Surveying a Curb Ramp Quadrant for 3D Modeling

1. Equipment needed
   - Safety – Hardhat, reflective vest, proper footwear and attire for conditions
   - Horizontal data – Survey tape (50’ or greater), blade tape measure
   - Vertical data – Optical level (automatic level), tripod, grade rod
   - Slope readings – Digital level
   - Layout – Construction line, stakes, hubs, nails, chalk, crayon
   - Stationary – Pens and pencils, eraser, scale bar, duct tape
   - Hand tools – Shovel, hammer, broom (may need hand tools for site prep)

2. Establish the back of sidewalk axis (or axes)
   - Run a taught construction line along the back of sidewalk and extend this straight line through to the opposing curb face for each existing sidewalk leg. In lieu of using construction line, the use of surveying tape held taught can also create a straight reference line. Mark the curb face intersection point with a fluorescent paint dot. For back of sidewalk axis A this point is defined as point number 9. For back of sidewalk axis B this point is defined as point number 5. Refer to the field data collection diagram for axis and point definitions.
   - Field conditions will vary, and a clear back edge of sidewalk may not be visible. Site cleaning and preparation may need to be done prior to laying out an axis and taking measurements. Removal of snow, ice, leaves, soil, etc. from the immediate area, and edging the sidewalk, will allow for a clearer reference line and may be necessary in order to take accurate distance measurements and grade readings. For instance, if there are leaves and debris next to the curb face at the edge of pavement you would first need to clear the area of the debris prior to shooting a leveling rod reading.
   - Establish the axis (or axes) to the best of your ability given varying conditions and configurations. The key to accuracy in this procedure is that the reference line is straight, it runs out to a defined intersecting point on the curb face, and the offset measurements are taken from the reference line (not necessarily the back of sidewalk at that point).

3. Determine and mark point number 1
   - For a quadrant with two sidewalk legs intersecting, point number 1 is defined as the intersection of axis A and axis B.
     i. If the intersection point between axis A and axis B ends being out in the roadway (which generally would be from a combination of large curb radius and minimal sidewalk offset), then this procedure will not work as developed. Please refer to the alternate procedure for quadrants with a large curb radius or severely acute skew angle.
• For a quadrant with one sidewalk leg, point number 1 is defined as being five feet (5’) back from the curb face along the existing back of sidewalk axis.

• Check the appropriate point number 1 box on the plan view diagram. See below.

4. Locate a sidewalk joint to tie into

• Determine a suitable tie in location approximately twenty-five feet (25’) from the curb face along an existing sidewalk joint. Mark the point at the back of sidewalk on the section that would be left in place, at the joint. Using surveying tape, measure from the curb face intersecting point along the back of sidewalk axis to this joint and record. For back of sidewalk axis A, this will be from point number 9 to point number 2. For back of sidewalk axis B, this will be from point number 5 to point number 3.

• Along the back of sidewalk axis, mark another point at a distance equal to the joint measurement (from the previous bullet point) minus ten feet (10’).

5. Mark and measure offsets

• Run a taught construction line (or taught surveying tape) perpendicular to the back of sidewalk axis from the points established in the previous step out to the face of curb. Use a 3-4-5 triangle (or multiple thereof) with field measurements and construction line to ensure the line is perpendicular. See detail below.

• Alternatively, existing sidewalk joints can be used to sight a perpendicular offset to save time and get an approximate offset line.
Laying Out a Perpendicular Line Using a 3-4-5 Triangle

- Measure horizontally from the back edge of sidewalk to the front edge of sidewalk, the back edge of curb, and the curb face. Mark these points with fluorescent paint dots. Repeat the process for both back of sidewalk points from the previous step, for each sidewalk leg that exists.

6. Mark and measure curb radius points

- For a quadrant with two sidewalk legs intersecting, points 6 and 8 are the intersections of the front edge of sidewalk and the opposing curb face. Point 7 is directly between points 6 and 8. Point 4 is two feet (2') from point 5 along the curb face away from the street corner, and point 10 is two feet (2') from point 9 along the curb face away from the street corner as well.

- For a quadrant with one sidewalk leg, only point 6 or point 8 can be defined by the front edge of sidewalk. The other point locations will need to be determined by the engineer in the field in order to distribute the points in a logical fashion across the curb radius. For example, if there is sidewalk only along axis A, then points 5, 6 and 7 should be placed along the curb relatively equidistant from one another in a way to represent the remainder of the radius when modeling. The distance between points 4 and 5, and points 9 and 10 will still be set at two feet (2').

- Measure the horizontal distance from point 1 to points 4 through 10, and record. If sidewalk only exists along axis A, measure from point 9 to points 5, 6, 7 and 8. If sidewalk only exists along axis B, measure from point 5 to points 6, 7, 8 and 9. If sidewalk exists along both axes, then you may choose point 5 or point 9 to measure the other points from. Dependent on what point is measured from, fill out the point-to-point measurements table appropriately.
7. Determination of the skew angle

- For a quadrant with two sidewalk legs intersecting, the data from the previous step will be sufficient in order to calculate the skew angle between the sidewalk axes A and B.

Using the law of cosines and solving for angle $C$, we get: $C = \text{ArcCos}\left(\frac{a^2 + b^2 - c^2}{2ab}\right)$

- Leg $a$ is defined as the horizontal measurement from point 1 to 9, leg $b$ is defined as the horizontal measurement from point 1 to 5, and leg $c$ is defined as the horizontal measurement from point 5 to 9. Re-enter these measurements into the corresponding boxes marked $a$, $b$ and $c$. See detail below.
For a quadrant with one sidewalk leg, the skew angle would not be between two sidewalks, but would be between the one existing sidewalk axis and the curb face of the opposing roadway. This is necessary in order to model what the roadway and curb are doing as they are going away from the street corner. There are two cases to consider when only one sidewalk leg exists, and it depends on whether the curb face intersecting point (point 5 or 9) is on the curb radius or is on the tangent section of curb.

i. When the curb face intersecting point is on a tangent section, two additional measurements are needed. Another point will need to be field determined by the engineer a minimum of five feet (5’) from the curb face intersecting point (point 5 or 9) away from the street corner. Measure the horizontal distance from point 1 and from the curb face intersecting point to this field determined, skew angle reference point. For example, if sidewalk only exists on axis A, then leg a is defined as the measurement from point 1 to point 9, leg b is defined the measurement from point 9 to the skew angle reference point, and leg c is defined as the measurement from point 1 to the skew angle reference point. See detail below.

**Skew Angle Case 2**

ii. When the curb face intersecting point is on the curb radius, three additional measurements are needed. Run a taught construction line (or taught surveying tape) along the tangent section of curb down to the back of sidewalk axis line. Continue the back of sidewalk axis line out to meet the tangent curb line and mark the intersecting point on the pavement. A skew angle reference point on the tangent section of curb will need to be field determined by the engineer a minimum of five feet (5’) from the curb face intersecting point away from the street corner. Horizontal distances between each point (point 1 and the two points that have just been established) can now be measured and recorded. See detail below.
8. **Shoot relative grade for each point**

- In order to create a 3D model only relative grade changes are needed; not true elevations. Therefore, a benchmark does not need to be established. Setup the optical level in a location that will be able to shoot all the applicable points without obstruction, and as not to be too low for higher elevations. Typically, you will want to setup on the opposite side of the roadway (not in the roadway) to provide sufficient distance between the level and the leveling rod.

  i. If field conditions require the use of a second setup location to shoot all points, then a back sight reading would need to be taken with differential field calculations for each grade reading from the second location. This basic surveying process is not covered in these instructions.

- Indicate on the data form what type of grade rod is being used. A typical engineer’s surveying rod has lower numbers on the bottom and higher numbers on top. Common types of these leveling rods are the Philadelphia (“Philly”) and San Francisco leveling rods. On the other hand, a direct reading rod, also known as a “True Elevation” or “Lenker” rod, has higher numbers on the bottom and lower numbers on top. Depending on which type is used for the grade readings, the relative grades would be inversed.

- Extend the tripod legs out to a comfortable viewing height. Attach the leveling head. Get the head nearly level, secure the tripod from moving, and then use the thumbscrews to completely level it out. Take readings and record the actual grade rod readings in the corresponding boxes of the data sheet. Back of curb readings will be at curb height, while curb face readings will be at the existing pavement elevation. For grading purposes, take readings two feet (2’) perpendicularly back from the back of sidewalk axis points already established (see field data collection diagram).

- Fill in all applicable rod reading (R.R.) boxes prior to disassembling the optical level setup. If the designer determines it may be useful, additional relative grade readings can be obtained for site-specific features and included on the designer sketch diagram. Features such as manholes, underground utility vaults, structural foundations, etc., may require consideration.
9. Digital level slope readings

- Running grade and cross slope reading areas are shown on the plan view diagram. For sidewalks, running grade readings are with the direction of pedestrian traffic, while cross slope readings are perpendicular to pedestrian traffic. Counter slope readings are with the direction of pedestrian traffic at the edge of pavement, while cross slope readings are perpendicular to crosswalk foot traffic. Roadway grade readings are shown at the extents of the diagram, and are useful for modeling what the roadway is doing immediately beyond the survey points previously obtained.

- Take representative slope readings at the areas shown on the plan view diagram and record the percent slope in the corresponding boxes. For each reading, circle the arrow head on one side to indicate the direction of positive drainage.

10. Capture standard photos

- There are five standard photo angles that should be captured at each site. The location and orientation are shown on the field data collection diagram.

- Along with the standard photos it is encouraged to take site-specific feature photos. Certain features such as utilities, drainage structures, ROW constraints, etc., should have photo documentation and are useful in the design process. Using conventional symbology that is depicted on the feature diagram, note the location and orientation of the camera and number in sequential order (beginning with 6).

11. Sketch and note existing features

- To compliment the spatial data already obtained, a sketch of the existing configuration and features should be completed on the feature diagram. Take note of the location of utilities, drainage structures, drainage flow lines, utility poles, street lights, fire hydrants, trees, building features, fences, and a host of other facilities that could be present.

- The designer notes section is an opportunity to detail characteristics of the site that spatial data and photographs do not capture. Anything pertinent to the planning and design of curb ramp alterations at the specific site should be sketched and/or noted.

12. Generate a 3D model with the data obtained

- The spatial data obtained can now be used to generate a 3D model which in turn can be used to design a curb ramp alteration. The capabilities of modern CADD software which allow the same model to be constructed in a multitude of ways, coupled with an individual’s own personal preferences when it comes to how a model is constructed, leaves the method of constructing the model up to each designer or drafting technician.

- The horizontal data works off of two axes with a known skew angle between them. Perpendicular offsets from these axes have been measured and recorded.

- The curb radius points gathered can be interpolated using triangulation. Each point has two other points with a measured horizontal distance between them.
Relative grade changes are shown in the form of actual rod readings. If an engineer’s grade rod was used, then a negative rod reading difference from one point to another is actually a positive relative grade change. Inversely, if a direct elevation rod is used, then a negative rod reading difference from one point to another is a negative relative grade change. Be sure to take note of which type of grade rod was used to collect the data.

Slope readings from the digital level at the extents of the sidewalk and roadway can be used to extend the model beyond the data points collected. These readings help answer questions regarding counter slope conditions, roadway grade, sidewalk profile grade, and sidewalk cross slopes.

Each completed 3D model showing the existing spatial elements should have an original design file kept free of alterations, with a copy made for each working design alternative being considered.

13. Design process of the curb ramp alteration

- Incorporating accessible pedestrian elements in the public right-of-way requires reference to standards and technical documents. Refer to the 608-01 Sidewalk Curb Ramp Details standard sheets for guidance in selecting an appropriate curb ramp configuration. The Critical Elements for the Design, Layout and Acceptance of Pedestrian Facilities form lists design and layout limits, and includes references to the technical documents that the information was gathered from.

- Alterations under the ADA are required to meet new construction criteria to the maximum extent feasible. Several design schemes may have to be developed and analyzed before a preferred alternative is selected. Check the proposed curb ramp design against the Critical Elements for the Design, Layout and Acceptance of Pedestrian Facilities form. Prior to accepting a design that is not fully compliant explore different configurations and imaginative solutions.

**HDM Chapter 18 Resource Links**
[Critical Elements for the Design, Layout, and Acceptance of Pedestrian Facilities](#)

- If unable to design a curb ramp that is fully compliant with all the critical design elements of a pedestrian facility, then a design that “provides accessibility to the maximum extent feasible” may be accepted. Where existing constraints in an alteration project prevent the full implementation of accessibility objectives, exceptions in alteration work that do not fully implement accessibility standards must be predicated on technical infeasibility. Non standard features need to be justified using Exhibit 2-15a.

**HDM Chapter 2 Resource Links**
[Exhibit 2-15a - Nonstandard Feature Justification for Pedestrian Facilities](#)