PDHonline Course L108 (2 PDH)

Railroad Surveys, Profiles and Topographic Surveys

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Course Content

Types of Railroad Surveys

Depending on the information needed for a particular project, and the design goals set for the project, different types of surveys may be required.

When submitting documents for a utility crossing under or over a railroad, a plan view and roadbed cross-section view are generally required. The plan view requires a **topographic survey** that incorporates an established coordinate system with control points, or uses the centerline of track as the survey base line. For utility crossings, a **cross-section** view is cut perpendicular to the track, and includes the roadbed shape, ground line, slopes, the top of rail elevation, and the right-of-way limits.

If a survey is required for the design of new track or track changes to an existing facility, a topographic survey using a coordinate system is usually most efficient.

Track profiles, based on top of rail elevations, are often required for projects involving highway grade crossings or grade separations, culvert and bridge replacement projects, and are also required for the design of sidings and spurs.

Cross-sections are often required when designing new tracks, using data from the cross-sections to develop earthwork quantities.

When investigating or defending claims of encroachments on the right-of-way, a **boundary survey** and/or **centerline base line survey** may be required. Centerline stations and offsets are used to determine whether a building, road, fence or other structure is encroaching on the right-of-way.

The railroad survey must be designed to incorporate all of the essential elements required to meet the design goals for the individual project.

The Basics of Railroad Surveying

The Railroad track centerline is the reference used in many railroad surveys. Each railroad is typically stationed every 100', measuring along 100' chords in curves, and stations are referenced on **Valuation Maps**. Val maps, as they are nicknamed, were created at the turn of the 20th century in order to have a basis for taxing each railroad property. Most railroads require, or at least prefer, that surveys be tied into an existing Valuation Station and milepost. It is best not to use moveable objects such as mileposts or whistle posts as references. Culverts and bridges are generally not moved, and make good reference points for tying into Val Stations.

Since the **centerline of track** is the basis for surveying and drawing railroads, the centerline must be established in the survey. The centerline is exactly one-half the gage distance from the gage side of either rail. A plumb bob and folding ruler or tape are typically used to set a tack or PK nail in a crosstie or hub to set the centerline. Tacks are usually set every 100' in tangent track (straight track) and every 50' in curves.

Gage is defined as 4' 8 –1/2", or 4.70', and is measured at a point on the rail 5/8" from the top of each rail. It is the standard gage between rails that allows railroad cars to travel on almost every railroad line in North America without any equipment modification or track modifications.

The track may be stationed using a 100' steel chain, marking stations on the rail every 100'. A paint crayon or lumber crayon (keel) may be used for marking stationing on the rail. Lumber crayon is not permanent.

Mileposts are used as reference points along each railroad. Stationing increases as mileposts increase. Milepost 0 is usually represented by Station 0+00.00. Measurements are taken either right or left of the centerline, perpendicular to the centerline of track, looking in the direction that stations increase. When performing a survey, make every attempt to locate the distance to the nearest milepost. It will be used as a reference for the railroad.

In centerline base line surveys, physical features are referenced to an offset in distance from the railroad centerline, perpendicular to the centerline of track, at a precise centerline station location. For example, a power pole might be located at Val. Sta. 103+10.05, 10.5' Left of centerline.

Profile surveys consist of taking top of rail elevations on one rail, usually every 100', on even stations if possible. In curves, the high rail is usually profiled, recording the superelevation (difference in elevation between the top of each rail at a given station). In design, the low rail top of rail elevation is used; then, superelevation is put in the track. Top of rail profiles are generally plotted on a 1"=100' horizontal scale and 1"=10' vertical scale, or other similar proportional scale. The choice of **scale** typically follows the scale used for the Plan view.

Railroad Curves are based on the chord definition, where:

D = degree of curve, in degrees

R = Radius in Feet

T = Tangent Length from PC to PI

L = Length of curve measured in 100' chords

I = Delta or intersection angle, in degrees

Elements of a Topographic Survey

Topographic surveys for new track construction or highway-related projects need to include the following elements:

- Location of existing track centerlines
- Terminals
- North Arrow (Magnetic or true north)
- Existing rail section
- Location of switches (turnouts), derails, bumping posts
- Culverts, bridges or other drainage structures
- Above ground and underground utilities
- Fences
- Roads

- Buildings
- Waterways
- Milepost reference
- Valuation Station reference
- Right-of-way width

Safety Issues

In the United States, trains can operate at speeds commonly approaching 80 – 90 miles per hour. On lines where passenger trains operate, train speeds are generally 10 mph faster for passenger trains than for freight trains. On downgrades, or level sections, engines are often in the 'idle' mode, resulting in a very, very low noise level. In rolling to hilly, or mountainous terrain, curves are more common, reducing the sight distance for spotting an on coming train. These conditions can result in extremely unsafe conditions for the surveyor.

There are several basic rules that must be adhered to in order to provide for the survey crew's safety:

1. Contact the railroad and obtain a right-of-entry permit. At that time, determine the railroad rules regarding permission for track time and safety rules. You may have to be accompanied by a railroad representative, and go through safety training particular to that Railroad.
2. Do not step on the rail, or rest your foot on the rail. This can, and has lead to many types of accidents.
3. Never place your foot or hand between switch points and stockrails. Some switches are operated by remote control, and the switch points can be thrown instantly, causing one's extremities to be crushed.
4. Never stand on, or near the track, or between the two rails without having permission for track time, which is permission from a dispatcher, following railroad rules.
5. Make sure that you are occupying the proper track in areas where there is double track or other multiple track configurations.
6. Wear a bright orange vest for visibility.
7. Wear hard hat and high top boots. Many railroads also require the use of safety glasses and hearing protection.
8. If you hear a train whistle or locomotive sound, get off the track immediately, and stand at least 10-15 feet from the edge of crossties. It is best to set equipment up just off the roadbed, and not in the track.
9. Try to determine whether there will be trains operating on your section of track, and what general time to clear up. This information should be determined when permission for track time is obtained each day.
10. Do not become complacent. Trains can be silent as they approach, especially on level track or down grades. Trains represent a safety hazard, but other on-track machinery can be just as dangerous. Be aware of maintenance and inspection vehicles and equipment.

Terminology

The following terms are used frequently in describing track geometry, track structures, and components, and are essential to the execution and documentation of a proper survey.

Branch Line – Usually a single ended line that runs from a main line junction to an ending terminal.

Bridge – A structure used to cross roads, other tracks, waterways, valleys, gorges, or other low ground. Bridges are usually considered open deck (you can see through the ties), or ballast deck (there is deck material that supports stone ballast and the track.

Centerline – The imaginary line, located exactly halfway between the two inside (gage side) faces of the rails. The Centerline can be established by measuring 2.35' (2' 4 ¼") from the gage side of either rail.

Culvert – A drainage structure used to convey storm water from one side of the track to another; or, a lateral drain situated under roads at grade crossings. The types of culverts under railroads are generally corrugated metal pipe (CMP); bituminous coated corrugated metal pipe (BCCMP), cast iron pipe (CIP), reinforced concrete pipe (RCP); vitrified clay pipe (VCP); terra cotta pipe (TCP) or concrete box culvert (CBC).

Derail – A safety device used to derail freight cars or engines in order to keep them from entering a main line track or other track that may be occupied by a train. Where locomotives or cars are being worked on, derails must be marked by a blue flag.

Easement – Usually refers to property with rights granted for railroad use, but reverts to original land owners if railroad use is discontinued, or the railroad abandoned.

Encroachment – Any building, road, fence or other structure, or portion thereof, which is built or placed on the right-of-way or easement, with or without permission.

Fee Simple Ownership – Usually refers to property purchased outright, with no restrictions to use or resale.

Frog – The track component found in turnouts where the two middle rails cross. The actual point of frog is located on the end of the frog closet to the switch stand.

Gage – The measurement between the inside faces of the two rails. Standard gage in the United States is 4' 8 ½" (4.70'). Half Gage is 2.35'.

Lead Track – A track, usually off of a main line, that leads to a facility or industry.

Main Line Track – A track running between major terminals.

N.G. the point in a switch where the two track centerlines cross, standing for 'no gage', also referred to as the I.P. (Intersection Point in the switch).

P.C. – Point of Curve, the point where the curve begins, as survey stations increase.

P.I. – Point of Intersection of two tangent lines that meet to establish a curve.

P.T. – Point of Tangent, the point where the curve ends as survey stations increase.

P.T.S. – Point of Tangent to Spiral, as survey stations increase.

P.S.C. – Point of Spiral to Curve, as survey stations increase.

P.C.S. – Point of Curve to Spiral, as survey stations increase.

P.S.T. – Point of Spiral to Tangent, as survey stations increase.

P.S. - Point of Switch– The point on the track where the moveable switch points end.

Rail Section – Refers to the design of the rail and the approximate weight per yard length of rail, e.g., 100 AREA (100 RE).

Right-of-Way – the limits of ownership of the Railroad's property. Commonly 50', 100', or 200' in width, but varies by railroad and location.

Siding – A double-ended track, generally used for passing trains, but sometimes used for storage or switching cars.

Spur Track – A single ended track, usually short in length, serving an industry or single function.

Switch (Turnout) – A track structure used to move trains from one track to another by means of moveable switch points.

Terminal – The name of the town, city or junction at the end of a section of main line track.

Track Centers – The distance measured between the centerlines of two track, perpendicular to the rail.

Survey Equipment

The most efficient means for conducting a railroad survey is the **total station**, with electronic distance measuring. Radial surveys can often be performed with very few set-ups and very tight control. **Data collectors** allow the surveyor to efficiently capture and earmark data for simple downloading and drawing.

Global Positioning Satellite (GPS) receivers can be used to establish control points, but are not always useful or cost effective on smaller projects.

Laser levels and measuring wheels may be utilized for a simple one-person profile survey where precision is not imperative.

A **theodolite or transit,** and steel chain can be used, but are far less accurate than modern equipment.