



7. A stop controlled intersection of one way streets carries 800 veh/hr/lane in 2-lanes on the major street and has a demand to cross the major street from the stop-controlled minor street of 100 vehicles. Assuming a critical gap of 6 seconds for entering vehicles, is it likely that the 100 vehicles could cross?



Questions under Development

1. The 2000 Highway Capacity Manual is a legal standard for planning, operating and designing highways.

   Yes

   No

2. The 2000 Highway Capacity Manual is 100% accurate.

   Yes

   No

3. A capacity at a location along a freeway is the most vehicles which have ever passed the location in one direction during one hour.

   Yes

   No

4. The capacity past a tow truck parked adjacent to a freeway lane would usually be less than the capacity when there is no tow truck present.

   Yes

   No

5. There was congestion along a freeway because of maintenance work. One lane was closed for several hours. The congestion was nonrecurring congestion.

Yes

No

6. Calculate the rate of flow as veh/hr where 140 vehicles pass a location during 15-minutes.

7. Calculate the volume to capacity ratio for the peak 15 minutes at a location along an urban freeway if the 1/4-hr volumes during the afternoon peak are 1500, 1850, 1800 and 1400 vehicles and the capacity is probably about 7600 vph.

8. The most traffic recorded during an hour along a rural highway where there are counts 24 hours per day every day of a year was 2688 vehicles. This would be the peak hour.

Yes

No

9. Volumes during 15-minute intervals of a peak hour were 750, 850, 800 and 700 vehicles. Calculate the peak hour factor.

10. Traffic conditions along a rural two-lane highway are excellent when the level of service is D.

Yes

No

11. For capacity calculations, a pickup truck with four tires is a truck.

Yes

No

12. One truck is equivalent to approximately two passenger cars along freeways on level terrain.

Yes

No

13. An intersection at a suburban area will be reconstructed. It would be appropriate to obtain traffic count data for design on a Monday during early January.

Yes

No

14. There is a 1-mile, +4% grade along a rural freeway. There is no existing congestion. The freeway must be widened. Truck speed data for level of service and capacity calculations could be obtained using radar.

Yes

No

15. A highway will be constructed from a valley to a summit. The first significant grade will be +6% for 3/4-mile. The speed of an average truck at the top of this grade would probably to approximately 26 mph.

Yes

No

16. Most recurrent freeway congestion is caused by traffic demand for all through lanes exceeding the capacity of the through lanes.

Yes

No

17. Typical capacities along urban freeways during commute peak periods are approximately 2250 to 2400 passenger cars per hours, but would be less measured as vehicles per hour due to the effect of trucks, when present.

Yes

No

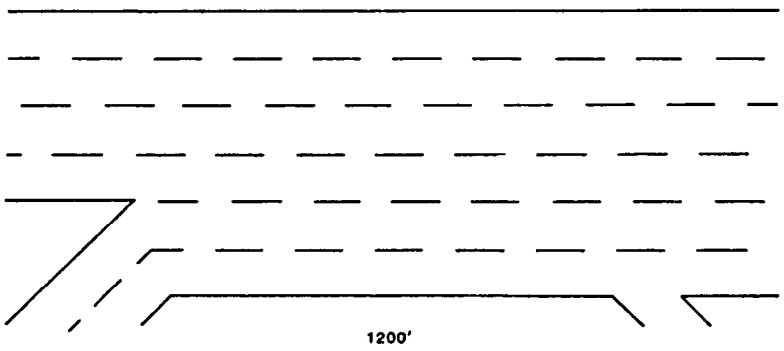
18. Five-minute counts were obtained immediately beyond a congested area along an urban freeway for three days. There were no incidents. The congestion lasted approximately 1-1/4 hours each day. The capacities for the three days were 5650 vph, 5700 vph, and 5675 vph. Calculate the approximate capacity.

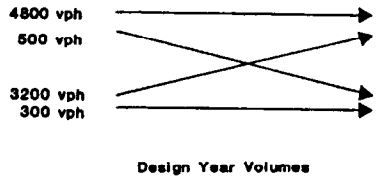
19. A freeway with three lanes per direction will be constructed at a city. There will be no

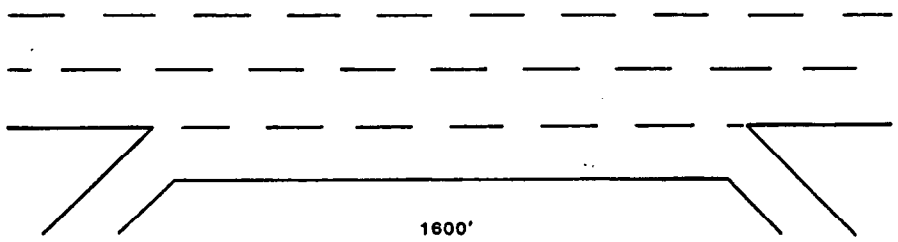
significant grades. The afternoon commute peak period volumes a year after construction will be approximately 2600 vph for one direction of travel. The peak hour factor will be approximately 0.85. There will probably be extensive recurrent congestion during most afternoon commute peak periods.

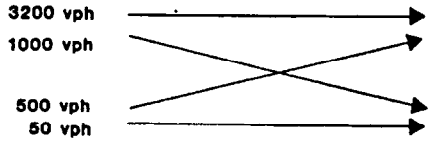
Yes

No









Design Year Volumes

20. There is a freeway with two lanes per direction at an urban area. Recurrent congestion occurs prior to and along most of a one-mile, +4% grade. The freeway will be widened. The capacity of the two lanes along the upgrade should be calculated using the 2000 Highway Capacity Manual procedures.

Yes

No

21. A freeway will be constructed at a rural, mountainous area. There will be two lanes per direction. There will be a three-mile, +5% grade. Peak periods will occur on weekends and holidays. Approximately 4% of the vehicles will be trucks during peak periods. Calculate the approximate capacity along the upgrade. Use an fp factor for population effects of 0.80.

22. There are many procedures that may be used to calculate approximate capacities at weaving areas.

Yes

No

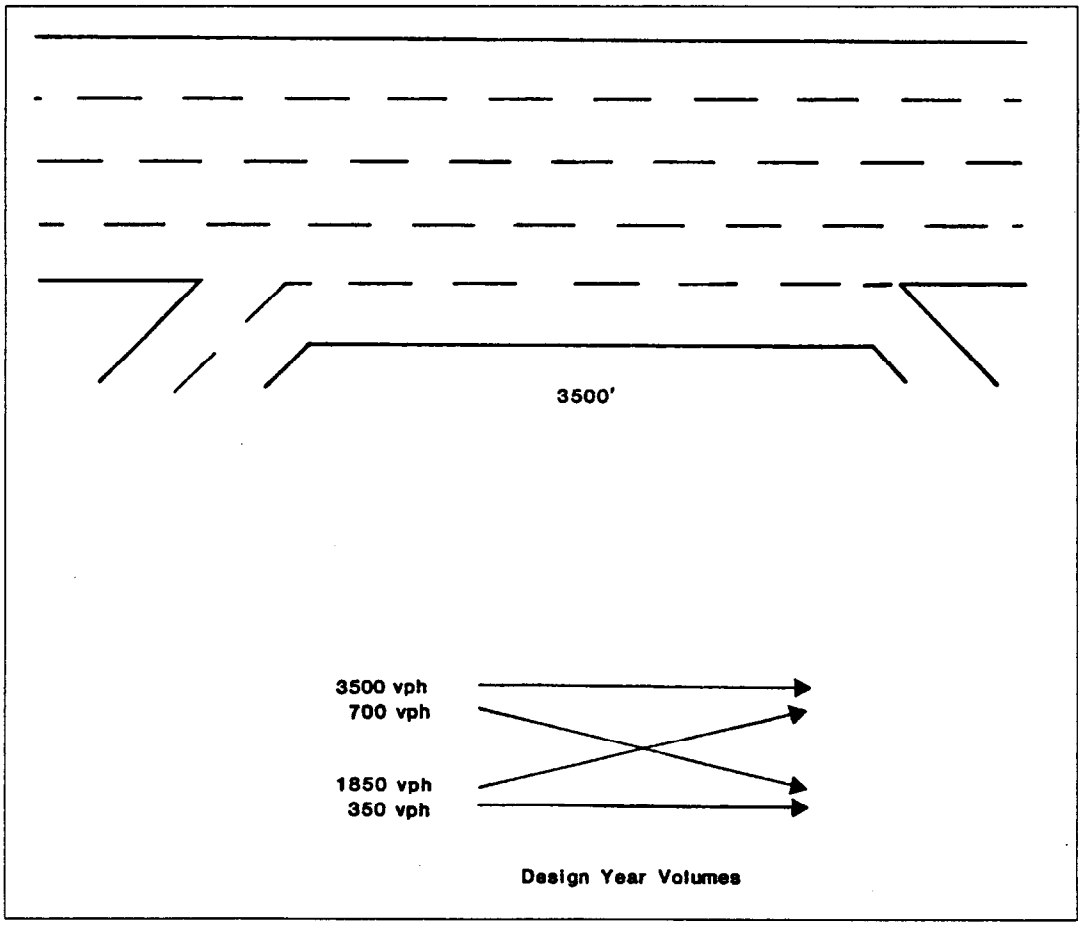
23. There is a freeway with four through-lanes per direction at an urban area. There are no significant grades. Approximately 3% of the vehicles are trucks during peak periods. Afternoon peak periods last approximately 3-1/2 hrs. A freeway-to-freeway interchange will be reconstructed. There will be a two-lane connector joining the four through-lanes, then five lanes for 3500 ft., and then a one-lane off-ramp. Refer to the sketch below. Volumes would probably not exceed the sign hourly volumes because of upstream geometric constraints along both freeways.

Use weaving capacity analysis. Do no use a peak hour factor. Use a factor on one truck equals two cars to change the vehicles per hour to passenger car equivalents per hour.

The design would be appropriate.

Yes

No


3500'
3500 vph
700 vph
1850 vph
350 vph
Design Year Volumes

24. A local interchange with a one-lane off-ramp may be constructed 1200-ft. beyond where a two-lane connector joins four through lanes along an urban highway. There are six lanes for almost one-mile beyond the merge. There is a sketch on the next page. There are no significant grades. Approximately 1% of the vehicles are trucks during afternoon peak periods. Peak periods last approximately three hours. The design hourly volumes would be about the most traffic that could get to the area.

    Use weaving capacity analysis. Use a passenger car equivalent of one truck equals two cars to change the vehicles per hour to passenger car equivalents per hour.

    This design would be appropriate.

    Yes

    No

25. A freeway with three lanes per direction will be constructed at a town. There will be no significant grades. Approximately 5% of the vehicles will be trucks during peak periods. Peak periods will probably last less than an hour. The peak hour factor will be approximately 0.80. There will be a one-lane on-ramp, an auxiliary lane, and a one-lane off-ramp 1600-ft. beyond the on-ramp. There will be no other ramps within 4000-ft. There is a sketch following.

    Use weaving capacity analysis to calculate if the design would be appropriate at LOS "C". Convert the design hour volume to a peak 15-minute flow rate by dividing the volumes by the PHF.

26. It is often appropriate in large urban areas when planning weaving areas to increase or decrease the design hour volumes for the through lanes to capacity volumes at rates of approximately 2000 vph, which could arrive at or leave the weaving area. It is also often appropriate at such urban areas to increase or decrease the design hour ramp volumes at weaving areas. It is occasionally appropriate to also adjust the design hour volumes when planning weaving areas at towns and at rural areas.

Yes

No

27. There is an urban freeway with four lanes per direction. The outer lane will be closed for pavement repair. The capacity of the other three lanes would likely be an average of about 1500 vph per lane.

Yes

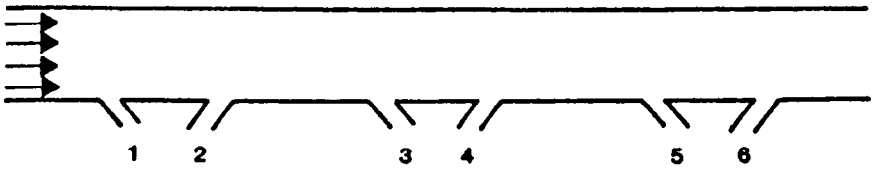
No

28. There is a freeway with two lanes per direction at a mountainous rural area where weekend and holiday peak periods occur. There is a four-mile +5% grade. Four percent of the vehicles are trucks during Saturday peak periods. One lane will be closed for pavement repair along two miles of the upgrade. Capacity would probably be about 1500 vph.

Yes

No

29. There is recurrent congestion from Ramp 1 to just beyond Ramp 6.

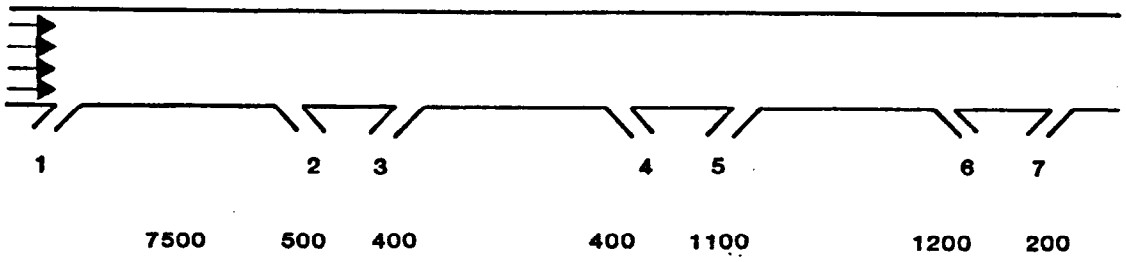


Widening the freeway from Ramp 2 to Ramp 5 would eliminate the congestion.

Yes

No

30. There is a freeway in an urban area where peak periods last approximately three hours. There are no significant grades. There are no parallel streets nearby. There is recurrent freeway congestion from near Ramp 3 to just beyond Ramp 5. Capacities average about 2000 per lane. An origin-destination survey was done.



Peak Traffic Demand Rates

Widening the freeway from Ramp 5 to Ramp 6 would probably initially eliminate significant recurrent congestion.

Yes

No

31. There are very accurate procedures that can be used to calculate capacities along rural two-lane highways.

Yes

No

32. There is a two-lane highway in a mountainous area beyond a valley. There are not many locations where passing can safely be done. The volume upgrade is 500 vph. At a location 15 miles from the valley, most of the vehicles would be rather evenly spaced at approximately 7-second intervals.

Yes

No

33. The 2000 Highway Capacity Manual's distance criteria for no passing zones for level of service and capacity calculations for two-lane highways is where the passing sight distance is 1500-ft or less.

Yes

No

34. There is a two-lane highway at a valley area. The pavement is 32-ft. wide except for a length of 25-ft. at a culvert where it is 28-ft. wide. If volumes at or near capacity were to occur, the critical location would probably be at the culvert.

Yes

No

35. The peak hour volume along a rural two-lane highway is 360 vph total of both directions. Approximately 1% of the vehicles are trucks and approximately 3% are recreational vehicles with six or more tires during peak periods. The directional distribution is 32-ft. wide. There are many obstructions adjacent to the shoulders. There are no passing zones along 95% of the distance. The design speed is 60 mph. The area is mountainous. However, there are no significant grades. The typical profile grade is only about 0.5%. The peak hour factor is 0.90.

    Calculate the level of service during the peak hour.

36. The AADT along a two-lane highway is 4000. The pavement is 40-ft. wide. There would usually be significant traffic operational problems.

    Yes

    No

37. There are many procedures for calculating the capacity of signalized intersections.

    Yes

    No

38. The 2000 Highway Capacity Manual's complex procedure for calculating levels of service at signalized intersections is generally accurate.

    Yes

    No

39. The best way to obtain delay data for an existing signalized intersection is to use the 2000 Highway Capacity Manual and calculate the delay.

Yes

No

40. Signal timing affects the amount of delay at signalized intersections.

Yes

No

41. At a signalized intersection, the level of service is F only when the traffic demand exceeds the capacity.

Yes

No

42. Using critical movement analysis, the sum of the critical volumes of 1450 vph is usually appropriate for the design of signalized intersections at suburban areas.

Yes

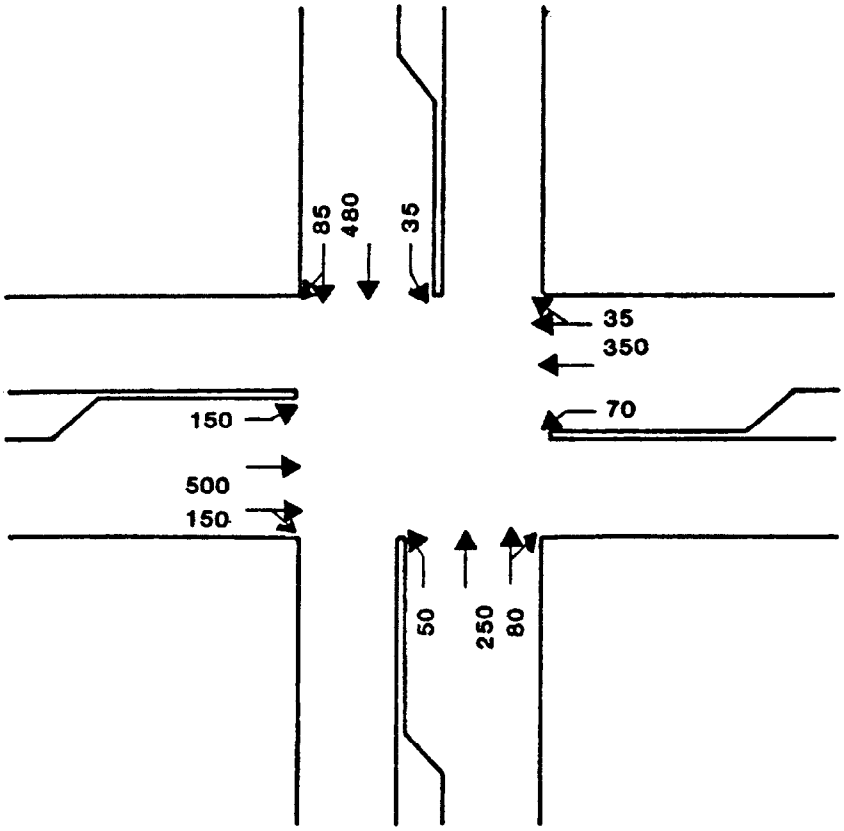
No

43. Peak hour factors or peak 15-minute rates should usually be used for the design of signalized intersections along most conventional state highways.

Yes

No

44. The rates on the following sketch are for the peak 15 minutes of a peak hour. The rates are the totals per direction for left-turning vehicles, through vehicles and right-turning vehicles. There are separate phases for all left-turn lanes. Calculate the sums of the critical volumes.


85
480
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