

## 4. SITE DISCUSSION

According to the American Society for Testing and Materials (ASTM) standard entitled *Standard Specification for Highway Weigh-in-Motion (WIM) Systems with User Requirements and Test Methods* (ASTM Designation E 1318-94), WIM users must provide and maintain an adequate operating environment for the system to perform properly (1). Several factors that influence the performance of a WIM system are in the geometric design and pavement condition of the roadway and the overall site location. These factors influence the dynamic behavior of the vehicle and thus influence the accuracy of the estimate of the static weight made by the WIM system (4). ASTM Standard, Section 6 has guidelines to be followed when evaluating a possible location for a WIM site. Table 4.1 shows the WIM site principles that should be considered when selecting a location for a WIM system.

### 4.1 WIM Site Selection



*“The quality of the WIM data is dependent upon the quality of the site selected.”*  
 ... Caltrans.

**Table 4.1**  
**WIM Site Principles Checklist**

WIM Site Principles	
4.1	<b>Select the site based on the required site design life and accuracy performance level.</b>
4.2	<b>Evaluate the geometric design of the location on the following qualities.</b>
4.2.1	Determine if the horizontal curvature is acceptable.
4.2.2	Determine if the roadway grade is acceptable.
4.2.3	Determine if the cross slope is acceptable.
4.2.4	Determine if the lane is wide enough and marked properly.
4.3	<b>Determine if the pavement is adequate or if the pavement should be replaced.</b>
4.4	<b>Evaluate the site location on the following qualities.</b>
4.4.1	Determine the availability of access to power and phone.
4.4.2	Determine if there is an adequate location for the controller cabinet.
4.4.3	Determine if the site provides adequate drainage.
4.4.4	Determine the traffic condition at the site.

## 4.1 SITE SELECTION

The site selected for a WIM system should be based on meeting the required "site design life" and accuracy necessary to support the user. In order to meet these requirements, the geometric design, pavement condition, and general characteristics of a potential site should be considered. Selecting an adequate site for the WIM location is a very important part of meeting the established WIM system requirements.

## 4.2 GEOMETRIC DESIGN

The geometric design of a roadway is an important factor that provides a foundation for using dynamic load measurements to estimate static loads accurately. This is due to the influence longitudinal and transverse offsets have on the behavior of a vehicle. The ASTM Standard sets guidelines for the horizontal curvature, the longitudinal gradient, the cross (lateral) slope, and the width of the paved roadway lane. The guidelines are set for each type (Type I, Type II, Type III, and Type IV) of WIM system installation (*I*). Table 4.2 shows the ASTM Standard geometric design requirements for each type of system.

**Table 4.2**  
**ASTM Standard (E 1318-94) Geometric Design Requirements**

Characteristic	Type I	Type II	Type III	Type IV
Horizontal Curvature	radius $\geq$ 1740m 46m before/after	radius $\geq$ 1740m 46m before/after	radius $\geq$ 1740m 46m before/after	radius $\geq$ 1740m 46m before/after
Roadway Grade	$\leq$ 2% 46m before/after	$\leq$ 2% 46m before/after	$\leq$ 2% 46m before/after	$\leq$ 1% 91m before/after
Cross Slope (lateral)	$\leq$ 2% 46m before/after	$\leq$ 2% 46m before/after	$\leq$ 2% 46m before/after	$\leq$ 1% 46m before/after
Lane Width	3 to 4.5m 46m before/after	3 to 4.5m 46m before/after	3 to 4.5m 46m before/after	3 to 4.5m 46m before/after

### 4.2.1 Horizontal Curvature

The maximum allowable horizontal curvature for the roadway is identical for all four types of WIM system installations. The roadway has to have a horizontal radius of not less than 1740 meters (5,700 feet) for a distance of 46 meters (150 feet) before and after the WIM sensor. The radius is measured at the centerline of the lane in which the sensor is installed.

### 4.2.2 Roadway Grade

The maximum allowable roadway grade is the same for Type I, Type II, and Type III WIM systems. For these systems the roadway grade can not exceed two percent for a distance of 46 meters (150) feet before and after the sensor. For a Type IV system, the roadway grade can not exceed one percent for the 91 meter (300 foot) distance. No documentation was found for the minimum allowable amount of longitudinal waves in the roadway approaching the sensor.

#### 4.2 Axle Weight Transfer and Roadway Grade

*“The major data problem effected by installing a WIM system on a grade, say anything in excess of one percent, is the weight 'transfer' from the steer axle to the drive axle of the loaded trucks.” ... Caltrans.*



#### 4.2.3 Cross Slope

The maximum allowable cross (lateral) slope of the road surface is the same for the first three types of WIM systems. For these systems the cross slope cannot exceed two percent for a distance of 46 meters (150 feet) before and after the sensor. The road surface 46 meters (150 feet) before and after a Type IV system cannot have a cross slope in excess of one percent.

#### 4.2.4 Lane Width

A guideline for the width of the paved roadway lane is the same for the four types of systems. For 46 meters (150 feet) before and after the sensor the width needs to be between 3 and 4.5 meters (10 and 14 feet) depending on scale width. For Types III and IV the lane must be marked with a solid white line, 100 to 150 millimeters (4 to 6 inches) thick, running parallel to the lane. Additionally, one meter (three feet) of clear space must be provided on each side of the WIM sensor lane when the system is used on a ramp.

### 4.3 PAVEMENT CONDITION

The roadway pavement condition is important in the reduction of vehicle bounce. According to Deakin, “Vehicle bounce, resulting in variations in the vertical load imposed by a moving axle, increases with road roughness, leading to greater variations in the instantaneous axle loads (5).”

The guideline set forth in the ASTM Standard E 1318-94 states that for a distance of 46 meters (150 feet) before and after the sensor the roadway surface “shall be maintained in a condition such that a 150 millimeter (6 inch) diameter circular plate 3 millimeters (0.125 inches) thick cannot be passed beneath a 6 meter (20 foot) long straightedge (*I*).” The standard also states that a foundation must be provided and maintained to accommodate the sensors. The Oregon Department of Transportation uses a profilograph to measure the pavement roughness, shown in Figure 4.1 on the following page.



Photo courtesy of Oregon DOT

**Figure 4.1 Use of Profilograph to Measure Road Roughness**

Caltrans' successful practice requires that all WIM systems be installed in Portland cement concrete (PCC) pavement to provide roadway stability, durability, and smoothness throughout the 10 to 15 year expected equipment life. Caltrans guidelines establish that the PCC pavement should be the thickness shown on the construction plans or 300 millimeters (one foot), whichever is greater. If the WIM system is to be used on a roadway that is asphalt concrete (AC) pavement, the AC pavement must be replaced with PCC pavement for a minimum distance of 15 meters (50 feet) before and 7.5 meters (25 feet) after the sensor (6). The base structure at the sensor location follows the established parameters for that roadway. The Draft Long-Term Pavement Performance (LTPP) Program Specification sets a minimum pavement strength using a falling weight deflectometer (FWD) test. Using an applied load of 4,080 kilograms (9,000 pounds), the pavement deflection must be between 0.305 and 0.457 millimeters (0.012 and 0.018 inches) and the area of the deflection basin must be 17400 square millimeters (27 square inches) or greater. The Draft LTPP Standard notes that the pavement must be designed to operate near these strength levels throughout the year, even during periods when the pavement structure is weakened by high moisture content or thaw conditions (7).

#### *4.3 Pavement Condition*



*“If the WIM equipment is not installed in pavement that is both stable and smooth, the estimates of static weight will not be very accurate.” ... Caltrans.*

## **4.4 SITE LOCATION**

The location of a WIM site should be based on more than just the need for truck traffic data (8). The site needs to be located in an area with specific qualities including:

1. Availability of access to power and phone
2. Adequate location for controller cabinet
3. Adequate drainage
4. Traffic conditions

### **4.4.1 Availability of Access to Power and Phone**

The site should have access to an AC power source and telephone utilities. Solar power and cellular phones can be used if utilities are not available. The power source and phone service used at a site is dependent upon the amount of truck data collected at the site. For more active sites Caltrans determined that wired phone service would be more cost effective than cellular (wireless) service.

### **4.4.2 Adequate Location for Controller Cabinet**

The controller cabinet should be located so that it will function throughout the design life of the site. The cabinet needs to be in an area so that:

1. It will not be subjected to runoff during heavy rains or to standing or moving water from irrigation or drainage facilities
2. It can not be hit by a vehicle leaving the roadway, preferably behind a guardrail
3. It is accessible with a clear line of sight to the sensors
4. It can be serviced without endangering the technician(s)

Items three and four are important because technicians may need to spend time at the controller cabinet during system testing, calibration, and maintenance.

### **4.4.3 Adequate Drainage**

Drainage should be adequate for the controller cabinet, junction boxes, and WIM sensors. The site should not be located in an area subjected to flooding. The water can be directed to the roadside's outside slope or an existing drainage facility.

#### **4.4.4 Traffic Conditions**

WIM systems should be in an area of free traffic flow with good sight distances. The traffic conditions should be such that:

1. Stop and go traffic is minimized
2. Slow moving traffic is minimized
3. Lane changing is minimized
4. Passing on two lane roads is minimized