FDM 9-50-1 When Used

October 28, 1994

The alignment of new and existing highways is the major control line for all types of records. All projects will have a center line or reference line with stationing assigned. This reference line establishes a base to which other engineering information can be referenced. A reference line should be established during the early stages of project development because cross sections, topography, and other needed engineering information is tied in to this base line. Some projects, such as an aerial project or a relocation, may not have the alignment staked before right-of-way acquisition time or even to time of construction.

FDM 9-50-5 Standards and Specifications

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Since the alignment serves as a reference line that other engineering information is based upon, it is essential that some general standards and specifications are followed to ensure a certain degree of accuracy.

5.1 Alignment Surveys

The horizontal alignment survey may be coincidental with the project base control survey, especially when an alignment can be surveyed early in project development and adequate control station spacing can be obtained. When the horizontal alignment surveys are not coincidental with project base control, the alignment should be either laid out from or tied to the base control survey to establish state plane coordinates on the alignment. In either case the alignment should be tied in to the "State Plane Coordinate System" on the appropriate North American Datum, if it can be done economically.

Normally, the horizontal alignment survey is executed as a control survey, based on the criteria in FDM 9-35-5, resulting in relative positional accuracies of at least one part in 10,000 for alignment points.

5.2 Reference Line With Stationing

The basic highway reference line should be the center line of a normal two-way roadway. The basic reference line of divided highways may be located either along the center line of the median or along the median edge of the traveled lane of the right-hand roadway in the direction of stationing. An auxiliary reference line along the median edge of the traveled lane of the left-hand roadway may be desirable when roadways are not parallel or concentric, or are widely separated.

All mainline stationing of projects should increase from west to east or south to north based on the cardinal direction of the overall highway route, not just the portion of the highway within the project under design. Side road stationing shall increase from left to right of main line stationing.

FDM 9-50-10 Field and Office Reconnaissance

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The existing alignment is very important, even if the project is only resurfacing. Before covering evidence of the existing alignment, it is essential to locate and preserve the alignment before construction operations. The perpetuation and monumentation of an existing alignment will help to ensure a consistent relationship between all previous survey data and any future surveys.

10.1 Establishing Existing Alignments

In most instances the horizontal alignment is coincidental with the right-of-way reference line. When the existing alignment or right-of-way boundaries are not monumented, the alignment is reestablished from available evidence. The evidence that is evaluated includes the following:

1. Existing field evidence (pavements, fences, property pins, right-of-way posts, and section corners),
2. County courthouse documents (deeds, plats, and certified survey maps),
3. Town road records,
4. Department records (old plans, plats, and survey notes),
5. Records of military, territorial, state, and plank roads.

The survey line that is initially established in the field should normally represent the center of pavement. When there is a large quantity of existing field evidence, it should be related to the survey line. Linear regression

analysis can then be used to evaluate the data and arrive at a center line definition that best fits existing field conditions. In these cases the analysis is usually done in the office. After a complete analysis has been performed, the line can be adjusted, if necessary.

10.2 References

The records of early roads in Wisconsin can be obtained from the State Historical Society. The records on file cover the period from 1835-1886. Reprinted below are their file locator number and a brief description as contained on the locator cards:

1. Series 234 (2/3/3-28): Records of surveys of state roads as laid out and established by the state Legislature, showing direction of courses, town and range locations, distances, bearing trees, map sketches, explanations, certifications of commissioners, their signatures, and names of surveyors. Volume 4 contains an index of the surveys and is arranged alphabetically by the name of the location of the origin of the road.
2. Series 235 (2/3/3-30): Plats and field notes of surveys for state roads, giving date, signature of surveyor, signatures of commissioners appointed to lay out the road, date filed with the Secretary of State, and his signature. The plats also show the page number on which they registered in the Record of State Roads. Alphabetically arranged by name of road.

The names of the early roads can be obtained from "A History of Wisconsin Highway Development, 1835-1945," State Highway Commission of Wisconsin, 1947.

FDM 9-50-15 Field Procedures

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15.1 Establishing Existing Alignments

After all available evidence of an existing alignment has been gathered, a field survey crew can then begin to re-establish the alignment in the field. The surveyor should pull the recorded distances obtained from all the available evidence such as: section corners, property corners, fences, and right of way points and mark this location with a temporary monument. These points should then be compared with points obtained from splitting pavements, structures and fences.

When splitting pavements care should be taken to avoid areas where widening may have taken place on one side only. In areas where concrete pavement is known to exist under an overlay, and reflection cracks are not visible, it may be advantageous to expose the concrete pavement in spot locations to aid in the determination of the centerline.

The existing curve information may be determined by several different methods: measuring the PI angle and either the external distance, tangent, long chord, or curve length. Try to avoid putting in small unintentional PI points that may have been created by pavement wander.

When re-establishing PI monuments that cannot be recovered, it is the surveyor's responsibility to restore the monuments as near as possible to their original positions. Re-establishment should be based on a thorough analysis of the existing evidence before replacing the missing monument. The re-established PI will usually result in a new slightly different intersecting angle. Generally when this occurs, use the original degree of curve and compute new curve data. However, certain conditions may exist that will require holding the original tangent distances, and recomputation of a new degree of curve and curve data may be necessary. There may be differences between the old and new tangent distances and, in order to maintain the original stationing, equations may be necessary to reflect these differences.

When all information has been evaluated, including comparison to as built plan, if available, a final determination of the alignment can be made. If the alignment is to be tied into the primary control survey, it should be done at this time to allow final adjustment of distances and angles. This will help to avoid small equations in alignment by the adjustment program. When the final adjustment is complete, the survey crew can proceed to stake the alignment in the field with stationing. Stationing in rural areas would normally be every 25 meters (100 feet) and in urban areas every 50 feet or 20 meters, including all PC's, PI's, PT's, and POT's where accessible.

15.2 New Alignments

New alignments to be staked in the field are most often done with a total station instrument linked to a data collector. The surveyor should be provided with a horizontal coordinate listing of all pertinent points, with stationing, to define the alignment. The alignment points should be referenced to the primary control survey to facilitate ease of layout in the field.

FDM 9-50-20 Alignment Computation

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Essentially, there are two methods for defining horizontal alignments. An alignment may be established in the field by conventional survey or an alignment may be established in the office by computational procedures (paper alignments). Combinations of these two methods may also be used to define a horizontal alignment. Except in those cases where control surveys are not required (see FDM 9-1-5), the coordinates of the PCs, PTs, PIs, and POTs are computed and used to describe the alignments.

20.1 Field-Surveyed Alignments

Field-surveyed alignments may be established by design controls, such as a distance from a building, or by reestablishing an existing center line of pavement. Once the alignment has been established, control surveys are run to establish coordinates for curve points and points on tangent.

Usually the points of intersection of the tangents (PI's) will be included in a traverse network. After the traverse network has been adjusted and coordinates for the PI's have been determined, the coordinates of the intermediate POTs should be computed.

Attachment 20.1 illustrates the adjustment of an intermediate POT. In Attachment 20.1, points one and three are PI's on an alignment. The coordinates for these points are computed as part of a traverse network adjustment. The distance between point one and three was not measured directly because of the terrain, but was measured indirectly by measuring from point two to one and from two to three. The total distance between points one and three (C) is adjusted during the network computations used to define points one and three. Consequently, distance A and B should be adjusted in the proportion they bear to the total distance (C) before defining point two. The use of the "compass rule" adjustment procedure in COGO when applied to straight lines with intermediate points will result in a proportional adjustment of the individual segments.

20.2 Alignments Established by Design Computation

Design-computed alignments occur most times when using photogrammetrically prepared mapping. With field-surveyed alignments, the first precise definition of the alignment occurs when the point is set in the field even though coordinates are computed later. With design-computed alignments, the first precise definition of the alignment occurs when the coordinates are computed or scaled from maps. The points are then established in the field at the predetermined coordinate position. When an alignment is to be defined by design computation, an attempt should be made to establish project base control survey stations near where the alignment PIs will be located, provided design requirements of the base control layout can be met. This will facilitate economical and accurate layout of the alignment at a later date.

Design computations should include layout information to enable survey crews to establish the alignment in the field. Ideally, these computations will include coordinate information, angles and distances from project base control stations to nearby PIs, PCs, PTs, POTs, and other selected points on the alignment. The computations should also include curve layout information and offsets to other alignments.

Once the points defining an alignment have been set at their predetermined coordinate position, the line between points is established by conventional field survey procedures.

20.3 Elements Common to All Alignments

Regardless of the method used to initially define an alignment, additional computations are required in order to provide a comprehensive data base for project development. In addition to the coordinates and curves defining the alignment, the following should be computed:

1. Station values for all alignment points
2. Intersection of section lines with the alignment, and the resulting station and the distance and bearing to section corners
3. Intersection with other alignments, such as side roads, and station equation and angle of intersection
4. Coordinates of property markers recovered during right-of-way surveys.

These computations can be carried out within one problem run for most projects. COGO has provisions for saving the information on a computer file for future retrieval, allowing for additional computations.

20.4 Data Storage

Alignment information should be put into an ICES COGO, CEAL, CAiCE, or other comparable computer program for future retrieval, allowing for additional computations. All other field notes and documents shall be put in the survey folder for that project.

LIST OF ATTACHMENTS

Attachment 20.1 Adjustment of Intermediate POT

FDM 9-50-25 Monumentation Required

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When dealing with the establishment of an existing alignment you may want to use temporary monuments such as spikes or paint marks, until the final alignment has been determined. Try to avoid using type 2 or 3 monuments, such as PK nails, which could later be confused with the final alignment monuments.

The final alignment should be monumented with type 2 or type 3 monuments on all PCs, PIs, PTs, POTs, side road intersections, and other pertinent points. Points needing to be referenced should have at least three reference ties. The final alignment should be tied into the primary control if applicable.