Electronic Tolling Point Design

2013 Design Training Expo

Presented By:

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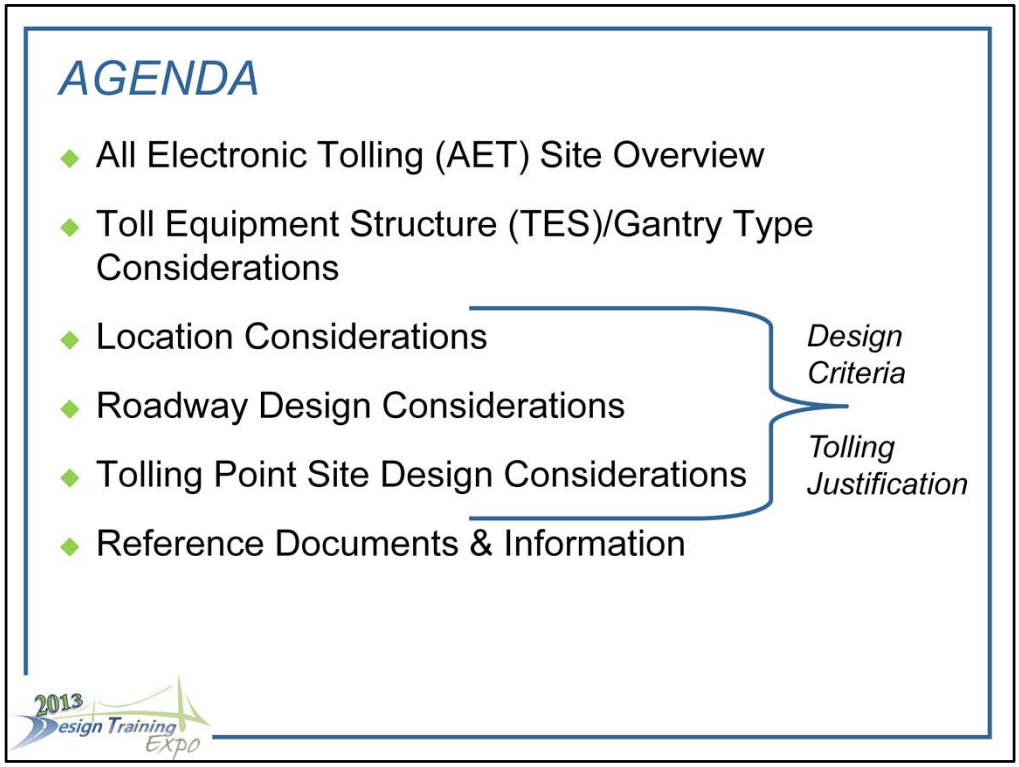
As existing cash-collection toll plazas are converted to all-electronic tolling and the planned implementation of new tolled lanes increases across the State, It is important to understand some of the unique tolling requirements that can impact the location, the associated roadway design, and site layout of the electronic tolling points.

The intent of this presentation is to discuss some of the major design criteria and guidelines that should be considered when planning for and designing a toll facility as well as present the justification from a tolling perspective.

The criteria and guidelines are based on the experiences of the Florida's Turnpike Enterprise and the specifications of our current toll equipment provider. This information presented is only intended to be used as a guide-line in laying out electronic tolling points. *As technology changes in every industry, tolling equipment will also change and so will the these guide lines.*



The agenda for this presentation includes:

• An overview of a typical electronic tolling site and the primary tolling components.

• A discussion of the different toll equipment structures and gantries that are utilized and the characteristics of each

• Things to consider in locating and designing the tolling site

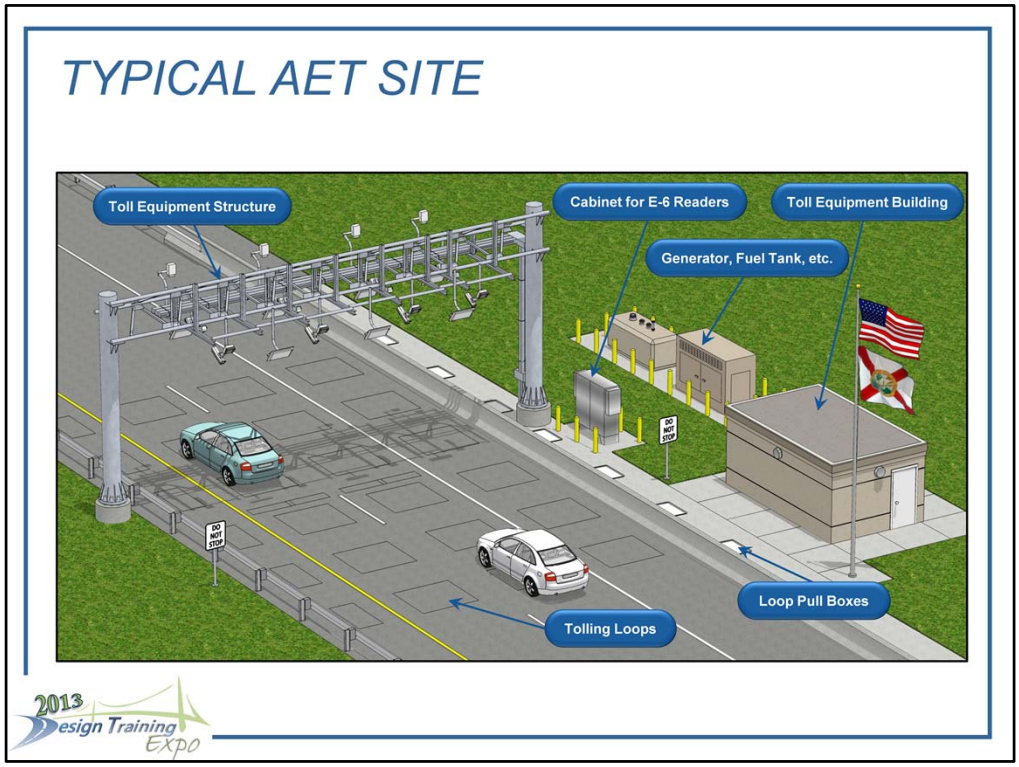
• Roadway design considerations associated with the tolling site

• ----For each of these I'll try to present the appropriate criteria and guideline as well as the tolling justification

• To wrap up the presentation I'll discuss available reference documentation,

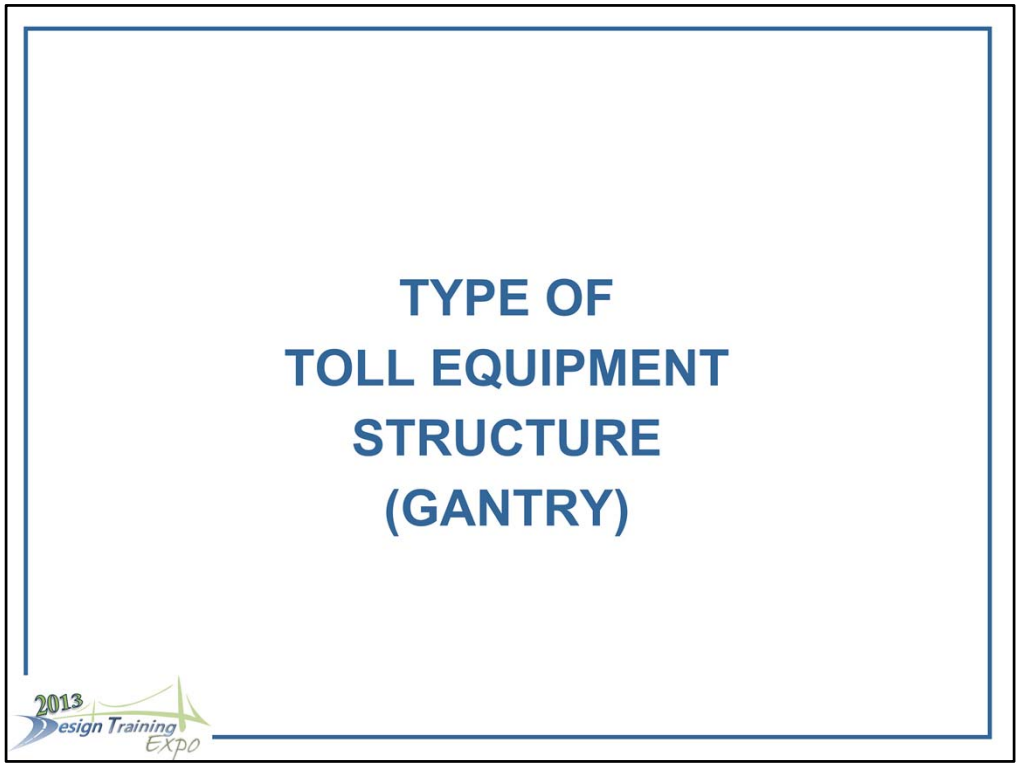
and list some of the completed and ongoing all-electronic tolling projects.

Then At the end we should have time for questions and answers.

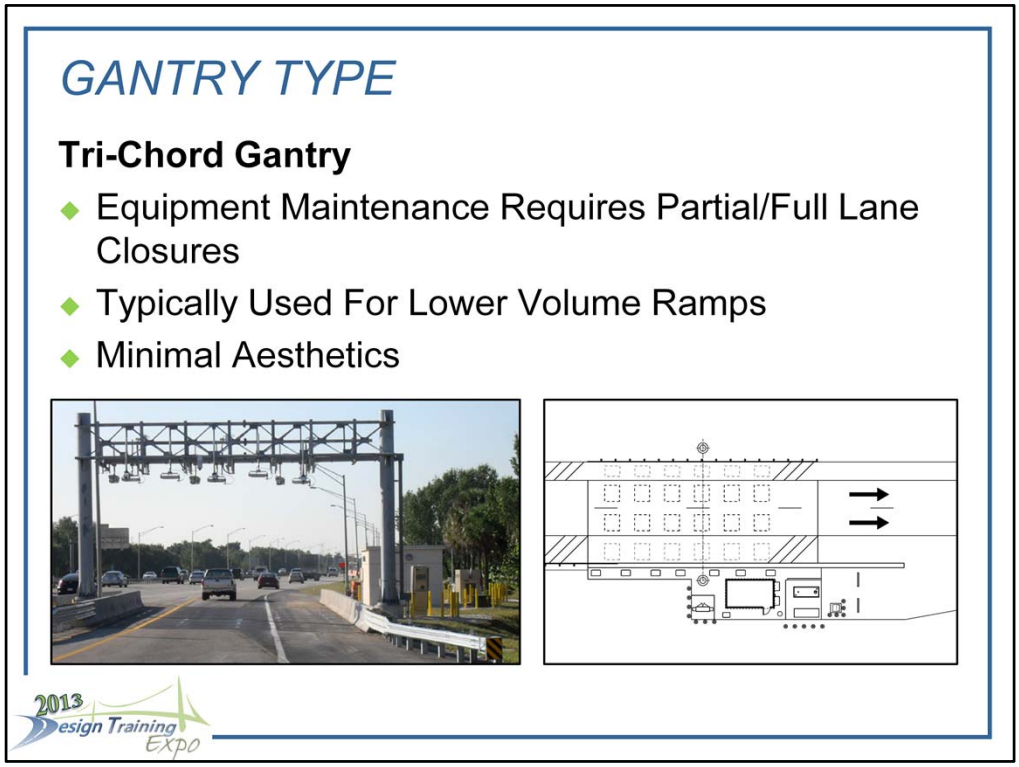


These are the main components of site:

-Gantry-structure: Is used for mounting the transponder-reader antennas, violation enforcement cameras (rear and sometimes front), camera light fixtures, and vehicle identification lasers.
-The roadway pavement contains the <u>detection loops</u>, used for vehicle classification and axle counting.
-The Building: houses the roadside equipment including; lane controllers, servers, DVRs, fiber communications equipment, UPS and the SCADA monitoring equipment. Sometimes we may have an exterior cabinet to house the transponder readers.
The site will also have a back-up emergency generator in case of primary power outages.



The choice of the equipment structure is primarily based on the volume of traffic on the roadway section, that is being tolled and what the impacts could be related to the necessary toll equipment maintenance activities.

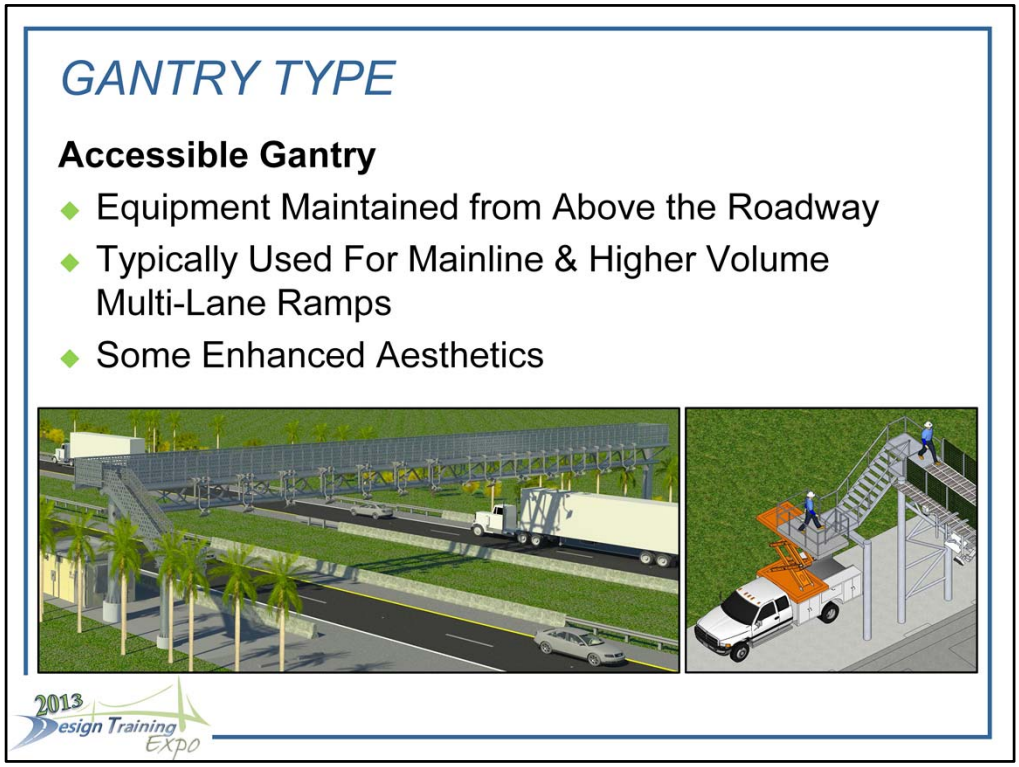


The most basic type of toll equipment structure is the tri-chord gantry which is basically an overhead sign structure.

This type of gantry requires that overhead equipment maintenance be performed with a bucket truck or platform lift. This will require a partial or full lane closure, depending on the roadway section.

Given the potential impact of Maintenance of Traffic requirements during overhead equipment maintenance, this type of toll equipment structure is typically used on lower volume ramps.

Also, this type of “bare bones” gantry offers minimal aesthetics.

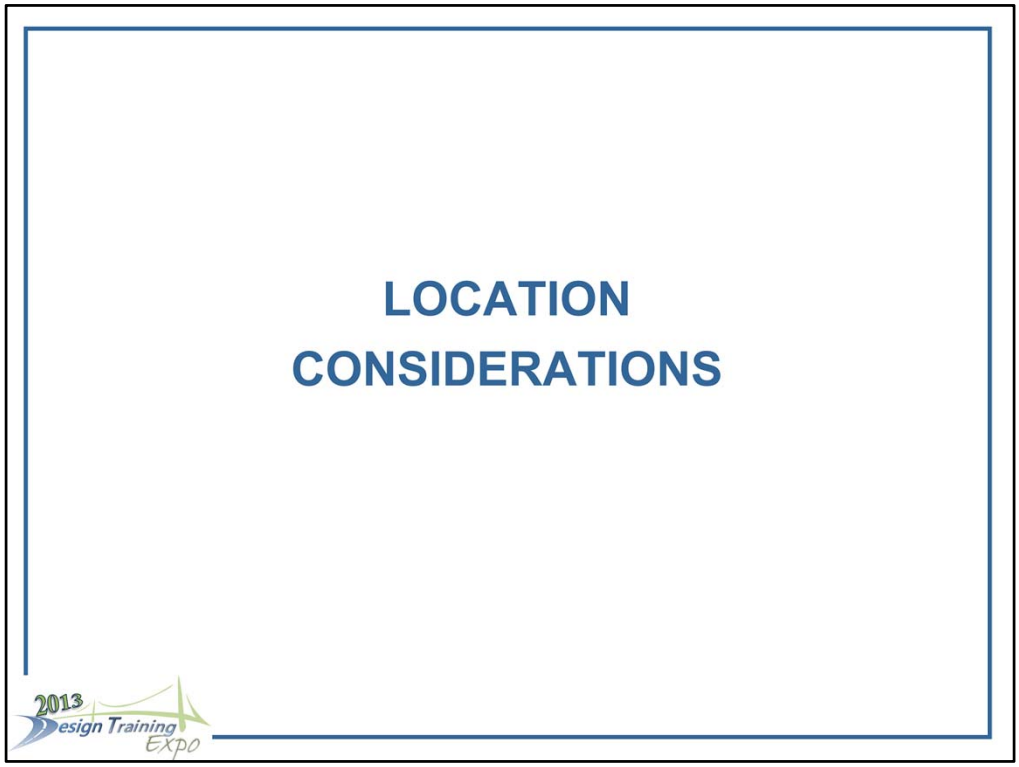


The second type of toll equipment structure utilized is the accessible gantry.

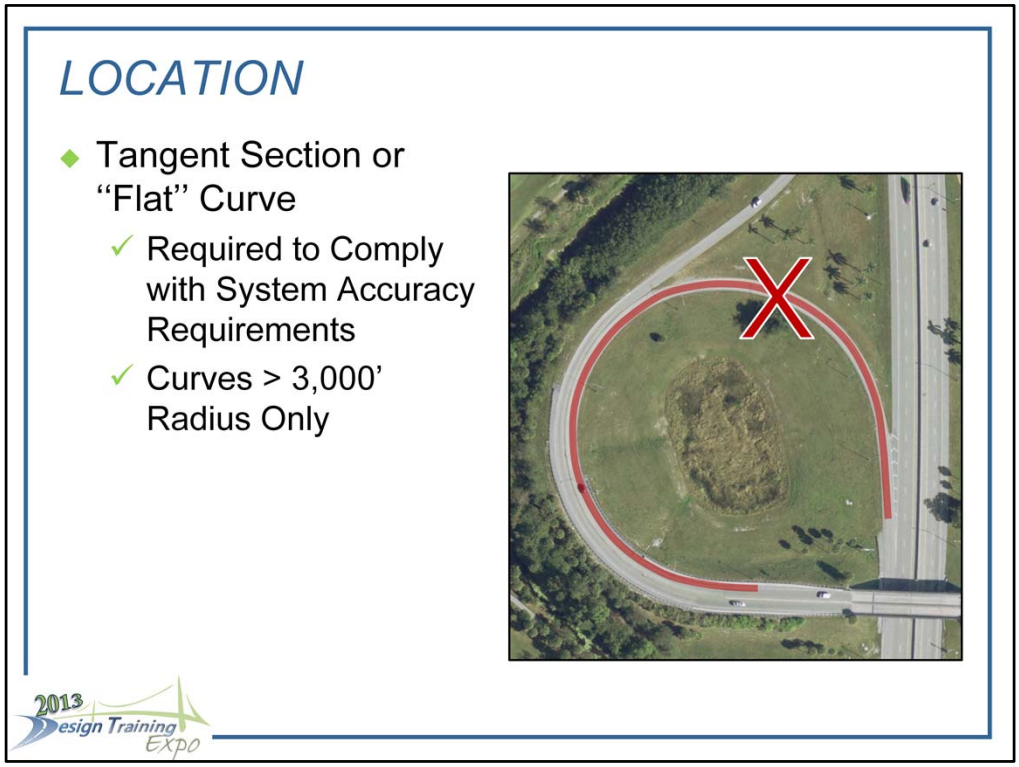
This type of gantry is so named because the toll equipment is accessible by the maintenance technicians from on the gantry structure. This means that equipment can be maintained from above the roadway during live traffic.
The toll equipment support arms are able to be rotated back onto the gantry walkway for serving.

Access to the overhead gantry structure, which is traversable, is with a scissor-lift truck which allows access to a raised platform and stairway.

This type of gantry provides a greater opportunity for some enhanced aesthetic treatments.

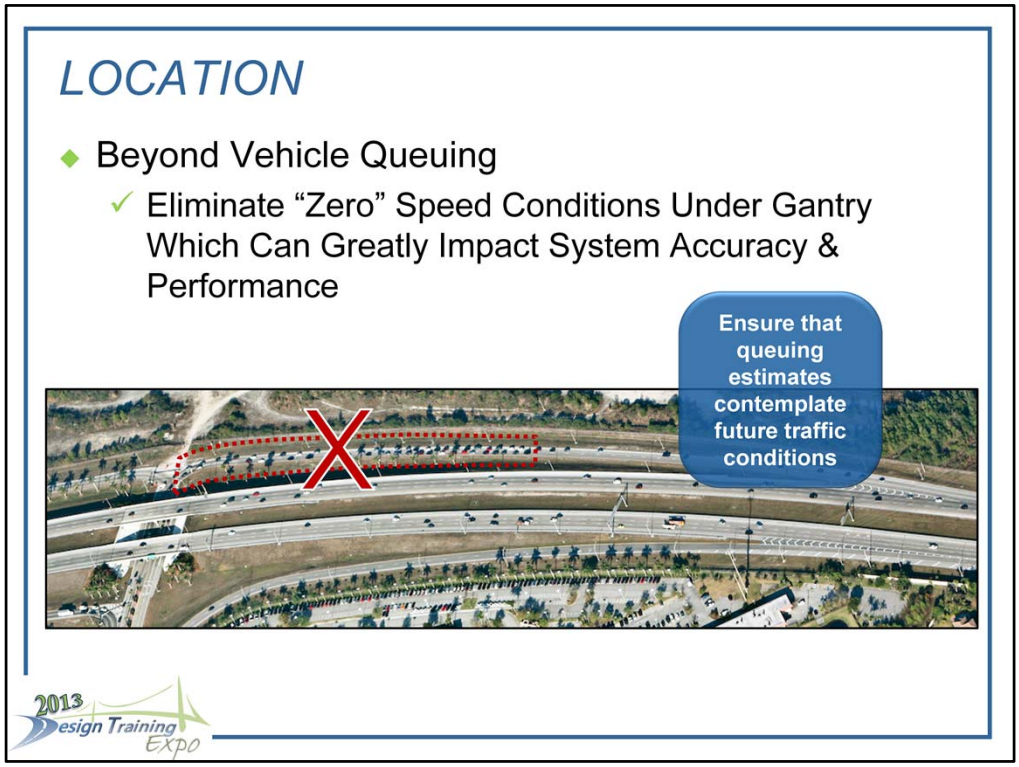


When locating tolling sites along the roadway, there are a number of geometric, traffic operating and physical conflict issues that <u>should</u> be considered.



One of the primary considerations when locating an electronic tolling point is that it should be on a tangent section.
The critical distance to consider is the 100 feet of tolling area.
This area should not be located on a curve as it could impact the accuracy of the tolling system performance.

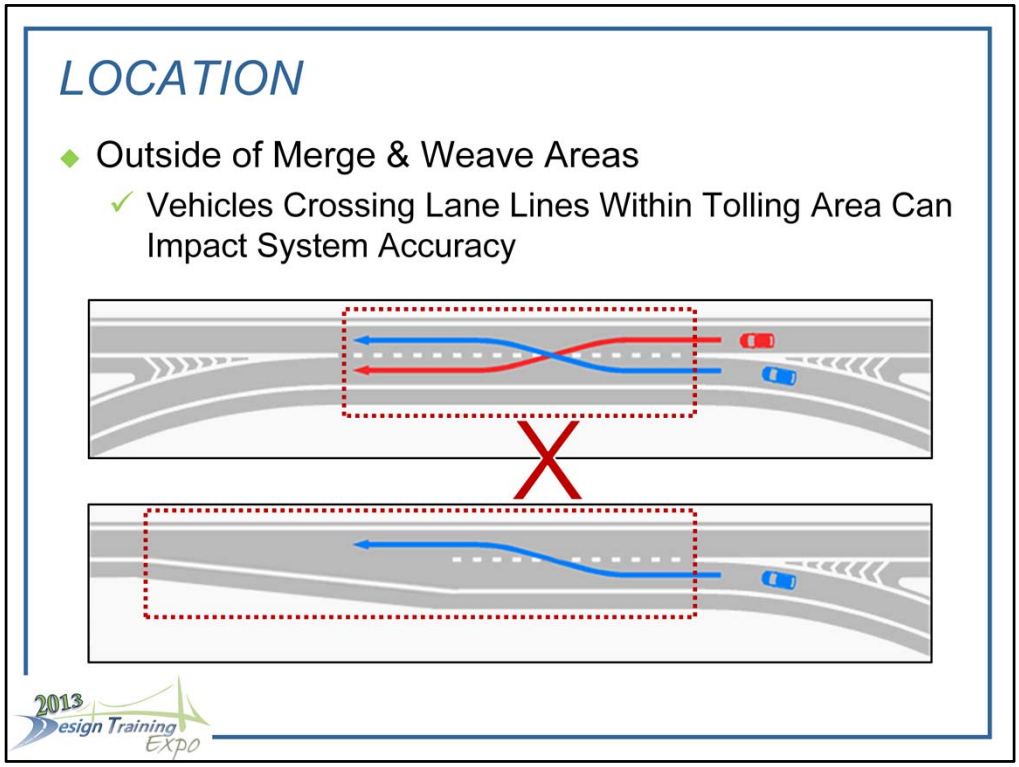
If other constraints and existing geometric conditions dictate that the tolling point has to be on a curve, it should be a "flat" curve with a minimum radius of about 3,000 feet. The current toll equipment has been tested and approved for this type of flat curve.



Another major consideration is keeping tolling points away from queued traffic, which typically occurs at ramp terminal intersections.

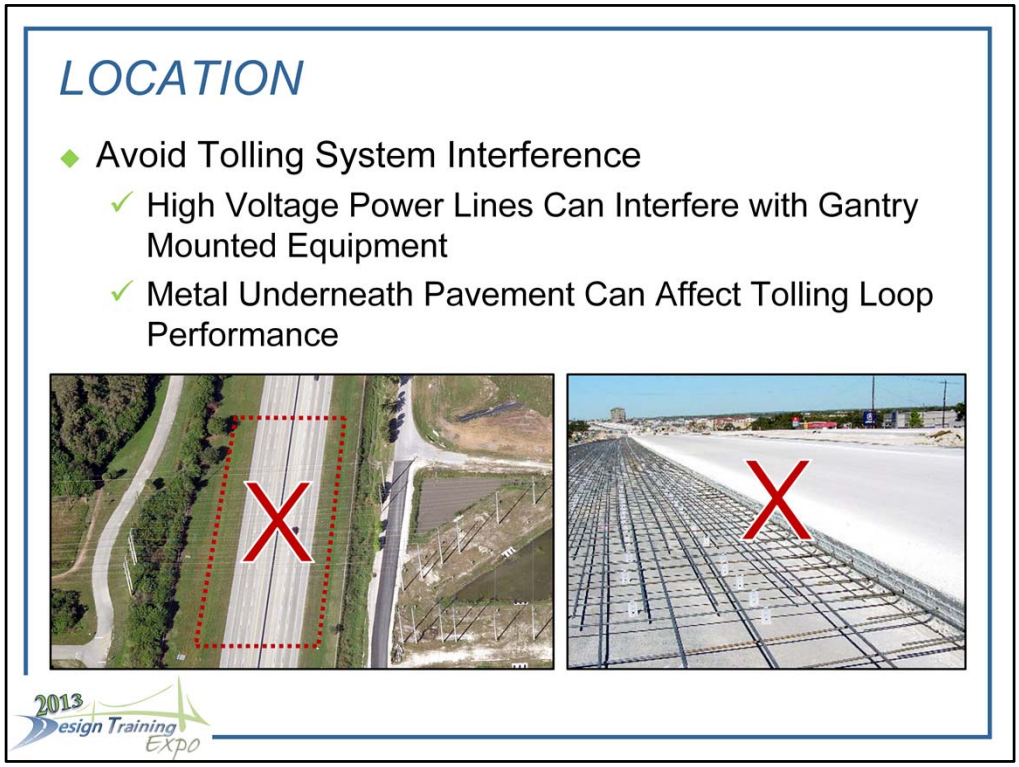
Tolling equipment is calibrated for some variation in travel speeds <u>but stopped</u> traffic within the tolling area can greatly impact the performance and accuracy of the system.

An important consideration with respect to evaluating vehicle queuing is to consider future year volumes and operating conditions.



Another traffic condition that should be avoided is locating a tolling point within merging or weaving traffic areas.

In both of these conditions,, vehicles have the potential for crossing lane lines within the tolling area.
This condition can impact system accuracy and performance.

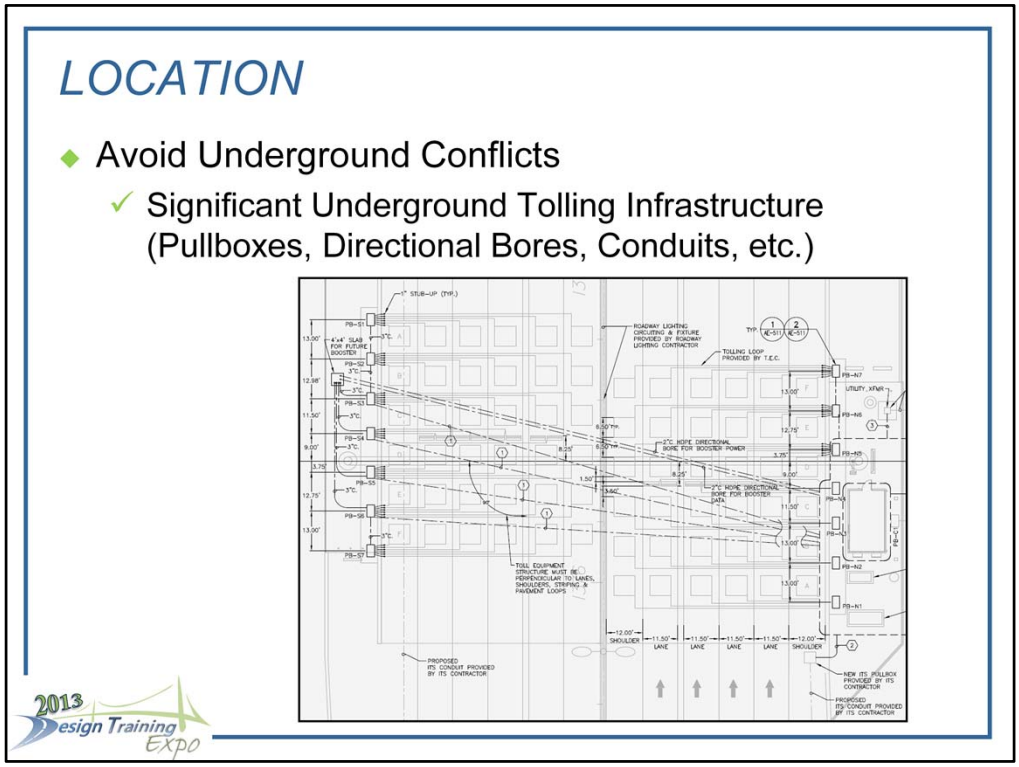


There are also certain types of interference that can significantly impact toll system performance.

Tolling points should not be located within the vicinity of high voltage power lines. These electrical lines can interfere with the operation of the gantry mounted toll equipment. ALSO—

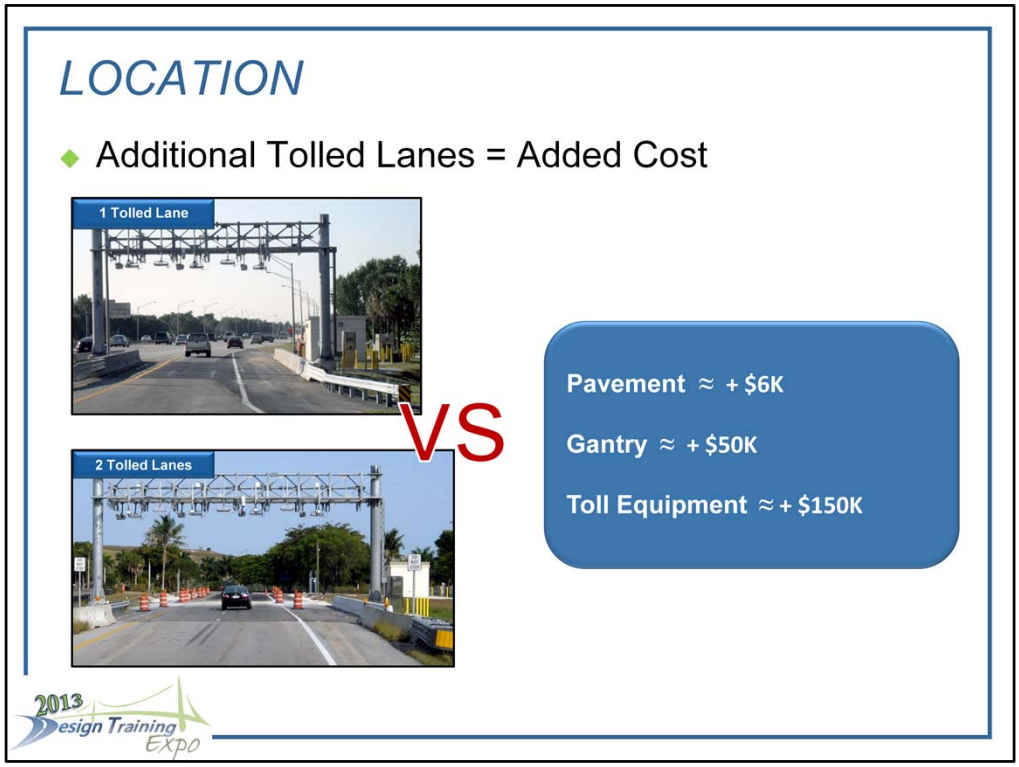
The tolling area pavement and subsurface should be free of any metal.
The presence of metal can adversely affect tolling loop performance.

Fiber -reinforced concrete is placed in tolling areas where concrete is used instead of asphalt pavement.



At any tolling site there is always a significant amount of underground tolling infrastructure, this will include pull boxes, a significant amount of conduits, directional bores, and loops.

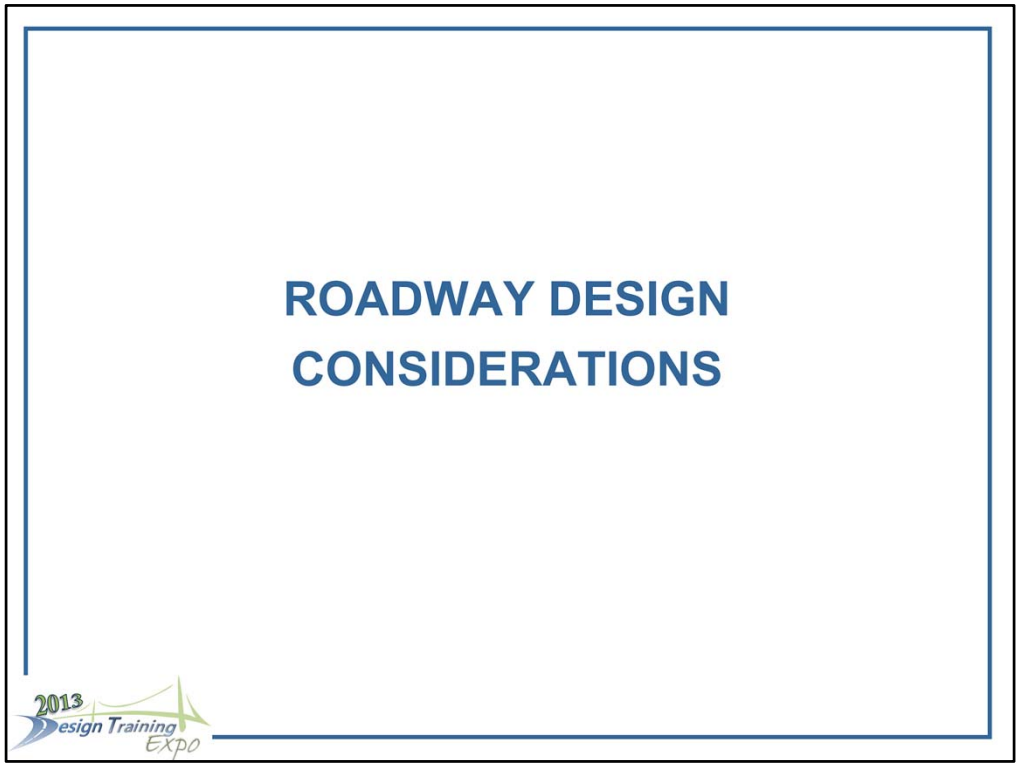
Therefore A scan of any potential tolling site should be made to ensure that there are no major existing underground conflicts.



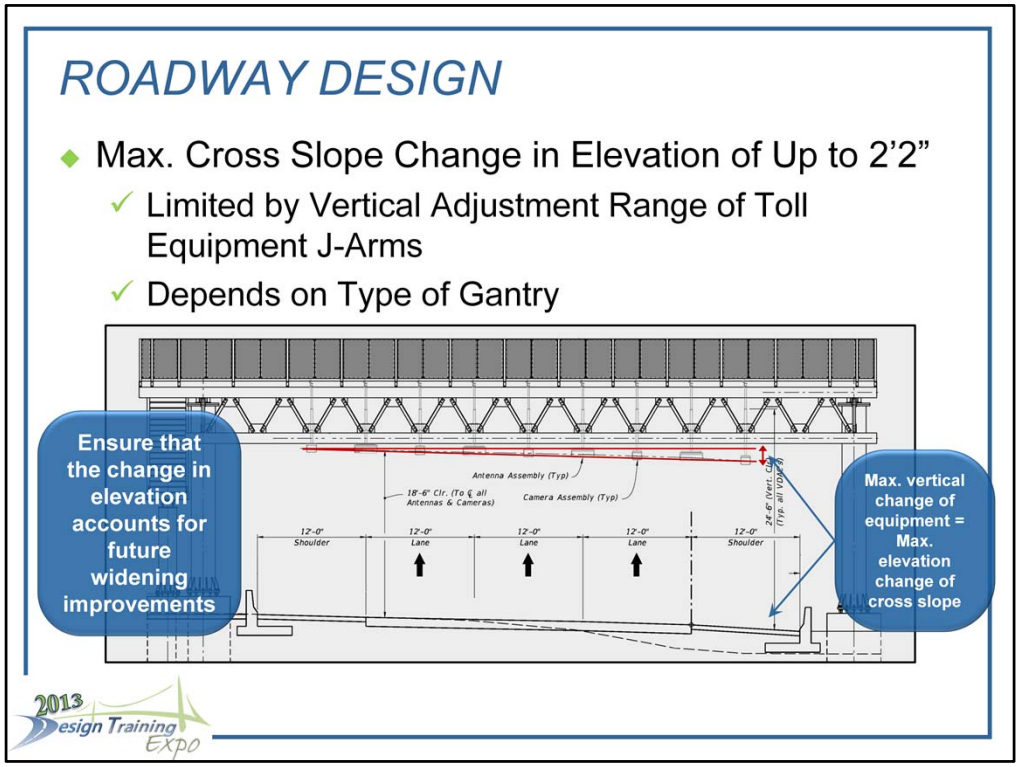
For tolling points located along ramps, there often exists the opportunity to locate a tolling point along ramps sections of varying lane configurations.

After an evaluation of the criteria and guidelines previously discussed, consideration should be given to locating the tolling point on the minimal width ramp section.

A general comparison of a 1-lane tolled ramp section to a 2-lane tolled ramp section, indicates an additional cost of over $200 thousand for the 2-lane site, with only a fraction of this cost related to the additional roadway infrastructure. The bulk of the cost will be associated with the additional tolling equipment needed.



There are certain design considerations which need to be accounted for at a tolling site which may be beyond standard ramp/roadway design criteria.



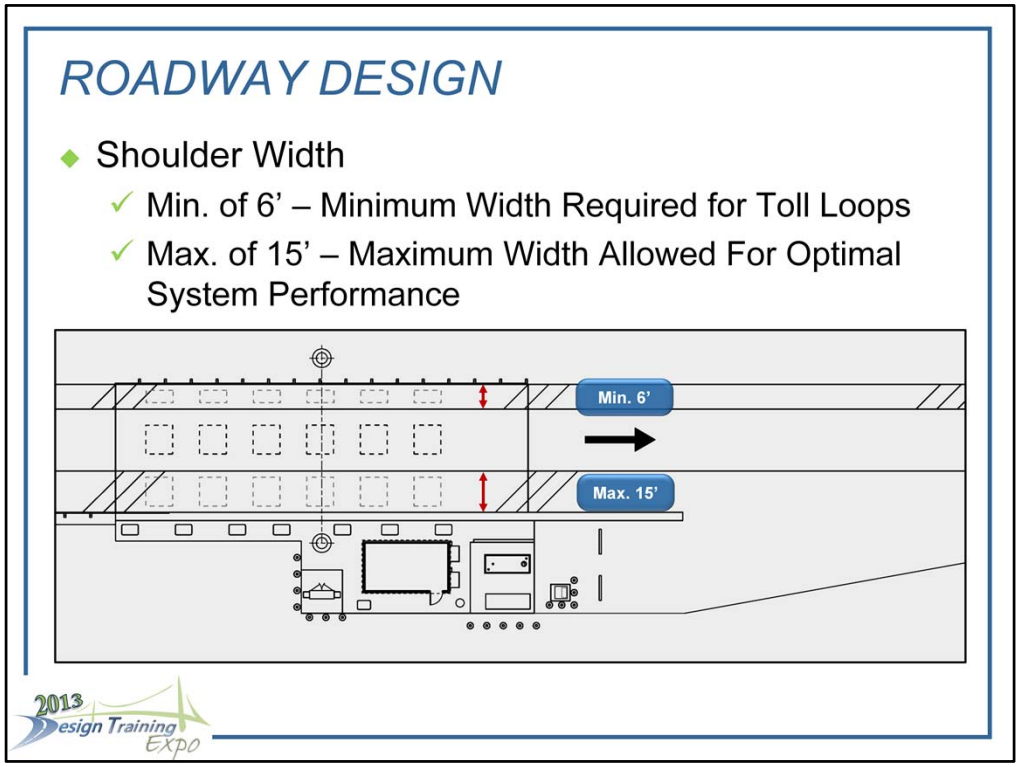
Cross –Slope - The toll equipment structure should be designed to be level with no change in elevation.

The gantry-mounted toll equipment, needs to be aligned parallel with the roadway surface. This is accomplished with the toll equipment j-arms which provide a range of vertical adjustment that allows the toll equipment to be at a consistent vertical clearance over each lane and shoulder.

This vertical adjustment is limited to a total of up to 2 feet, 2 inches, depending on the type of gantry.

This same limit in vertical adjustment would then also apply to the cross slope of the roadway, whereby the maximum change in elevation for the entire tolled roadway section, including the shoulders, is 2 feet, 2inches.

This is an important consideration for tolling point sections where future lanes are constructed but not opened initially. Therefore the ultimate cross slope change in elevation should be calculated to ensure that it does not exceed the maximum of 2 feet, 2 inches.



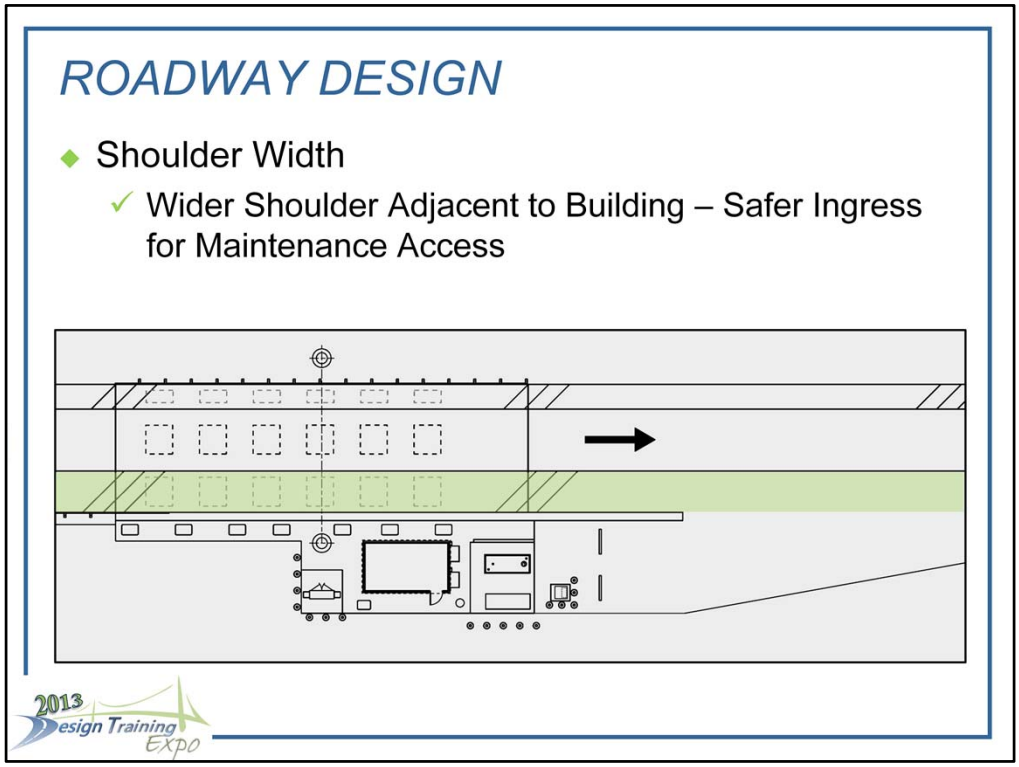
Another roadway design consideration to take into account within the tolling area is the <u>shoulder width</u>.

The minimum shoulder width that can accommodate a tolling loop is 6 feet.

Narrower shoulders without loops will lead to potential violation issues, especially for smaller vehicles and motorcycles.

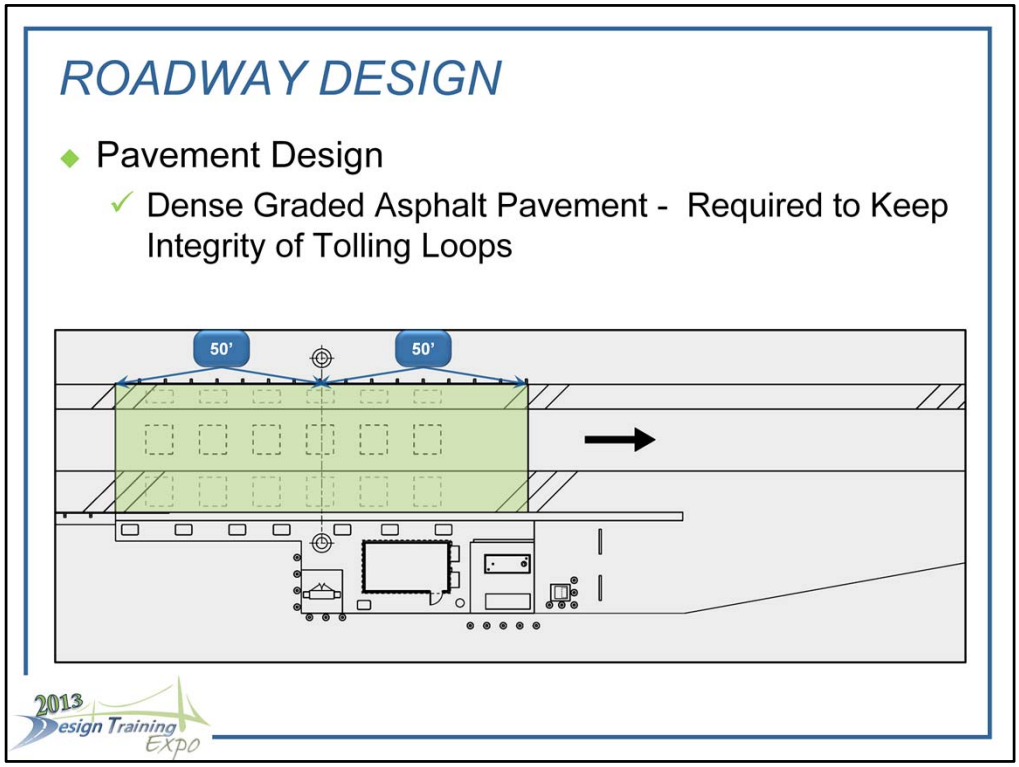
SO, If a 6 foot shoulder can not be provided, consideration should be given to minimizing the shoulder width within the tolling area.

The maximum desirable shoulder width, or lane width, within the tolling area is 15 feet. Beyond 15 feet the performance of a loop in that lane or shoulder is degraded.



Another consideration related to shoulder width, is the use of the shoulder adjacent to the toll equipment building as a deceleration lane for maintenance vehicles to access the sites pull off area.

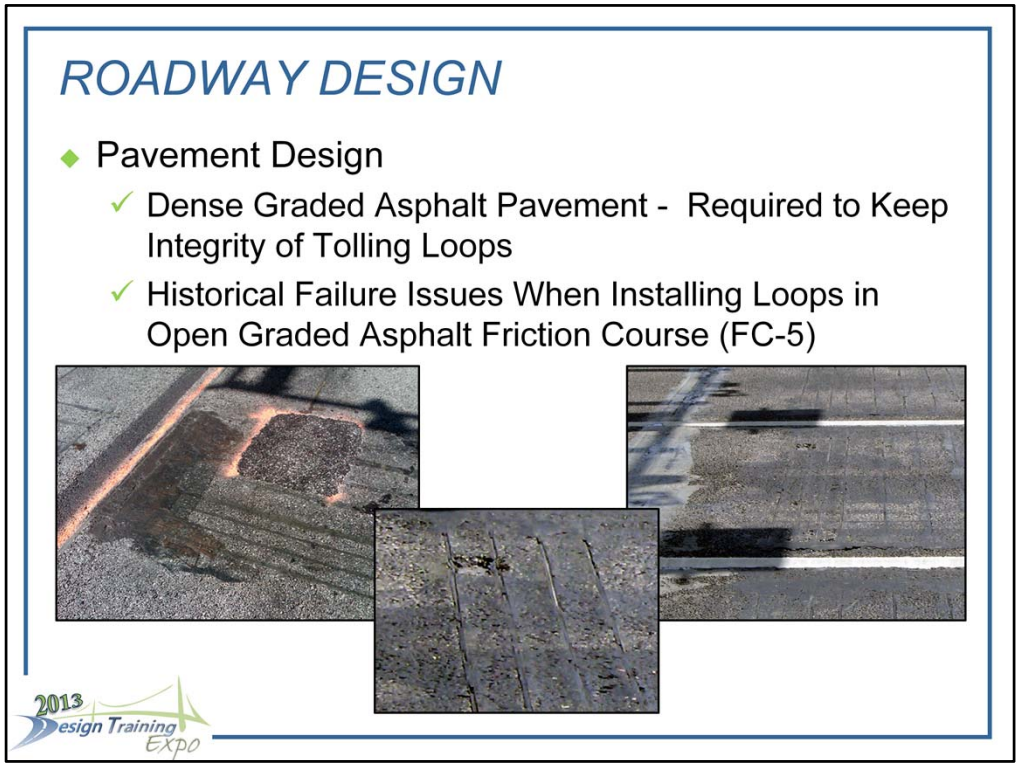
Given this operating condition, the equipment building and pull-off area should be located adjacent to the wider shoulder along the roadway or ramp, typically the outside of the right shoulder or left shoulder is acceptable.



Within the tolling area a significant amount of pavement cuts are required to install the necessary tolling loop array.

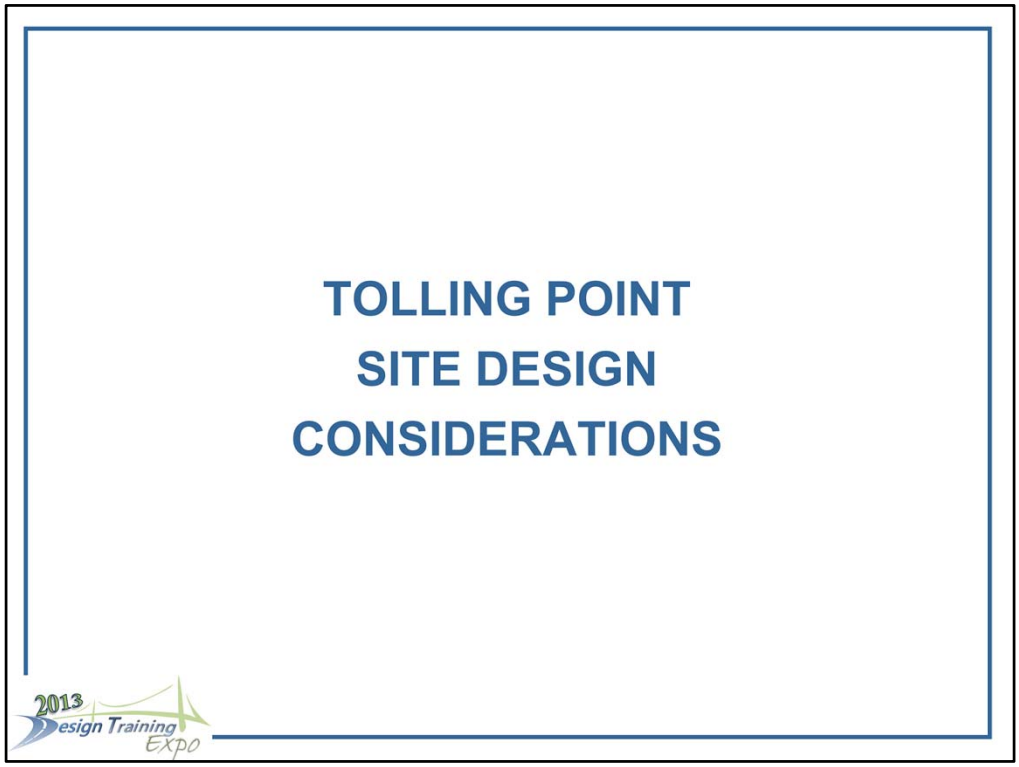
In order to maintain the integrity of the tolling loops it is required that the 100-foot tolling area, which is centered on the gantry with 50 feet on each side, consists of a dense graded asphalt pavement friction course.

A thorough evaluation of the existing pavement should be made to determine how the required tolling area pavement design can be accomplished, whether through milling and resurfacing or full reconstruction.

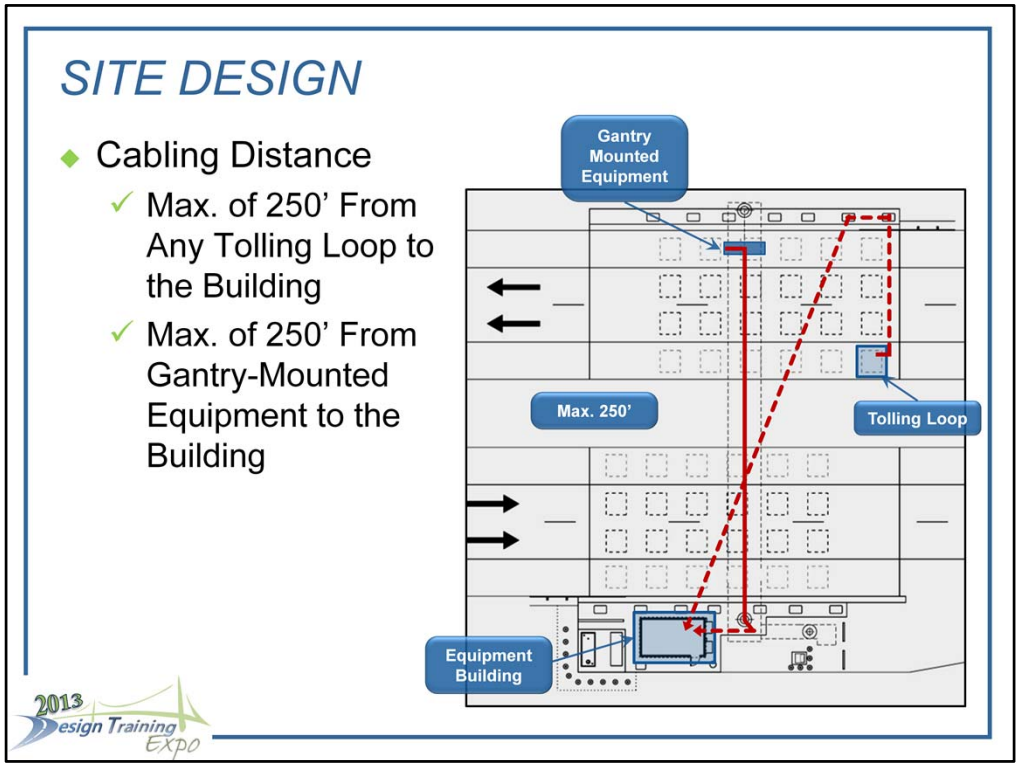


The requirement for a dense graded asphalt within the tolling area is based on historical failure issues that have been experienced when loops have been installed in open-graded asphalt friction course (FC-5).

These pictures illustrate FC-5 pavement raveling and failures which has led to reduced performance of the loops.
Replacement of the pavement and loops within a tolling point, results in significant maintenance costs, impact to traffic and can also result in a loss of revenue during the replacement construction.



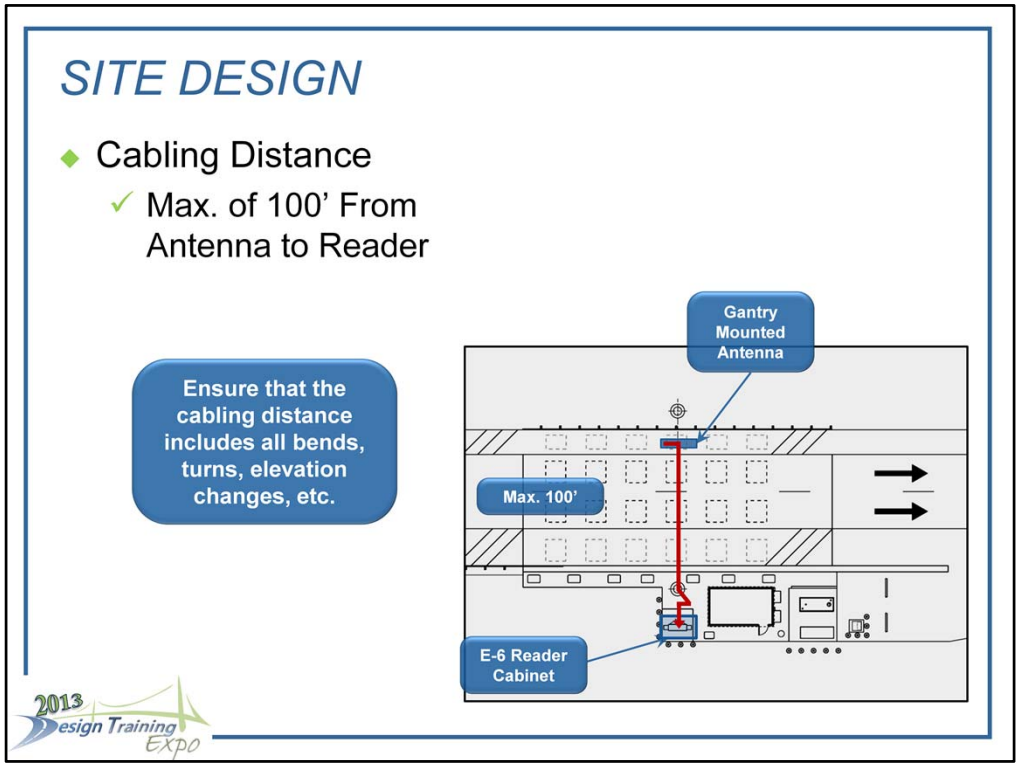
There are site design issues that should be considered when laying out and designing the tolling point, which includes the toll equipment building, associated infrastructure and the maintenance pull-off area.



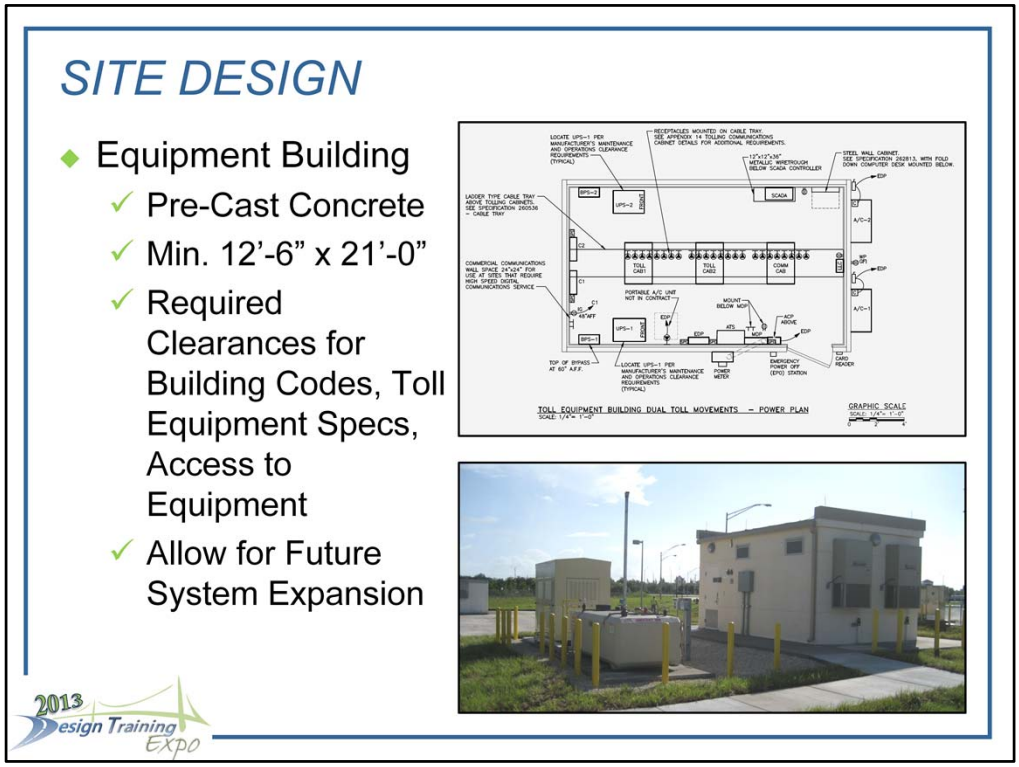
There are a number of cabling distance requirements that are of critical importance and represent criteria that cannot be exceeded.

There is a maximum cabling distance of 250' feet from any tolling loop to the servers/controllers in the equipment building.
There is also a maximum cabling distance of 250' from the gantry-mounted tolling equipment to the building.

These cable distances are required to ensure proper operation of the tolling system and meet accuracy and performance requirements.



Another cabling distance requirement is the distance between the gantry mounted antenna and the E-6 reader which can not exceed 100 feet, including bends and turns.
For a tri-chord gantry, the readers may be located in a separate NEMA cabinet or the equipment building.
For the accessible gantry the readers <u>can</u> be located within the gantry span, thus this cabling distance requirement is not an issue.



The tolling point site requires a building to house the racks of tolling equipment.

At the Turnpike we have tried to standardize the size and type of building used.

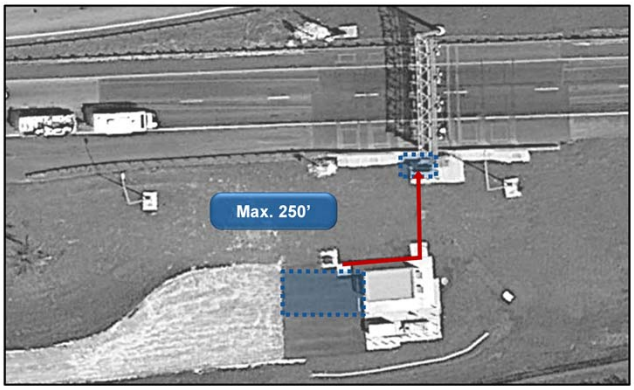
The standard is a pre-cast concrete building, a minimum of 12 feet, 6 inches by 21 feet.

Important considerations with respect to the building size are that
- The building be climate controlled for the computer equipment.
- The building meets the building code requirements for aisle space and electrical panel clearances.
- AND we meet the specifications for maintenance access clearances of the toll equipment itself.

Another important consideration in sizing the building is the ability to allow for future system expansion and the potential for accommodating other tolling systems.

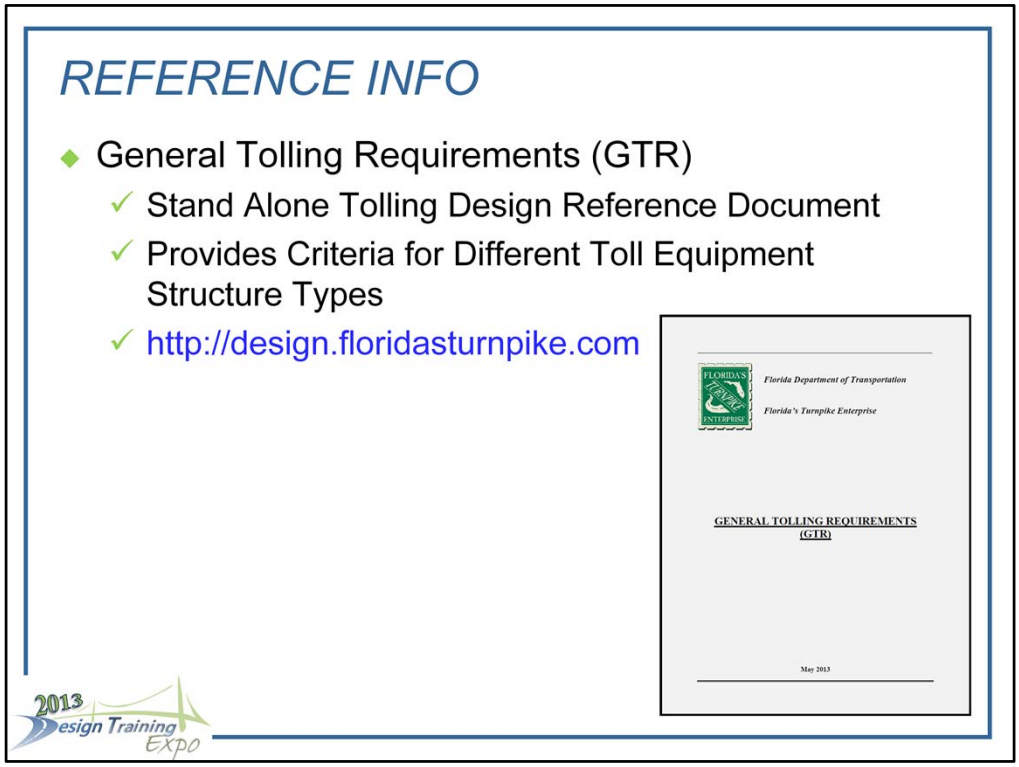
SITE DESIGN

- 250' From Pull Off Area to Equipment Building & E-6 Cabinet
  - ✓ Facilitate Maintenance of Toll Equipment



Another site design consideration is the distance from the maintenance pull off area to both the equipment building and the E-6 reader cabinet.
As previously shown on the standard site layouts, these facilities are typically located in close proximity and this is not an issue.
However, as site conditions dictate, especially in urban areas with limited right-of-way, the location of the pull-off area may need to be re-configured.
The preference is to limit the distance to the building or E-6 cabinet to 250 feet, if practical, in order to facilitate their maintenance.

REFERENCE INFORMATION



The Turnpike has prepared a General Tolling Requirements document that details the technical requirements for designing and constructing a new tolling point.
This document provides criteria for different toll equipment structures.
This is a stand alone reference document that will be available on the Design page of the Turnpike's website.
This document can be utilized by other FDOT Districts and agencies for new tolling projects in preparing Design-Build RFP's or in providing guidance to consultants for Design efforts.

REFERENCE INFO

- FTE AET Conversion Projects Completed & Under Construction
  - ✓ Phase 1, 2 & 3 (Homestead Ext., 43 Sites) - *Complete*
  - ✓ Phase 4A (Golden Glades Plaza, 1 Site)
  - ✓ Phase 5B (Sawgrass Expressway, 23 Sites)
  - ✓ Phase 6A (Veterans Expwy S. of Gunn Hwy, 10 Sites)
  - ✓ Phase 6B (Veterans Expwy N. of Gunn Hwy, 6 Sites)
  - ✓ Phase 6C (Suncoast Pkwy., 14 Sites)

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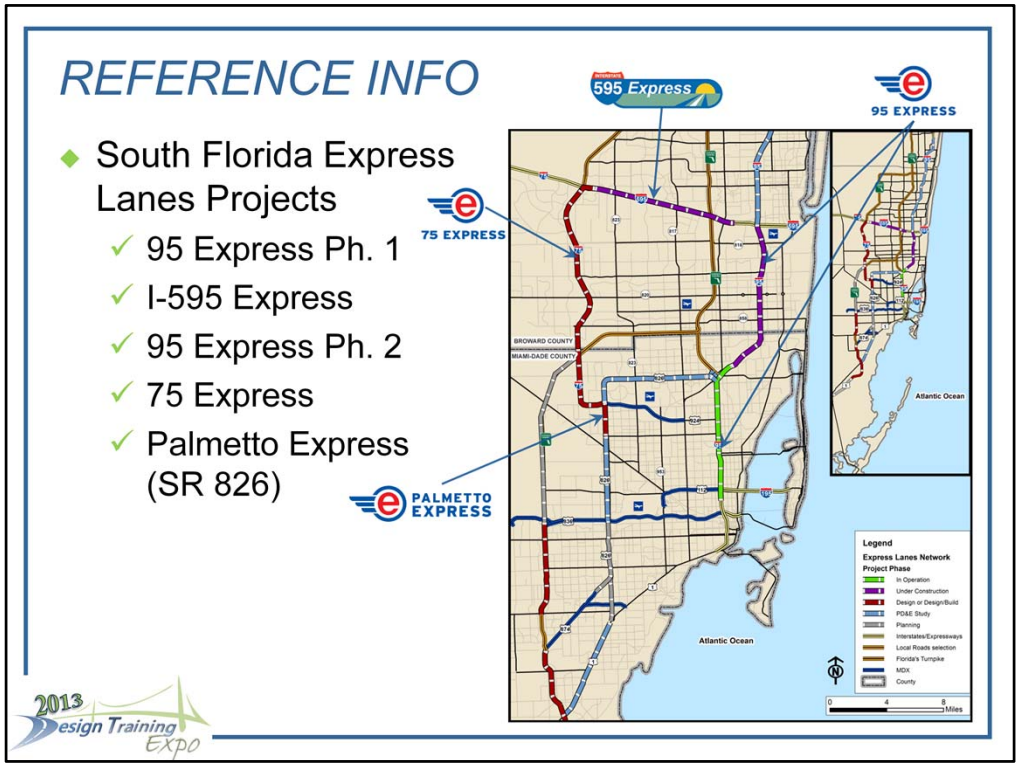
Another source of reference design information of tolling points are the completed and ongoing Turnpike projects, as well as a number of other major toll lane projects underway by FDOT Districts across the State.

The Turnpike has completed the conversion of the Homestead Extension in Miami-Dade County to AET. This 47-mile corridor includes 43 tolling points.
Other AET conversion projects the Turnpike currently has under construction:

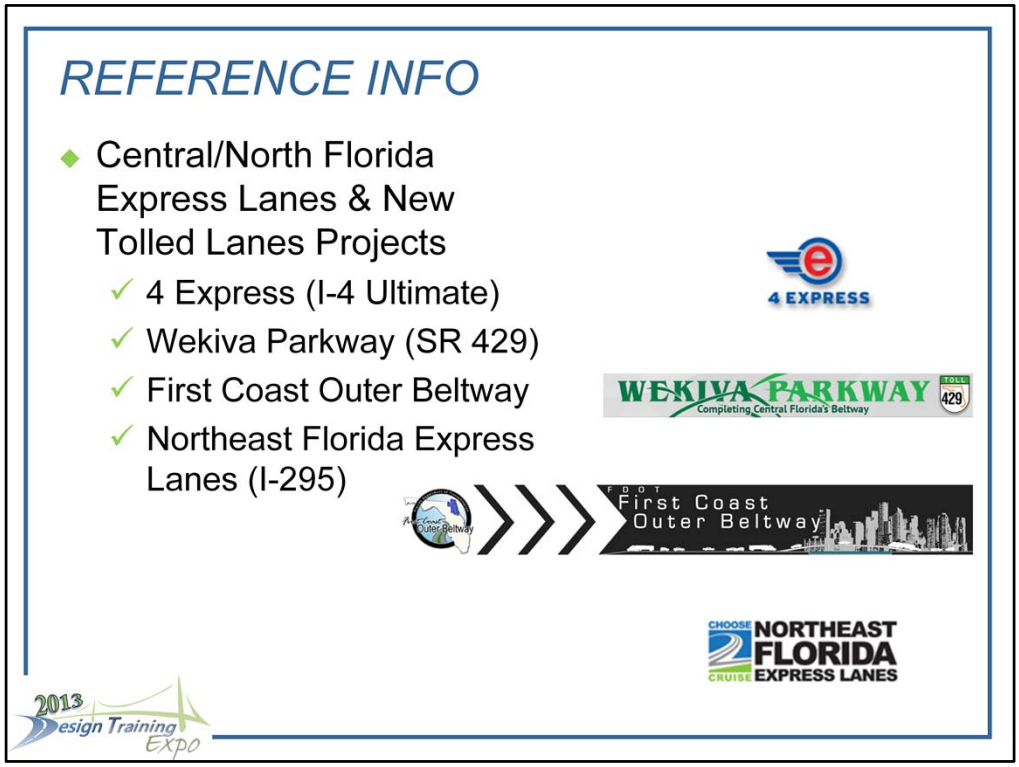
- Phase 4A at the Golden Glades mainline plaza along the Turnpike Spur in Miami-Dade County
- Phase 5B along the Sawgrass Expressway in Broward County, which is a design-build project
- Phase 6A along the southern portion of the Veterans Expressway in Hillsborough County, which is being completed in conjunction with the widening of the Veterans
- Phase 6B along the northern portion of the Veterans Expressway in Hillsborough County AND
- Phase 6C along the Suncoast Parkway in Pasco and Hernando Counties



In South Florida, the 95 Express Phase 1 project, which added tolled express lanes to Interstate 95 is open and operational.

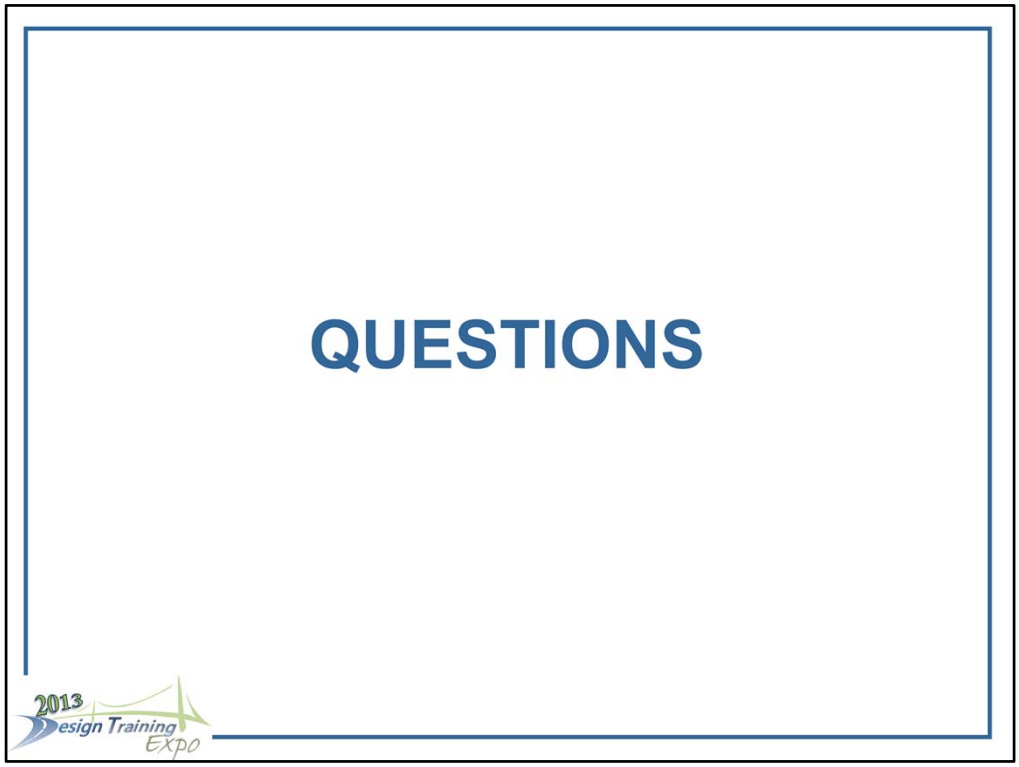
Some of the other major new toll lane projects in South Florida that are either under construction or in final design include:

- I-595 Express in Broward County, a triple p project.
- 95 Express Phase 2 in Miami-Dade and Broward Counties
- 75 Express in Miami-Dade and Broward Counties
- Palmetto Express (SR 826) in Miami-Dade County



There are also a number of major projects underway in Central and North Florida that will construct new toll lanes.
This includes:

4 Express, which is part of the I-4 Ultimate project in Central Florida
Wekiva Parkway, a new tolled roadway in Central Florida
First Coast Outer Beltway, a new tolled roadway in northern Florida
Northeast Florida Express Lanes (I-295)



Rodrigo De paula and Todd Bettger from Atkins.