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Level II Evaluation

NATIONAL HIGHWAY INSTITUTE

AUTHORIZED INTERNATIONAL ASSOCIATION FOR CONTINUING EDUCATION AND TRAINING PROVIDER
IACET

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Introduction

The National Highway Institute (NHI) is committed to design, develop and deliver the best learning opportunities available for their Customers. From our Federal to the State, local and private customers, they can be sure that every effort was made to provide learning at the highest level possible. In order to do this, our approach is to design and develop the training for a Level II evaluation. This Level of evaluation goes beyond the immediate reaction to the training, but measure the actual learning that happened during.

This document is an attempt to describe the various levels of evaluation, define various types of Level II Evaluations and provide practical examples of each type.

Five Levels of Evaluation

The Five Levels of evaluation has been used since the late 1950s. Donald Kirkpatrick developed this very popular evaluation model to be used by the training community. The focus in on measuring four kinds of outcomes that should result from a highly effective training program. Then taking it one more level, while not included in Kirkpatrick's model, the need to measure the return on the organizations investment.

As adult learners, we derive our most valuable lessons from what we experience and do, not from what we're told. Exercises and activities can be developed that result in long-term retention and behavior change. Through a series of hands-on exercises, participants will not only have fun learning but the exercises can build retention and improve performance if developed correctly. Thus, evaluation is necessary to make sure all efforts are made to effectively advance learning.

The five levels of evaluation are discussed in more detail in the following pages.

Level I – Reaction

Level I evaluations focus on the participants' "reaction" to the planned event (e.g. training course). Another way to describe it would be: Level I evaluations measure customer satisfaction specifically to gain feedback on the instructor, course material and learning environment.

Evaluations provide quantitative information and are usually occur immediately upon completion of the planned event. Though Level I evaluations have limited value, they rely on the measurement of attitudes and gauge subjective reactions to the event. This level is inexpensive and easy to administer, but is not sufficient to measure the impact of the event. Rather, a Level I evaluation should be used in combination with other levels of evaluations, as described below.

Level II – Learning

Level II evaluations measure the participants' "learning" or achievement of the course objectives/outcomes. Level II evaluations measure knowledge, skill and attitudes of the participants.

Level II evaluations have the best results when measured before and after the planned event (pre- and post-testing) specifically for knowledge based training. To measure knowledge prior to the learning event, pre-test, compared to the results of a post-test, will provide a gauge of the amount of learning that occurred as a result of the training and a way to improve future versions of the training event. However, skill measurement typically requires some kind of performance testing. Participants must demonstrate the skills taught in the course at the end of the training.

Level III – Behavior

Level III evaluations measure the participants' "on-the-job behavior" or application of the knowledge, skill and abilities learned in a planned event. Level III evaluations measure the transfer of knowledge, skills and attitudes to a specific environment (e.g. workplace).

A level III evaluation often involves others (i.e. supervisor, peers) that have noticed a change in behavior or attitude in the training participant. Level III is often harder than Level I or II evaluation because behavior changes at the workplace are often harder to measure than reaction and learning directly after the training event. Therefore, time must be factored in to give the behavior time to transfer and collect data at the workplace.

Level IV – Results

Level IV evaluations focus on the "bottom line" or business impact. The object of Level IV evaluations is to quantify the impact of the planned event on the organization's goals. For example, one might measure whether a State Department of Transportation (DOT) saw a significant reduction in serious accidents due to the training its safety engineers received last year or greater job satisfaction.

Level IV evaluation is difficult in the sense that it is quite difficult to establish firm evidence that the training event was the key or only source that produced the Level IV outcome.

Level V – Return-on-Investment

Level V evaluations are similar to Level IV but goes one step further. It answers the question: What has been our return-on-investment for this planned event? Level V evaluations make a business case for whether the gains that resulted from implementing a planned event (e.g., training) were worth the investment. Did it save money? Lives? Time?

Developing a Level II Evaluation

Level II evaluations are used to measure whether "learning" has truly occurred. Some examples of planned events that tend to use Level II evaluations are academic or training courses, workshops, and seminars.

The most common type of Level II evaluations is pre- and post-tests. Pre- and post-tests are usually given before and after a training event. They measure a learner's knowledge before the planned event and at the conclusion of the event to identify the gap in the knowledge, skills and abilities.

Before developing any Level II evaluation, there must be properly written and evaluated learning outcomes, also known as objectives. If the training event has proper outcomes/objectives the creation of the Level II evaluation is easy to develop because the evaluation questions are directly related to the outcomes/objectives. If the outcomes/objectives have not been written, it is very difficult to determine what content to test and how to assess achievement of the course goals.

Types of Level II Evaluations

Oral Quizzes

Oral quizzes or tests are most often given face-to-face and can be conducted individually or in a group setting. A typical example of oral quizzing in a group setting is lesson reviews. However, oral quizzes do not take the place of an end of course or continuous assessment tool.

Example

1. When it comes to Highway Safety tell me two safety challenges you are facing right now in your State or region.

2. What are "special use" vehicles and what is special about them?

3. What type of crossing is required for train speeds over 201 km/h (125 mph)?

4. Identify the following safety device? (Some a graphic on a slide).

5. Define what a passive device is? Can anyone give me an example of a passive device?

6. What are three types of light rail alignments?

7. Why is aiming of roundels so critical?

Written Exams

Written exams can include various question types such as: essay, fill-in-the-blank, matching items, and multiple-choice test items. Written exams are the most common type of Level II because they are one of the easiest to develop.

Example

1. What does the acronym ISD stand for in course development?

   A. Independent student development
   B. Instructional strategic design
   C. Instructional school development
   D. Instructional systems design

2. Which of the following statements best describes the conditions under which a project located outside a nonattainment or maintenance area may be eligible for CMAQ funding?

   A. The project reduces emissions of any pollutant that contributes to air quality nonattainment status anywhere within the State
   B. The project is located in close proximity to and primarily benefits a nonattainment or maintenance area
   C. The project is located in an area designated by the State as being "at-risk" for air quality nonattainment
   D. A project located outside a nonattainment or maintenance area is <u>never</u> eligible (unless it is located in a "Minimum Apportionment" State)

3. Match the following terms with their appropriate definitions:

1) Measures of Effectiveness	a. Specific, measurable statements related to the attainment of goals.
2) Objectives	b. Tests, which reflect the degree of attainment of particular objectives.
3) Goals	c. Variety of techniques that can be used to identify goals.
4) Visioning	d. Generalized statements, which broadly relate the physical environment to values.

4. Public involvement is integral in which of the following transportation planning process

steps.

A. Visioning and Goals
B. Problem Identification
C. Plan and Program Development
D. All of the above

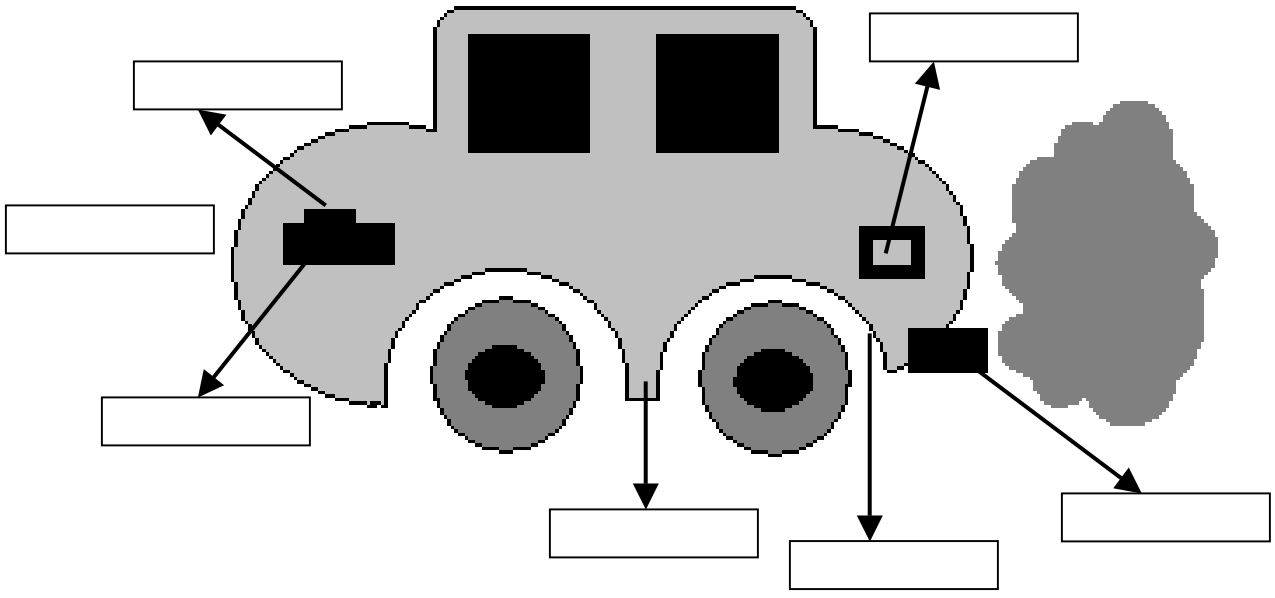
5. Name three variations of reporting hydrocarbons.

1)_____

2)_____

3)_____

6. Label the mobile source emissions.



7. Draw the composite speed-emission rate curve for NOx running exhaust for the freeway driving cycle.

8. Why is the Aggressive Driving offset in MOBILE6?

9. Write the fleet average emission rate equation expanded to show exhaust emissions.

10. Fill in the blanks of the five steps of designing ITS-Supported Safety Countermeasures.

Step 1: Identify _____

Step 2: Identify _____ measures & data _____

Step 3: Identify _____ to address the safety challenge

Step 4: Identify _____ to _____ traditional approaches

Step 5: Combine & form _____

Performance Exams

Performance exams (also known as proficiency tests or task simulations) allow an instructor to observe and evaluate the learner as he/she performs a task or demonstrates a skill. Most often, performance exams are administered to assess whether an individual can complete a task or demonstrate a skill to a pre-determined performance standard.

Performance exams are typically used when a written exam is not an effective testing instrument and can be the basis for certifications.

Example

Sieve Analysis of Fine Coarse Aggregates FOP for AASHTO T 27

Materials Finer than 75 μm (No. 200) Sieve in Mineral Aggregate by Washing FOP for AASHTO T 11.

Procedure Element:	Yes	No
1. The tester has a copy of the current procedures on hand?	☐	☐
2. All equipment is functioning according to the test procedure, and if required, had the current calibration/verification tags present?	☐	☐
3. Minimum sample mass meets requirement of Table 1 from FOP for AASHTO T308?	☐	☐
4. Test sample dried to a constant mass by FOP for AASHTO T 255?	☐	☐
5. Test sample cooled and mass determined to nearest 0.1 percent of mass?	☐	☐
6. Sample placed in container covered with water? (If specification requires the amount of material finer than the No. 200 sieve is to be determined.)	☐	☐
7. Contents of the container vigorously agitated?	☐	☐
8. Complete separation of coarse and fine particles achieved?	☐	☐
9. Wash water poured through nested sieves such as No. 10 and No. 200?	☐	☐
10. Operation continued until wash water is clear?	☐	☐
11. Material retained on sieves returned to washed sample?	☐	☐
12. Washed aggregate dried to a constant mass by FOP for AASHTO T 255?	☐	☐
13. Washed aggregate cooled and mass determined to nearest 0.1 percent of mass?	☐	☐
14. Sample placed in next of sieves specified? (Additional sieves may be used to prevent overloading as allowed in FOP.)	☐	☐
15. Material sieved in verified mechanical shaker for minimum of 10 minutes?	☐	☐
16. Mass of residue on each sieving determined to 0.1 percent of mass?	☐	☐
17. Total mass of material after sieving agrees with mass before sieving to within 0.3 percent?	☐	☐
18. Percentages calculated to the nearest 0.1 percent and reported to the nearest whole number, except No. 200 – reported to the nearest 0.1 percent?	☐	☐
19. Percentage calculations based on original dry sample mass?	☐	☐

20. Calculations performed properly? If material passing No. 4 sieve is split and only a portion is tested, calculation as noted in FOP performed properly? ☐ ☐

First Attempt: Pass ☐ Fail ☐

Second Attempt: Pass ☐ Fail ☐

Examiner (Please write): _____

Signature of Examiner: _____

Comments:

Source: Washington State Department of Transportation T 27/T 11

Case Studies

Case studies are one of the best ways to evaluate learning and application of knowledge and/or skills.

A case study provides a detailed description of a problem (e.g. setting, parameters) and typically contains a list of questions pertinent to the case. The participant is asked to analyze the case and determine the best course of action. An effective case study emulates a real world situation that the learner can expect to encounter on the job.

Example 1 – Big I Case Study - Simple

Big-I Case Study

- Now we are going to utilize an actual work zone situation to go through an exercise in addressing characteristics of developing ITS approaches.
- The exercise begins by outlining the challenge. Later, after the exercise, we will discuss the actual ITS applications used.
- The applications used were evaluated throughout the actual project and their benefits have been reported.

Background Information: The New Mexico State Highway and Transportation Department (NMSHTD) rebuilt the Big-I Interchange in Albuquerque to make it safer and more efficient and to provide better access. The Big-I is where the Coronado Interstate (I-40) and the Pan American Freeway (I-25) intersect in Albuquerque. The original Big-I was designed to support an average daily traffic (ADT) of only 40,000 vehicles and was severely over capacity, experiencing an average of 1.7 crashes per day that were estimated to cost about $12 million annually (data from 1999). ADT in the interchange was approximately 300,000 vehicles prior to its redesign; the redesigned Big-I has a design capacity of about 400,000 ADT.

The two-year project began on June 30, 2000 and involved 111 lane-miles of construction and 45 new and 10 rehabilitated bridges. For the Big-I project, NMSHTD employed ITS in the form of mobile traffic monitoring and management systems to help move the large number of vehicles through the extensive construction area. Mobile traffic monitoring and management systems use electronics communications equipment to monitor traffic flow and provide delay and routing information to drivers and agency personnel.

The Big-I project was designed to address a severe safety challenge and capacity need. The work zone was going to have to be in-place for two years and traffic through the work zone was of course a major concern.

Instructions: (If instructors are going to observe each participant to make sure that each participate equally and understand the concepts and material.) (However, if it is going to be used to test individual performance, change phrasing of the instructions.) Please break up according to the tables you are sitting at. Elect a scribe to take notes and present your findings at the end of the discussion time. Use any and all training resources plus the knowledge and experiences you have in your group to answer the following questions:

1. What are the work zone safety challenges present in the Big-I project?
2. What ITS functions (that we covered) could help mitigate?
3. What ITS applications could be utilized?
4. What are the anticipated benefits from ITS?
5. What data could help measure performance?
6. What are some institutional considerations involved?

Example 2 – Alternative Contracting Case Study – More Complex

Alternative Contracting Case Study

Background Information: Your workgroup is responsible for selecting the project delivery system, procurement methods, and contract management methods for the project to reconstruct the section of combined Interstate 65 and 70 through downtown Indianapolis, Indiana. Before making selections, however, your workgroup must become familiar with the project.

Assignment One: Project Scope and Considerations

Your first assignment is to understand the scope of work, project considerations from the perspective of the major stakeholders, and develop objectives and goals. The conclusions you reach during this assignment will guide you toward selecting an appropriate project delivery system, procurement methods, and contract management methods.

After the instructor presents some background information on the project, take 20 minutes to complete the following tasks.

1. Use the information provided to identify the project location and the major city streets affected by the project.

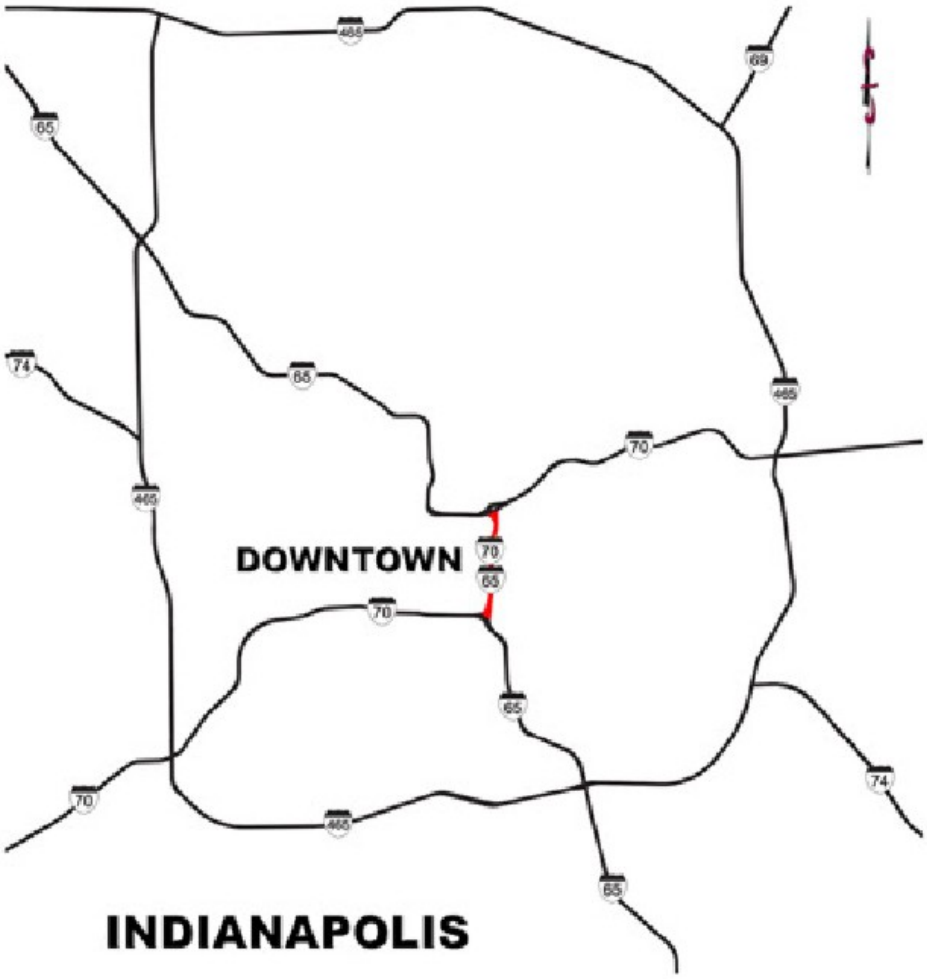
2. Identify city streets that may provide alternate access into downtown area during construction.

3. List advantages and disadvantages of completely closing I-65/70 from the perspective of the owner, contractor, and community. Record and be prepared to discuss your advantages and disadvantages with the entire class.

4. Make a list of project goals and objectives. Narrow your list to the top five in order of descending priority. Record your goals and objectives and be prepared to discuss them.

5. Has anyone in your workgroup been involved with a similar project? If yes, what challenges did that project present that will likely be repeated here?

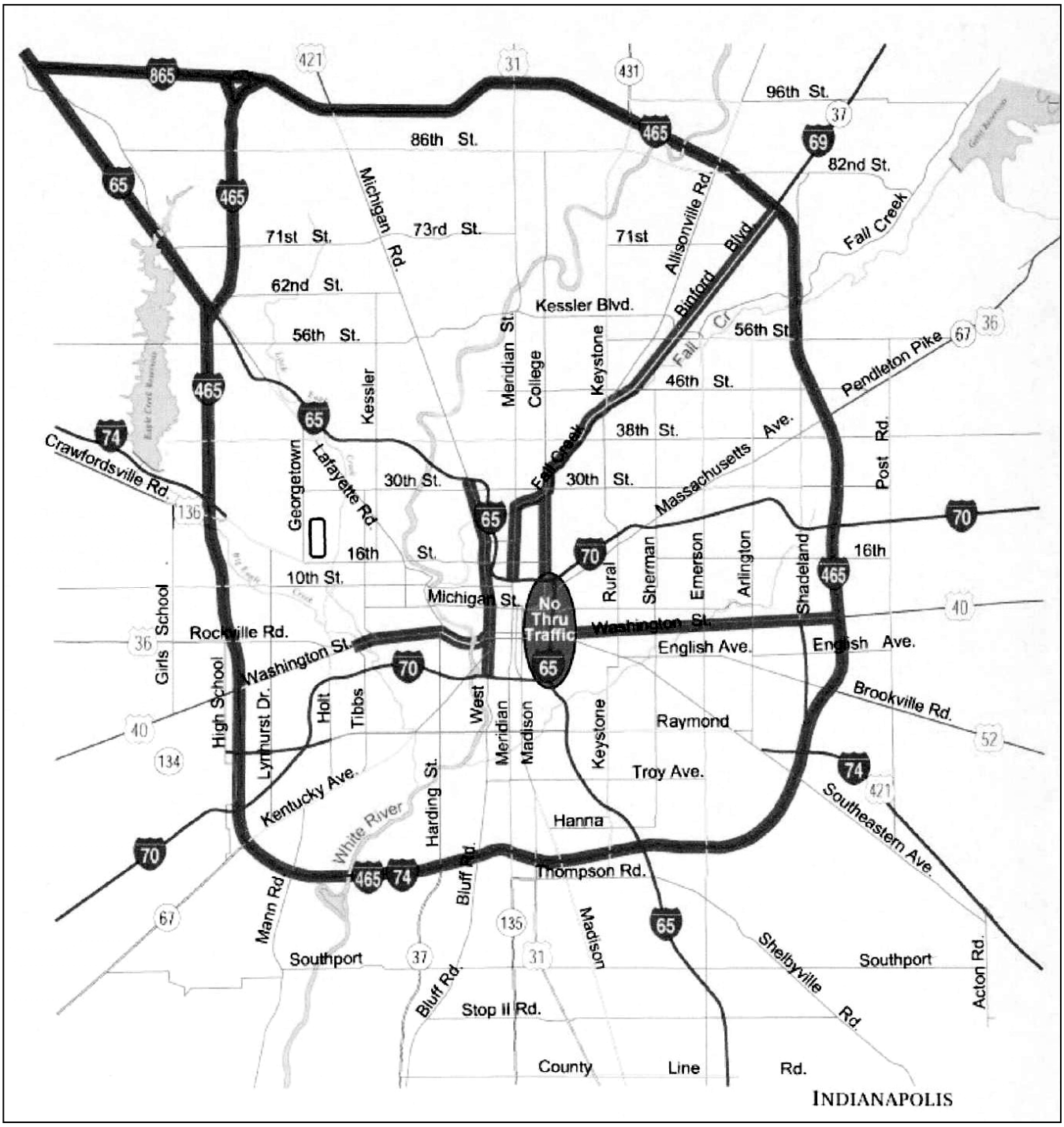
Project Location: The Interstate 65/70 project is located in downtown Indianapolis, Indiana. The two interstates share a stretch of highway through the downtown area. The sketch below shows the project location relative to downtown Indianapolis and the major routes in the surrounding area.



Project Facts: The section of I-65/70 through downtown Indianapolis was built around 1976. The daily traffic volume now exceeds 175,000 cars and trucks. In recent years, the road section has required many emergency repairs and the number of repairs is expected to increase. The scope of the project includes 31 bridge deck overlays, 2 bridge deck replacements, 35 lane miles of pavement to repair including 87,000 square yards of new pavement, two merge lanes, and upgraded traffic control and roadside safety devices.

Downtown Area

I-65/70 is the main route providing access to the downtown area. The downtown area has many stakeholders affected by the project. These include the convention center, city government, neighborhood associations, visitors, city airport, and the Indianapolis Motor Speedway, which hosts three single-day sporting events each year. Alternate access to the downtown involves the use of city streets. A more detailed map of the project location and city streets is shown below.



Photographs show total length of project, 3.5 miles. Interchange on both north and south ends in downtown area through several neighborhoods.

Maintenance of Traffic: Preliminary planning for the project assumed that I-65/70 had to remain open to traffic throughout construction using lane closures and temporary crossovers. Construction was estimated to span two construction seasons. The high daily road user costs made project planners compare options to maintain traffic. The three options are:

1. Phased Construction: Maintain three traffic lanes in each direction on I-65/70 using phased construction and crossovers. The estimated duration is 180 construction days.

2. Partial Closure: Close the southbound lanes completely and close the northbound lanes on weekends only. The estimated duration is 135 construction days.

3. Complete Closure: Close I-65/70 completely and maintain traffic on alternate routes. The estimated duration is 85 construction days.

Project Scope: There are few existing utilities within the project limits. The facilities of Citizen's Gas exist within the project limits, but should not be affected by construction. Likewise, facilities of AT&T are within the project limits and should not be affected.

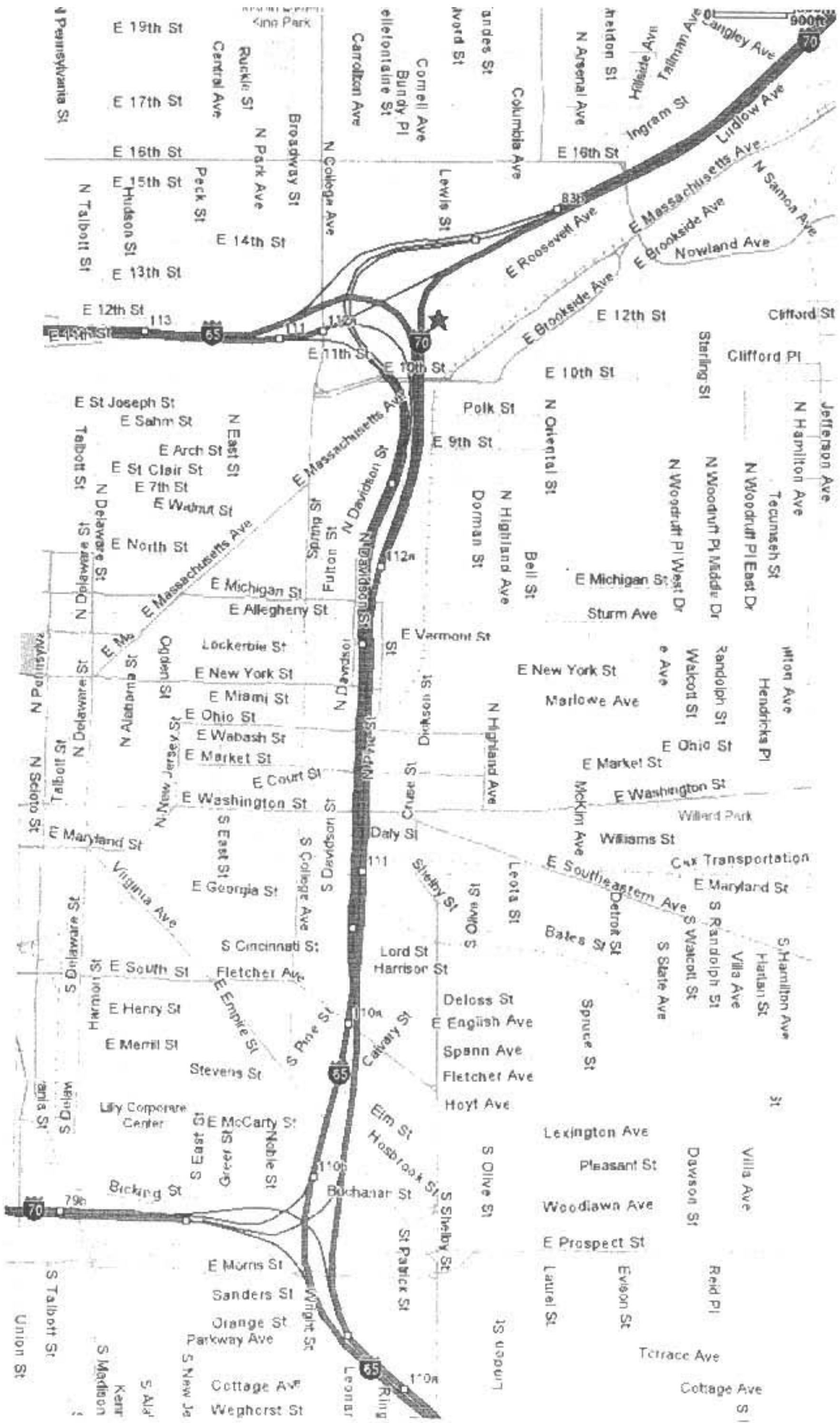
Indianapolis Power and Light (IPL) has a power pole at the corner of Lewis Street and 12th Street. IPL will not relocate the power pole and the pole must be protected during construction.

There is an abandoned 48-inch brick sewer close to the widening of the pier foundation at the 10th Street Bridge. The condition of the sewer is unknown. It must be filled before constructing the pier foundation for I-70EB over 10th Street Bridge.

The project involves reconstruction of several bridges. Reconstruction involves removal and replacement of structural steel, surface preparation and painting, and deck repair. Some bridges require mill and overlay while others require full-depth repair. The bridges include:

I-65/Washington Street
I-65/Market Street
I-65/CSX & Ohio Street
I-65/New York Street
I-65/Vermont Street
I-65NB/Michigan Street
I-65SB/Michigan Street
I-65NB/Pine Street Ramp
I-65NB/St Clair Street
I-65SB/St Clair Street
I-65SB/10th Street
I-70WB/10th Street
I-70WB/Lewis Street
I-65SB/I-70WB & CD
I-70WB/I-65NB
I-65EB/I-70WB & CD
I-65NB/I-70WB & Ramp
I-65NB/Proposed Ramp under I-65/70
I-65NB Ramp/Proposed I-70 Ramp
I-70 WB/Future Ramp
Virginia Ave over I-65NB
Virginia Ave over I-65SB
Calvary St over I-65SB
Calvary St over I-65NB
Fletcher Ave over I-65
Conrail over I-65
Bates St over I-65
Conrail over I-65
Conrail & CSX over I-65

With several railroad bridges involved, construction will have to comply with both Conrail and CSX requirements for both maintaining rail traffic and construction means and methods.



1. The major city streets affected by the project are:

_____ _____

_____ _____

_____ _____

2. Alternate routes to I-65/70 into downtown are:

_____ _____

_____ _____

_____ _____

3. Advantages and Disadvantages

	Advantages	Disadvantages
Owner		
Contractor		
Community		

4. Goals and Objectives

Brainstorm List:

5. Top Five

1.

2.

3.

4.

5.

Role Playing

Also referred to as skill practice, role-playing is an activity/assessment method whereby an instructor can observe desired behaviors in a controlled environment. With role-playing participants are typically assigned a role with specific instructions on their attitudes, actions or driving factors. Participants then practice their skills by interacting with others to accomplish a set objective. The best role-play resembles "real life" or workplace situations. The instructor typically becomes the facilitator during this exercise and moves things along when the role-play goes off track or gets bogged down. (If using role-play, only the learner should be a variable.)

Example

CMAQ Activity – Divide the class up into groups of 4 or 5 participants. Assign one person from each group of the following roles (MPO Staff, State DOT Representative, State Air Quality Agent, Local Jurisdiction Representative (City B), Local Jurisdiction Representative (City E) and Regional Transit Agency (optional).

Goal: Use information given to negotiate a list that protects each of your interests and fits the budget while answering the following questions:

1. What are the Federal requirements for a CMAQ project selection process?
2. What are some general requirements for transportation planning?
3. How can the CMAQ process support the air quality planning process?
4. What are some reasons to conduct an initial screening of candidate projects?

MPO Staff

You have a (rather awkward) role of serving as both the MPO staff person working with the CMAQ program, and advocate for the MPO's projects. As staff person, you have checked projects for eligibility and assembled the information on costs and benefits. Project sponsors provided estimates of emissions benefits, based on formulas that the MPO developed. The MPO provided project sponsors with emission factors, but left it to the project sponsor to determine usage information such as number of bicyclists/pedestrians, number of transit riders, vehicle-miles traveled, etc. You gave a cursory check of the estimates for reasonableness but did not have time to perform any in-depth analysis or verification.

You are aware that the MPO has nominated only two projects, but that one of them is quite large – a $2.6 million request for a regional signal coordination project using radio frequency transmitters and an existing communications system. Your consultant has estimated the emissions benefits and cost-effectiveness of this project to be quite significant – greater than the emission reductions of all other candidate projects combined – so you are advocating this as the top priority regional CMAQ project. However, you also realize that others may be upset that more than half of the available CMAQ funding is going towards a single project. Therefore, you are willing to ask for only one-quarter the level of funding (which is estimated to yield one-

quarter the emissions benefits). If people insist on reducing funding for this project, you will agree but will note that total emission reductions from the CMAQ program would drop considerably if funding for this project were reduced.

State DOT

Your interests in this exercise are as follows:

- You are concerned about achieving maximum overall emission reductions, since you are responsible to FHWA to ensure that the CMAQ program is achieving emissions benefits.
- You are concerned with the accuracy/reasonableness of emission reduction estimates. You know that often project sponsors estimate emission reductions using very crude assumptions and methodologies. You have not been closely involved in the review of data/methodologies for specific projects, but you are skeptical about estimates for some projects that seem particularly optimistic – for example, two of the bicycle/pedestrian projects which are isolated improvements but yield greater emission reductions than City E's signal interconnect project covering the entire CBD. You are concerned that funding decisions be made based on reliable data.
- You are somewhat concerned about equity in the distribution of project funds, but for political reasons you are also supportive of the largest city in the region (City E).
- You have a preference for traffic flow improvement projects, since you believe that the mobility benefits are significant, and should be considered in addition to the air quality benefits.

State Air Quality Agency

Your interests in this exercise are as follows:

- Your primary interest is in maximizing the emissions benefits of the program, especially the long-term benefits.
- Your research shows that the region is NOx-limited with respect to ozone formation, so you are especially supportive of projects that have significant NOx reductions and cost-effectiveness, relative to VOC reductions.
- You are concerned with the technical merits of the emission reduction estimates. While you have not had a chance to review the specific assumptions for each project, you know that the methodologies used are sometimes rather crude. You also question whether induced demand was taken into consideration in the traffic flow improvement estimates.
- You are not concerned with equity in the selection/distribution of projects.

Local Jurisdiction (City B)

Your interests in this exercise are as follows:

- You are **most concerned** with getting City B's projects funded.
- You are **also concerned** with funding equity for the various cities. As a member of the regional council of governments you are sensitive to the fact that other local jurisdictions want their projects funded as well. Since you are serving on this committee as a

representative of other local jurisdictions, you are sensitive to their interests and realize that City B may find itself shortchanged in other forums if you do not deliver with the CMAQ program.

- Consistent with your concern for equity, you believe that it is unfair for any one project to usurp a significant amount (more than $1 million?) of the available funding. You raise these concerns regarding the MPO regional signal coordination project (#9), the RTA bus fleet improvement project (#12), and the RTA transit spine (#11). You also don't believe that it is fair to fund both of RTA's major projects.

Local Jurisdiction (City E)

Your interests in this exercise are as follows:

- You are **most concerned** about getting City E's one project (#8) funded, and you are willing to go to great lengths to include this project on the list.
- You **strongly defend** the emission reduction estimates for this project, which are based on a simulation model. You believe other projects should be held to the same standard for developing emission estimates.
- This project is Phase 2 of a three-phase project. Since Phase 1 of this project previously received CMAQ funding, you believe it makes sense to continue funding Phase 2 through the program. Furthermore, you note that the emission reductions of the entire project (including all three phases) are greater than the benefits for phase 2 alone (shown).
- You note that while cost-effectiveness may not appear to be as good as some other projects, the project would rank highly on other (non-CMAQ) criteria such as reducing traffic congestion and traveler delay.

Regional Transit Agency (Optional Role)

Your interests in this exercise are as follows:

- You are **most concerned** about getting the RTA's projects funded, especially the Transit Spine.
- You are willing to accept partial funding for your projects, since other funding sources may be available.
- Because your governing board is made up of representatives of local jurisdictions, you are also sensitive to local interests and equity in funding. You are most supportive of projects that would support transit use, such as bicycle and pedestrian improvements.

Exercises and Activities

As adult learners we derive our most valuable lessons from what we experience and do, not from what we're told. Exercises and activities can be developed that result in long-term retention and behavior change. Through a series of hands-on exercises, participants will not only have fun learning but the exercises can build retention and improve performance if developed correctly.

Another advantage of exercises and activities is that they can cover several outcomes (objectives) with fewer questions. Exercises can be simple or complex.

Example

Participant Exercise: Session 6: Wall Design and Detailing

Problem: The following example problem presents the design of a mechanically stabilized earth (MSE) retaining wall with geogrid reinforcements as shown in Figure 6.8 to illustrate geotechnical aspects of the wall design by LRFD. The wall supports a roadway embankment and is to be designed for a 100-year design life. The leveling pad will be constructed using precast concrete.

During the subsurface exploration, it was determined that the foundation soils consist predominantly of hard clay to a depth of 10 m beneath the base of the proposed MSE wall. Bedrock underlies the hard clay. Consolidated undrained triaxial compression testing indicates that the clay has no effective cohesion intercept and an effective stress friction angle, φ'f, equal to 28 degrees. The undrained shear strength of the clay, Su, is equal to 230 kPa. Similar triaxial testing of the reinforced backfill and embankment fill material indicates an effective stress friction angle of 38 degrees. The seasonal high groundwater table is located at a depth of 6 m below the bottom on the MSE wall.

Instructions: The following pages present a complete design example for an MSE wall. In this exercise there are various locations throughout the example where you are required to complete the computations and/or determine a specific value. An empty rectangular box in the midst of the computations identifies these locations. You have 10 minutes to review the design calculation and fill in the empty boxes. When complete, be prepared to share your answers with the class and explain how they were obtained.

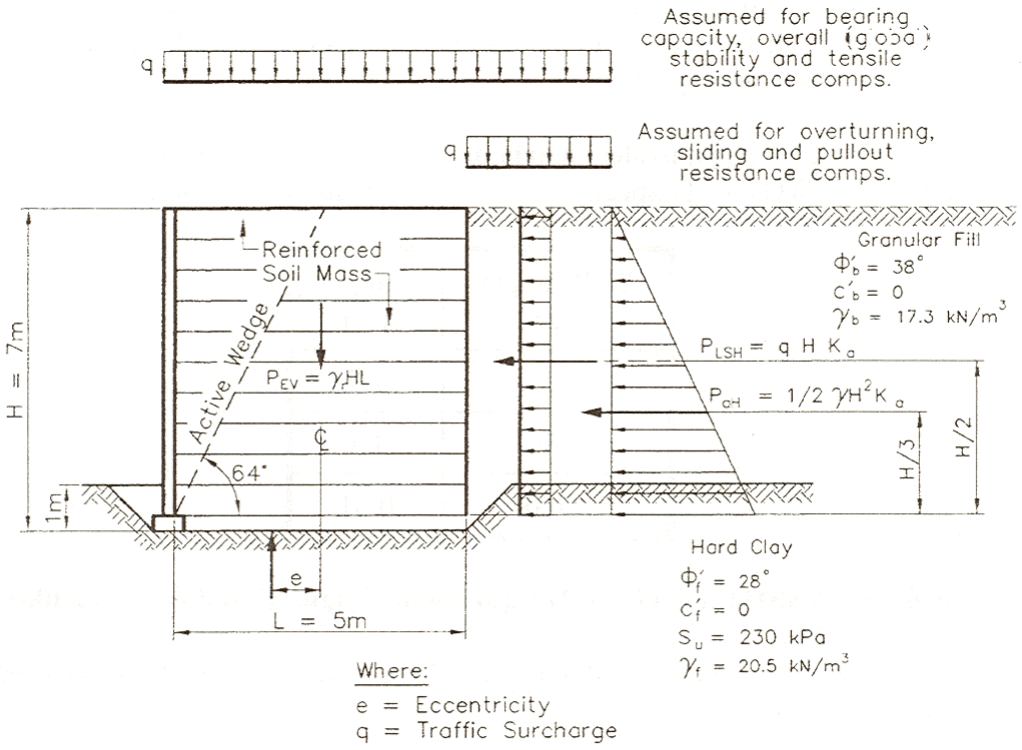


Figure 6.2.20 - Problem Geometry

Solution: For this example, an extensible reinforcement will be installed. For extensible wall systems, the zone of maximum stress should be determined using the Rankine method. The failure surface is represented by a linear surface oriented at an angle of 45o + φf'/2 from the horizontal, which passes through the toe of the wall as shown in Figure 6.2.20.

Step 1: Unfactored Loads

Length of Soil Reinforcement

The minimum soil reinforcement length, L, is the greater of either 70% of the wall height, H, measured from the leveling pad (i.e., 0.7 X 7.0 m = 4.9 m) or 2.40 m. However, for many problems, longer reinforcements are required. As a preliminary estimate, use L = 5.0 m.

Vertical Earth Pressure

The weight of the reinforced soil backfill is:

PEV = H L γr

PEV =

Live Load Surcharge (LS)

The live load surcharge, LS, is applied where vehicular load is expected to act on the backfill within a distance equal to the wall height behind the wall. Because LS is applied above the reinforcing strips, both the vertical and horizontal forces will be considered.

Using Table 6.2.6, the equivalent height, h_{eq}, of soil for the effect of vehicular loading from the AASHTO LRFD Specification (1998) equals 0.61 m for a wall height of 7.0 m

Wall Height (m)	h_{eq} (m)
1.5	1.5
3.0	1.1
$\geq$ 6.0	0.61

Table 6.2.6 (AASHTO 3.11.6.4-2) Equivalent Height of Soil for Vehicular Loading

The vertical force associated with the equivalent height of soil (for the effect of vehicular loading) is:

$PLSV = (\gamma_r)(h_{eq})(L)$

PLSV =

Note that the live load surcharge over the reinforced zone is not considered for checks on sliding, overturning (eccentricity) or reinforcement pullout, but is considered in evaluation of bearing capacity, overall stability and reinforcement rupture.

Horizontal Earth Pressure (EH)

The active earth pressure coefficient, ka is:

$$k_a = \frac{\sin^2 (\theta + \phi') \ldots .}{\Gamma \sin^2 \theta \sin (\theta - \delta)}$$

$\varphi' = \varphi'_b =$

$\theta = 90°$ for vertical wall from which:

$k_a =$