USE OF PHOTOGRAMMETRY
FOR DETERMINATION OF EXCAVATION QUANTITIES

GENERAL

Aerial survey methods used by the Photogrammetry Unit for determining excavation quantities have been proven to be as accurate as ground survey methods. Use of aerial surveys for this purpose may allow a Resident Engineer to better utilize available manpower. The decision to utilize the Photogrammetry Unit to provide this service should be based on several factors, which are listed below. In general, the safety of NCDOT employees, the quantity of earthwork involved, and extent of acreage under construction must be of sufficient volume to make this type of operation economical.

Factors to Consider Before Requesting the Use of Photogrammetry:

1. Are there safety issues that exist where NCDOT employees are at a higher risk of injury to perform field surveys?
2. Are there 100,000 cubic yards or more of unclassified excavation?
3. Is the workload of the Resident Engineer's office such that Photogrammetry is needed?
4. Are there environmental concerns that make it cost prohibitive to use Photogrammetry (can only clear small areas at a time)?
5. Does traffic control phasing cause a need for numerous flights?
6. Natural ground and finished excavation must be above water.
7. It is necessary to have the area, to be flown, cleared and grubbed prior to the aerial survey. It is important that all required erosion control measures be installed in conjunction with clearing and grubbing.
8. Cost of ground surveys versus aerial surveys with respect to project topography and complexity must be considered. For a 17 – 20 acre site, the cost for both ground surveys and aerial surveys are approximately the same. As a rule, the smaller the site the more economical it is for ground surveys and the larger the site the more economical it is for aerial surveys.
9. Total turn around time for original and final terrain compilation and earthwork computation will be based upon schedules between the Resident Engineer and Photogrammetry.
10. It should be shown that it is in the best interest of the Department from the standpoint of construction personnel utilization and total construction engineering cost.
11. Aerial photography provides a permanent record of terrain on the date of photography and can be a valuable source of information for verifying earthwork quantities, ground conditions, etc., in the event of disputes or litigation.
12. Safety of field personnel, particularly in areas adjacent to high-speed, heavy traffic volumes, should be a consideration when determining whether aerial surveys should be used.

The Resident Engineer and Division Construction Engineer should decide the method of terrain data collection to be used on a project prior to the Preconstruction Conference. If Photogrammetry is chosen as the most economical or practical method, the State Photogrammetric Engineer's office should be contacted in writing so that work scoping and scheduling can begin.

ROLE OF THE CONTRACTOR

The Contractor should be informed at the Preconstruction Conference if photogrammetric methods will be utilized to determine terrain data used for earthwork quantities. Article 225-7 of the Specifications indicates that the decision to use either aerial or ground surveys for excavation quantities is the Engineer's, but it is important to let the Contractor know as soon as possible since the decision will have a significant impact on his operations. All communication between the Contractor and the Photogrammetry Unit should be through the Resident Engineer.

The Contractor may be required to clear and grub more than the 17 acres included in Article 225-7 of the Specifications, which means the erodible surface will be in excess of that normally deemed desirable for the control of erosion. Projects can and should, if feasible, be flown in stages. The Contractor must simultaneously install all measures required by the plans for the clearing and grubbing phase and have the necessary equipment available to maintain these devices over a relatively large area. The Contractor should be advised that the opening of larger areas to accommodate photogrammetric methods would not affect the areas allowed for grading operations. **To ensure high resolution in the aerial photography, the Resident Engineer must prohibit the Contractor from performing any burning on the day a photo mission is scheduled to be flown.**

In some instances, the Photogrammetry Unit will not always be able to fly a project before a Contractor is ready to begin his grading operations. **In these instances, the Resident Engineer must take the required original terrain data by ground survey methods so the Contractor will not be delayed.** The original terrain data representing these areas must then be forwarded to the Photogrammetry Unit prior to or concurrent with the ground control surveys so they can be combined with the aerial survey terrain data for incorporation into the total earthwork computations for the project.

Information to Provide to the Photogrammetry Unit:

1. Written request to the State Photogrammetric Engineer notifying of the intent to use Photogrammetry.
2. **Notice** should be provided to the Photogrammetry Unit **prior to the Preconstruction Conference so that scoping and scheduling can begin.**
3. Approximate the length that will be cleared and grubbed before flying starts. This length should normally be **2000 feet or greater**. The decision on length of project to be flown should be mutually determined by the Resident Engineer and the Photogrammetry Unit.
4. Estimate the date when the project would be ready for a flight to take place.
5. The Resident Engineer's office will be responsible for coordinating the placement and control of ground control panels. These panels should be set according to the panel plan provided by Photogrammetry. Questions concerning placement of panels may also be directed to the Photogrammetry Unit. **Ground control surveys must be performed either by Location & Surveys staff or by state approved licensed Professional Land Surveyors.** Weather and schedule permitting, the photo mission will be flown immediately upon completion of the paneling operation. **IMPORTANT NOTE: Panels cannot be disturbed until area has been flown and the ground control surveys have been completed.** The aerial photography is normally processed the same day the mission is flown. The Photogrammetry Unit notifies the Resident Engineer the next workday if the photography has been accomplished.

6. The Resident Engineer must furnish the Photogrammetry Unit with electronic copies of the ground control (including the localization report), slope stake data, and available project profile levels before compilation of the terrain data can begin.
7. The Resident Engineer should inform the Photogrammetry Unit, preferably with a MicroStation design file and associated explanation, of any construction areas that will require special consideration (such as detours, borrow pits, etc.)

ORIGINAL TERRAIN DATA

After the Photogrammetry Unit has compiled an original terrain model, the Resident Engineer should be furnished an electronic copy of the original terrain data. Upon request, a copy of the printout and a graphic plot can be provided.

In order to provide a check of the original terrain data determined by the Photogrammetry Unit, the Resident Engineer should collect some terrain data points as slope stakes are set. These terrain data points should be furnished to the Photogrammetry Unit with the slope stake data. The Digital Terrain Model from the Photogrammetry Unit should be checked to ensure that coverage is carried out far enough. Any corrections or extensions that are needed should be identified and furnished to the Photogrammetry Unit. After all corrections and/or additions are made, the Resident Engineer will be furnished with a copy of the digital terrain model. **The Contractor should be provided with one copy of the original cross-sections printout.**

FINAL TERRAIN DATA

After the Contractor has completed grading the project, the Resident Engineer should contact the Photogrammetry Unit for an estimated date when aerial survey can be performed. The Resident Engineer must furnish a copy of all plan changes that affect horizontal or vertical limits as originally shown in the plans as this may impact the original terrain data. Panels will also have to be set by the Resident Engineer's office prior to the flight. The Photogrammetry Unit requires a minimum of 3 days notice prior to the flight. Weather and schedule permitting, the photo mission will be flown immediately upon completion of the paneling operation.

Before the final terrain data and excavation quantities can be determined, the Resident Engineer must furnish the Photogrammetry Unit electronic copies of the final ground controls, slope stake data, and available project profile levels of the final profile along each line. Template information accounting for the sub-grade earthwork will be taken from the plans.

After the final terrain data has been determined, the Photogrammetry Unit may compute the unclassified earthwork estimate. After the unclassified earthwork estimate has been computed, it will be furnished to the Resident Engineer. The Resident Engineer's office should provide a check of the final terrain data by collecting some terrain data points in the field and comparing them to the Photogrammetry Unit's terrain data. The Digital Terrain Model from the Photogrammetry Unit should be checked to ensure that coverage is carried out far enough. Any corrections or extensions that are needed should be identified and furnished to the Photogrammetry Unit. After all corrections and/or additions are made, the Resident Engineer will be furnished with a copy of the digital terrain model and an earthwork summary sheet with an estimated volume of unclassified material.

DOCUMENTATION

Where terrain data is determined by aerial surveys, the source documents to establish payment for the excavation quantities will be pay record data, all electronic terrain and data files, photograph negatives, and control prints. The Photogrammetry Unit, as part of their permanent records, will retain the film negatives, control prints, digital images, electronic files of terrain data, and all official correspondence.

AERIAL PHOTOGRAPHY

Aerial photography provides an accurate and efficient means of obtaining earthwork quantities for a project. Control panels enable the Photogrammetry Unit to orient the film both horizontally and vertically and to obtain the correct scale. A survey party is required to install control panels prior to the aerial photography. The Resident Engineer's survey party normally installs all of the control panels. If the Resident Engineer needs assistance in installing the panels, the Location and Surveys Unit should be contacted. Ground control surveys **must** be performed either by Location & Surveys staff or by state approved licensed professional surveyors. See **Records and Reports** elsewhere in this Manual.

Preliminary Planning

The Photogrammetry Unit should be notified at least one week prior to paneling the project. Photogrammetry will need the following information for their flight:

1. Project and TIP Numbers
2. The alignment that the flight is being scheduled for.
3. Estimated construction schedule (clearing & grubbing and final grading)
4. Beginning and ending stations of each alignment
5. Special criteria, if any. (Right side only, left side only, or other considerations)
6. The need for final intermediate flights.
7. If the flight is for borrow pits a location map and limits will need to be supplied.

Paneling

The Photogrammetry Unit will develop a panel plan for the required area. The panel plan will be supplied to the Resident Engineer.

- Panels should be placed according to the supplied panel plan. If a panel(s) needs to be moved from the designated location, notify and coordinate with the Photogrammetry Unit for the new location(s).
- Panel arrows should have legs approximately 5 feet in length and 6 inches in width.
- The panels will either be on a 5' x 5' sheet of black plastic, painted on a roadway surface, or use temporary striping tape (See Figure 1). Regardless of what is used, there needs to be sufficient contrast between the panel and the background material.
- Duron Alkyd Hiding White exterior paint is recommended.
- Panels should be placed on an unobstructed level area.
- The point of the arrow should represent the control point and should be where the horizontal and vertical data is read.

Controlling Panels

The control for all panels should be based off of the same control monuments used to control the final design. This information is located in the Plan Sheets. If there is any question concerning the control monuments, the Location and Surveys Unit should be contacted.

- All panels should be fully controlled (x, y, and z).
- Panels are to be placed and numbered according to the supplied panel plan.
- When more than one flight is necessary, coordinate with the Photogrammetry Unit on which panels to set.
- The panel number should be painted on the top right hand corner of each panel.

Field Data

The horizontal and vertical control data for the panels should be provided to the Photogrammetry Unit as soon as possible within a maximum of two weeks after the flight. The control data should be delivered to the Photogrammetry Unit electronically in the following format:

Panel ID# *x – coordinate* *y - coordinate* *z – coordinate* *Alignment Station offset* (as needed)

Example:
P1 1123456.78 212345.67 312.34
P2 1123465.87 212354.78 223.45 L 10+00
P3 1124567.89 212367.89 321.98
P4 1124567.89 212456.78 345.67
P5 1124676.89 212567.89 258.36 L 19+00 35' left

Borrow Pits

Prior to paneling any borrow pit, discuss the specifics with the Photogrammetry Unit. The Photogrammetry Unit will provide a panel plan for the pit. Control for the panels should be based off the localized NCGRID.

General

Requesting the use of Photogrammetry for aerial surveys depends on various factors. Some of these factors are: the size of the area to be flown (the cleared and grubbed area); the number of 'original', 'intermediate' and 'final' flights required; the number of panels to be set prior to flying each section; the length of time to control the panels for each flight; and having adequate weather conditions to fly the aerial photography.

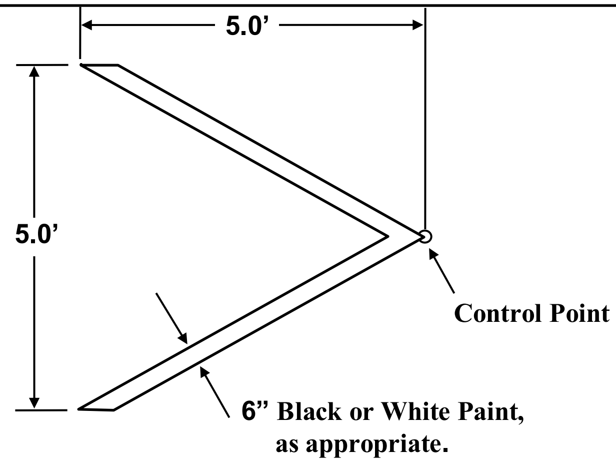
Once the Photogrammetry Unit has been notified in writing and the scope of the required photogrammetry work is clear, the acquisition of photography and unclassified earthwork estimation can begin. The preparation of the panel plan for the project can take up to a month to prepare. Placing the panels at the prescribed locations is important to properly control the project area.

To schedule a flight, the Photogrammetry Unit should be notified 3 days prior to the panels being completely set. The Photogrammetry Unit coordinates with the Aviation Branch to fly the project. The flight over the project area is dependent on adequate weather conditions.

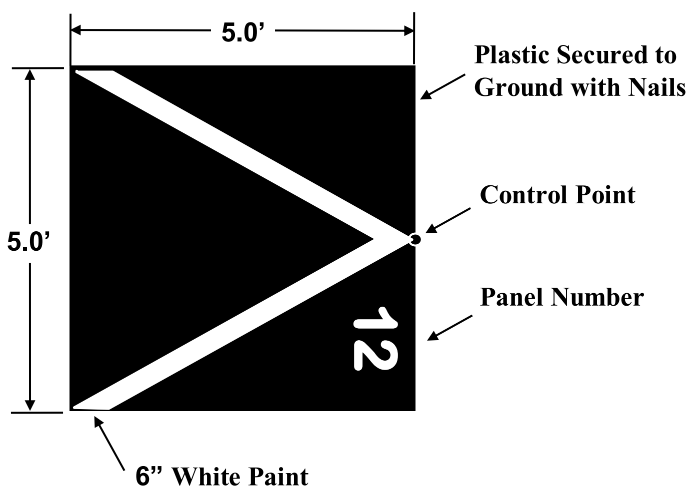
Occasionally it will be necessary to field inspect the control panels to ensure their condition when there have been weather delays.

When the Photogrammetry Unit receives the control, the collection of terrain data will begin, in the form of a Digital Terrain Model (DTM). The process of developing a DTM will be repeated for all subsequent flights, either for original ground, intermediate quantities (partial earthwork estimate), or for final earthwork estimate. Volume calculations are based off comparisons between the original DTMs and the final DTMs.

AERIAL FLIGHT PANEL CONFIGURATION



Typical configuration for asphalt or concrete surfaces.



Typical configuration for earth or other surfaces.

Figure 1

STA.	+/-	H.I.	+/-	Elev.	
# 112 TBM	-9.88	271.66		281.54	
690+00	Cl Panel		-0.70	270.96	
690+00	Lt. # 1A		-1.42	270.24	
690+00	Rt.# 2A		-2.42	269.24	
690+50			-0.66	271.00	
691+00			-0.71	270.95	
691+50			-0.91	270.75	
692+00			-0.93	270.73	
692+50			-0.53	271.13	
693+00	Cl Panel		-0.15	271.51	
693+00	Lt. # 3A		-3.90	267.76	
693+00	Rt.# 4A		-3.92	267.74	
693+50			+0.25	271.92	
694+00			+0.65	272.31	
694+50			+1.14	272.80	
695+00			+1.65	273.31	
695+50			+1.92	273.58	
696+00	Cl Panel		+2.60	274.26	
696+00	Lt. # 5A		-5.22	266.44	
696+00	Rt.# 6A		-5.24	266.42	
T.B.M.			+9.88	281.54	
T.B.M.	-1.03	280.51		281.54	
696+50			-5.89	274.62	
697+00			-4.63	275.88	
697+50			-3.59	276.92	

Typical Field Notes for aerial flight panels.

Figure 2

DETERMINATION OF “S” DIMENSIONS

The field verification of “S” dimensions for ground mounted and overhead signs is a critical step in the design and construction process. Due to time constraints, this process should take place early in the project stages as soon as the project stake out information is available. The project phasing should be reviewed and discussed with the Contractor so that any signs that will need to be erected during early phases of the work are reviewed first. Slope stake data as determined by the Resident Engineers staff should be used in lieu of waiting for grading to be complete. When the project stake out is completed by the Contractor, the Resident Engineer should encourage this to be completed early and check the information for accuracy before requesting a plan revision.

The dimensions listed on the plans must be checked against the actual field conditions and any corrected distances provided to Traffic Engineering so that they may issue revised plan sheets. Form sheets for this will be provided by Traffic Engineering upon request. It should be noted that the distances **below** the point of reference on the drawings are **positive** and the distances **above** are **negative**. The following procedures should be used for verification of “S” dimensions:

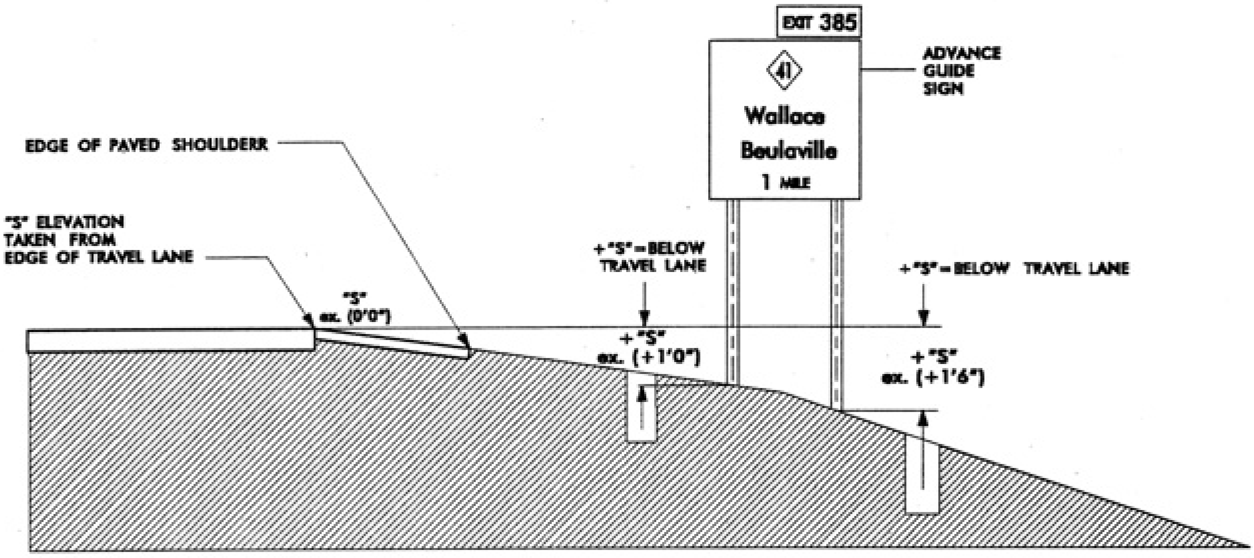
1. The Resident Engineer or Contractor (depending on who is responsible for project stake out) should review the overhead sign drawings as shown in the original plans for accuracy. These drawings shall then be compared against the project typical sections as well as against the project roadway plans (including cross- sections). The location of these signs should then be reviewed in terms of placement or location of other conflicts including existing or proposed drainage systems, underground and/or above ground utilities, drainage ditches, etc. Adjustments in the location of these signs may be necessary to avoid these obstacles. Any relocation of these signs by any appreciable amount should be done only with consultation of the Project Signing Engineer.
2. Once signs are “conflict free,” the typical section at each station will then be used to determine the actual theoretical finished section at that station. The actual section will be determined using proper lane and shoulder widths (taking into account any tapers existing at these locations), roadway superelevations, shoulder rollovers, side ditches, barrier rail sections, etc.
3. Where applicable, slope stakes will be set at each sign location to verify all theoretical calculations. It is **essential** that the Contractor build the slopes in accordance with these slope stakes.
4. All of the above information will then be used (in conjunction with the finished grade at each sign location and the minimum clearance as indicated on the plans) to determine the “S” dimensions.
5. The fill and cut slopes at each sign support location also needs to be verified to ensure correctness of the plans. Any changes in these side slopes need to be noted and corrections sent to the Signing Unit along with the completed verified “S” dimensions.
6. Once field verification is complete, the results will be transmitted by the Resident Engineer to the Traffic Engineering Signing Unit.

Once this information is received by Traffic Engineering, and the revisions are complete, the revised plans will be forwarded to the Resident Engineer for his use and further distribution to the Contractor. The Resident Engineer should verify any changes that were made during the field verification are properly reflected. The Contractor may then proceed with the design of the overhead structures.

Any plan revisions must be taken into account when these dimensions are verified. Also remember to revise these “S” dimensions as necessary if plan revisions come out after the field verification process is complete.

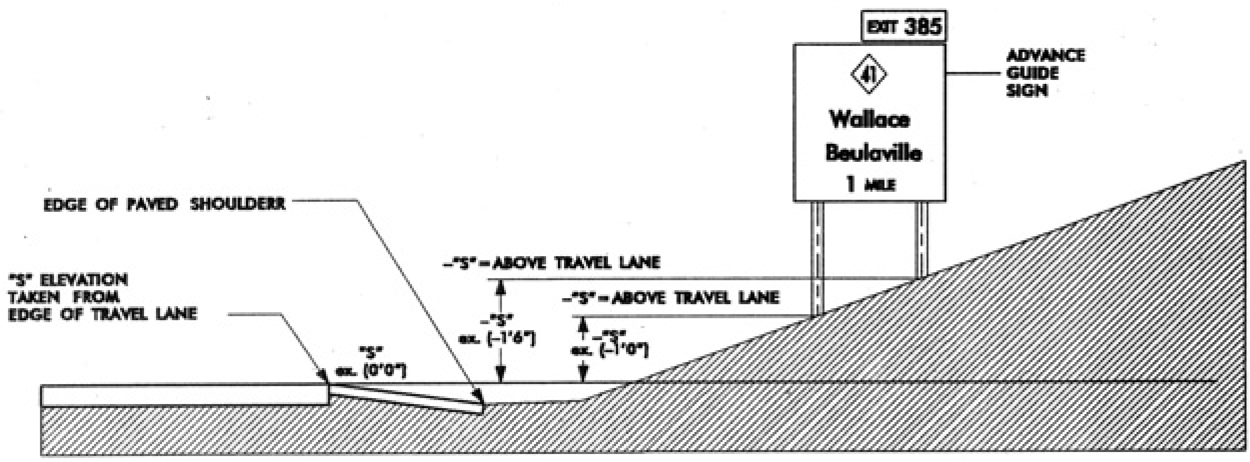
VERIFICATION OF GROUND MOUNTED SIGNS

The “S” dimension for ground mounted signs is the difference in elevation from the edge of travel lane to the point where the centerline of the support touches the ground. The edge of the travel lane is not the outside edge of the paved shoulder. When determining the “S” dimension, note if the elevation is above the travel lane or below the travel lane. In signing, positive (+) is used for elevations that are below the travel lane and negative (-) for elevations above the travel lane. If a sign is relocated in the field, note the new station and “S” dimensions so that the plans can be changed. See the following drawing titled “Verification of Ground Mounted Signs” for clarification.



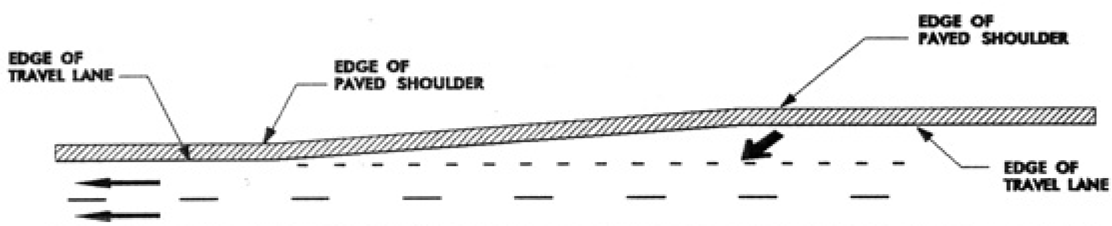
BELOW THE TRAVEL LANE ELEVATION

FRONT VIEW



ABOVE THE TRAVEL LANE ELEVATION

FRONT VIEW



ROADWAY

TOP VIEW

NOTES:

1. MAXIMUM -"S" DIMENSION CAN NOT EXCEED -3'0"
2. FOR GROUND MOUNTED SIGNS THE OFFSET IS FROM THE EDGE OF TRAVEL LANE NOT THE EDGE OF PAVED SHOULDER

+"S" INDICATES POSITIVE DIMENSION

-"S" INDICATES NEGATIVE DIMENSION

Verification of Ground Mounted Signs

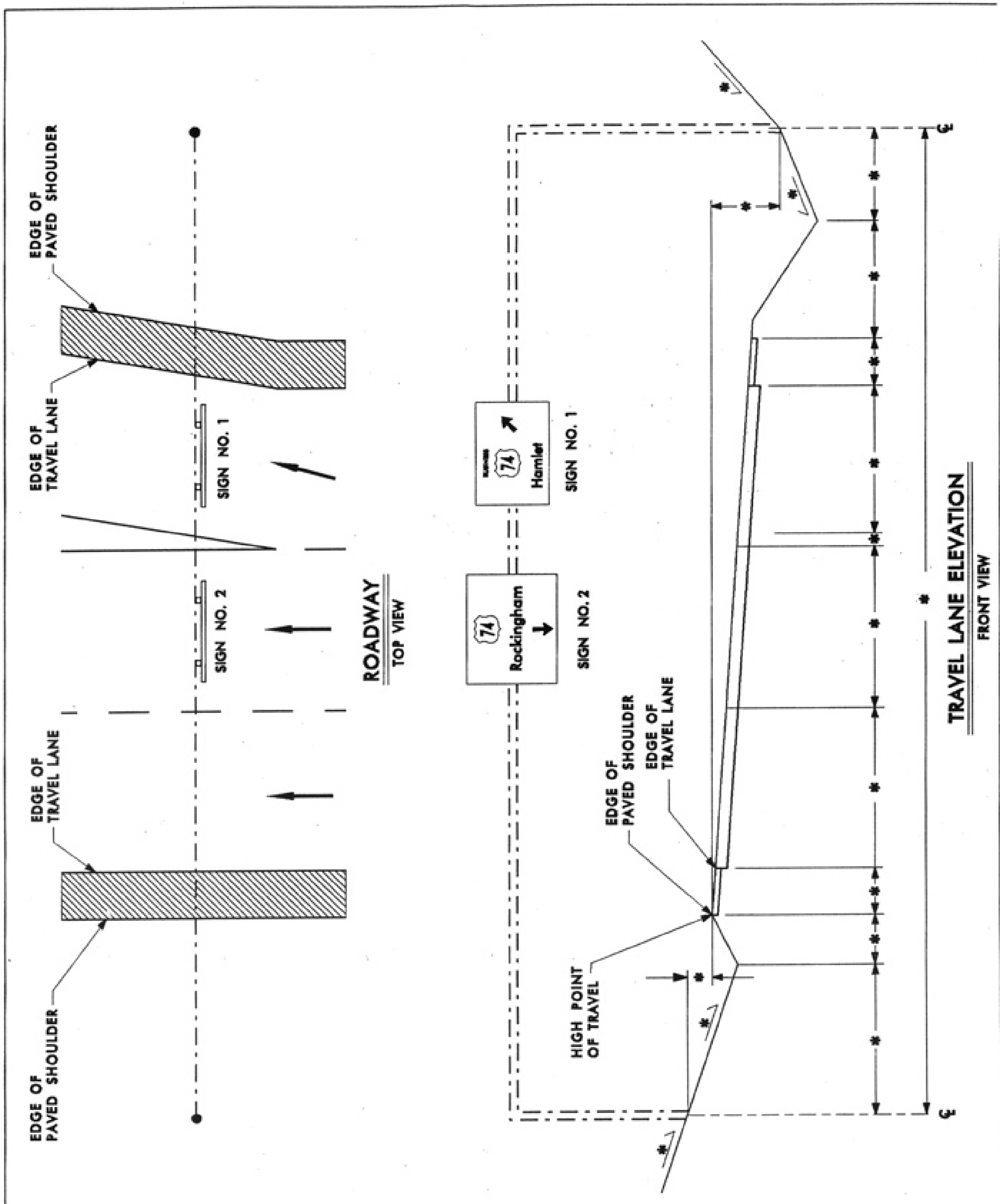
SCALE	NONE	N. C. DEPARTMENT OF TRANSPORTATION
DATE	01/03/2002	DIVISION OF HIGHWAYS
SIGNING TECHNICIAN	W JOHNSON	TRAFFIC ENGINEERING BRANCH
SIGNING DESIGN ENG	F MURRAY	
SIGNING PROJECT ENG		

VERIFICATION OF OVERHEAD SIGN ASSEMBLIES

Checking the information on overhead sign assemblies in the field will consist of "S" dimensions at the center of the structure upright supports, cut or fill slopes, and pavement width information. The "S" dimension for overheads is different from that of ground mounted signs. The elevation of the center of the upright is from the **high point of the road**. This includes paved shoulders, mountable medians, future lanes, or any point that a vehicle could physically drive on under any sign on the overhead structure. The side slope is the slope at the centerline of the uprights and at least 2 feet on both sides. Both the "S" dimension and the slopes are used by Structure Design to check the footing design. The width of each lane or part of a lane, shoulders, and the offset to the uprights should be verified. This is the cross section that the contractor will have to construct. See attached drawing on the proceeding page for clarification.

For projects that have contract surveying, the Contractor will be responsible for providing this information to the Resident Engineer in accordance with Article 801-2(H) of the 2006 Standard Specifications. The Resident Engineer will forward the information to the Signing Section for review and the design of the revised signing plans.

Verifications of these dimensions must be made before supports for the ground mounted or overhead signs can be ordered by the contractor.



NOTES:

* ALL OF THESE DIMENSIONS AND SLOPES NEED TO BE VERIFIED BEFORE THE OVERHEAD DESIGN IS DONE.

Verification of Overhead Mounted Signs

SCALE	NONE	N. C. DEPARTMENT OF TRANSPORTATION DIVISION OF HIGHWAYS TRAFFIC ENGINEERING BRANCH	REVISIONS
DATE	01/03/2002		
SIGNING TECHNICIAN	W JOHNSON		
SIGNING DESIGN ENG	F MURRAY		
SIGNING PROJECT ENG			

STRUCTURE STAKEOUT

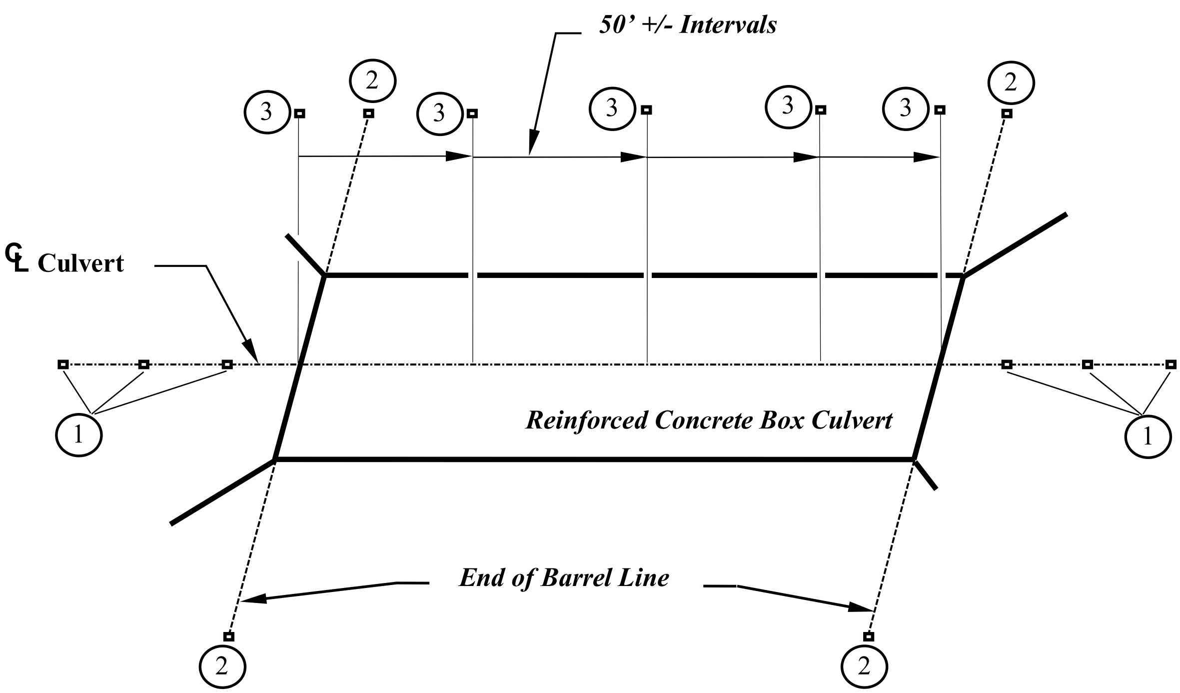
Structure and Roadway plans should be studied together prior to beginning staking in order to become familiar with the planned work, to establish where reference points may be placed and remain undisturbed, to check lengths of box culverts as required on the culvert plans, and **to check and recalculate slope, roadway widths, and elevations common to structure and adjacent roadway**.

During stakeout and construction of the structures, bound field or level books shall be used for structure work books in which shall be recorded: diagrams and sketches showing location of construction stakes set; complete level notes of elevations set for all parts of the structure and grade hubs; the names of all those doing the survey work, what each person did, and the date the work was done.

Structures should be staked using the most accurate equipment and methods at the Resident Engineer's disposal. Total stations or transits equipped with electronic distance measuring devices are preferred. However, with skill, care, and proper procedure, the one minute transit and chain can produce adequate results. Chaining must be done level, utilizing tension handles, and performing any necessary corrections, such as temperature. All angles should be doubled. Distances should be read at least to the nearest 3 millimeters or one hundredth (0.01) of a foot. Control lines to be staked and referenced for bridges are: centerline or long chord line, end bent fill face lines, and interior bent centerlines, or other designated work lines. For box culverts the lines are: centerline of culvert and ends of barrel. Offset grade hubs should also be set for culverts. Hubs with tacks and clearly marked guard stakes shall be used to reference these lines. When grade separations, either highway or railroad, are to be staked, it is the best practice, where possible, to begin the stakeout from the equality on the alignment being spanned. By proceeding in this manner, accumulative differences in chaining or errors in stationing along the line on which the structure is to be built will not affect the horizontal clearance.

The sketches represent typical bridge and culvert layouts. They should be varied to suit individual cases.

TYPICAL REINFORCED CONCRETE BOX CULVERT SURVEY LAYOUT



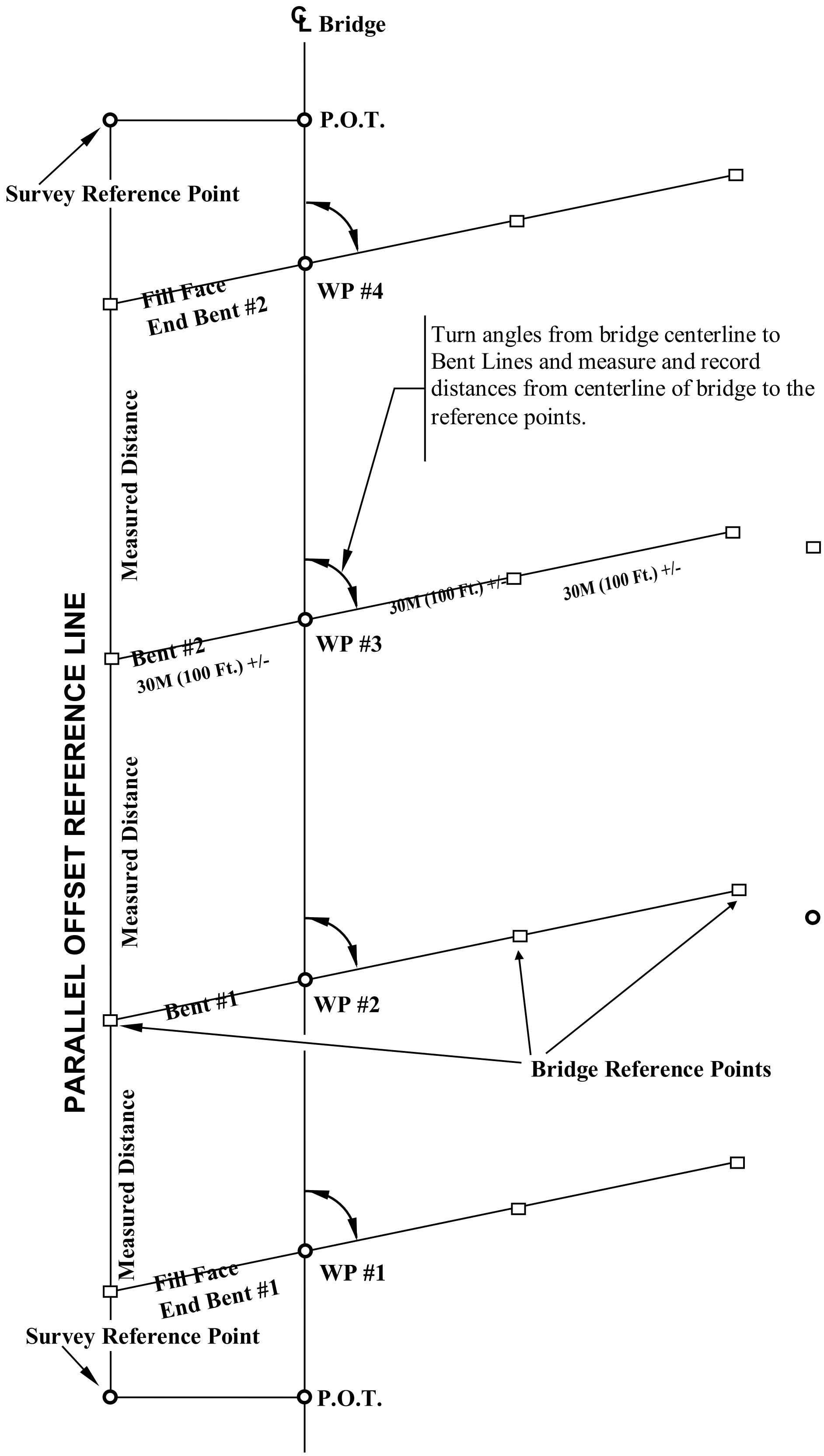
(1) Tacked hubs along centerline of culvert.

(2) Tacked hubs along end of barrel with distance marked to centerline of culvert and cut/fill to top of bottom slab on guard stakes.

(3) Hubs with marked guard stakes giving offset and cut/fill to top of bottom of slab - including camber.

Note:
See **Section 3 - Pipe Culverts** for camber calculations.

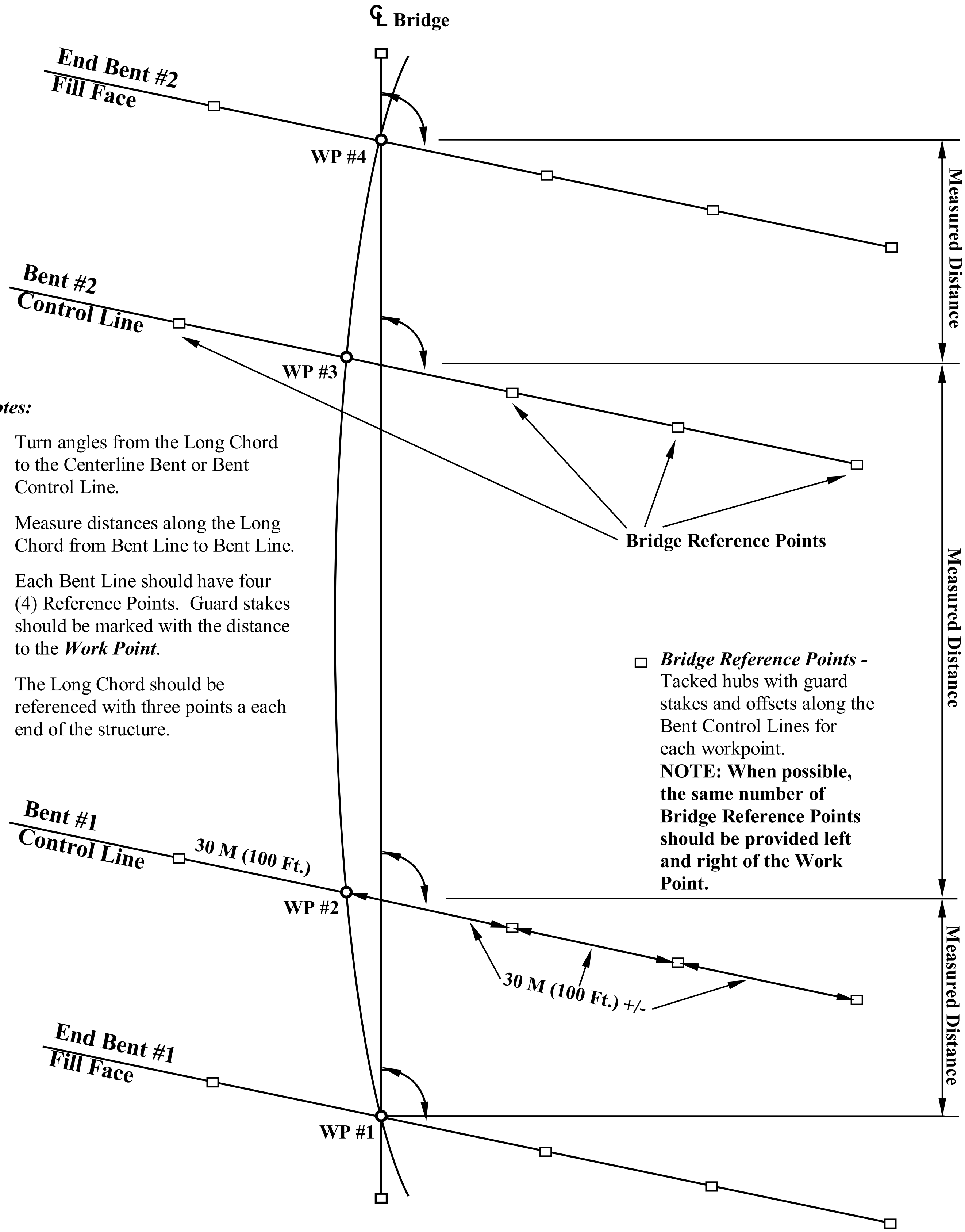
TYPICAL BRIDGE - TANGENT
SURVEY LAYOUT



Bridge Reference Points -
Tacked hubs with guard stakes and offsets along reference lines for each workpoint.
NOTE: When possible, the same number of Bridge Reference Points should be provided left and right of the Parallel Offset Reference Line.

Survey Reference Points -
Tacked hubs with guard stakes and offsets for P.O.T.s on survey line.

TYPICAL BRIDGE - CURVE
SURVEY LAYOUT



Notes:

1. Turn angles from the Long Chord to the Centerline Bent or Bent Control Line.
2. Measure distances along the Long Chord from Bent Line to Bent Line.
3. Each Bent Line should have four (4) Reference Points. Guard stakes should be marked with the distance to the ***Work Point***.
4. The Long Chord should be referenced with three points a each end of the structure.

□ ***Bridge Reference Points -*** Tacked hubs with guard stakes and offsets along the Bent Control Lines for each workpoint.
NOTE: When possible, the same number of Bridge Reference Points should be provided left and right of the Work Point.

Checking Layout

Resident Engineers and Party Chiefs should develop a systematic scheme for checking a structure stakeout both during the stakeout and after the structure has been laid out. Each measurement, whether a chained distance, angle turned, or elevation given should be checked. One scheme that will serve to check the work is to let entirely different personnel check the layout. This is one scheme of many and would not necessarily involve an entirely new party but a simple change in duties performed.

For example, the head chainman could read the plans to check the Party Chief's plan interpretation, the rear chainman could serve as head chainman to read the measurements between previously placed points, another party member could measure the complement of the angle previously set accumulatively by repeated measurement, elevations could be checked by double rodding from independent bench marks, or a reversal of rodman and levelman duties. This scheme will also serve to provide additional experience and training for party personnel.

Engineering Practices To Follow

1. Check instruments periodically for accuracy.
2. Check alignment stationing in the field from two independent references.
3. Check bench marks in the field from two independent references. All bench marks which are established for use during construction should be, as nearly as practicable, of a permanent nature. Check bench marks used for structure construction with bench marks used for roadway construction. When setting bench marks, avoid setting them in deep embankments that have not set for several months or in any embankments in the vicinity of anticipated pile driving operations. This can be an inconvenience, but problems can arise due to settlement of the bench marks. Levels can be run from bench marks in other areas and temporary bench marks set, or checked, each time critical elevations are necessary, or at least once a week while in use **except** when pile driving has been taking place. If pile driving has taken place in the vicinity, the temporary bench marks set in embankments should be checked at least daily when in use.
4. Completely stake structure when practicable before construction begins.
5. Systematically and uniformly identify all points with clearly marked guard stakes.
6. Set extra points to facilitate replacing those destroyed.
7. Check railroad rail elevations against bottom of beam elevations at railroad separations during stakeout and compare difference in elevations to vertical clearance shown on plans.
8. Check cut and fill slopes at end bents during and after grading but prior to starting structure construction.
9. Immediately prior to casting the cap of a substructure unit, elevations are to be checked on the chamfer strip for each bridge seat. Immediately after all concrete the cap has been cast, another check is to be made at each bridge seat using an independent set-up of the instrument. Any falsework slippage or excessive settlement will then be apparent. After the first substructure unit has been completed, both of the above checks shall include a check on a bridge seat of a previously cast cap. All rod readings and computations for the above shall be recorded, dated, and initialed in the structure field book.
10. Check camber in beams and girders after they are erected but before connections are tightened. Beam camber shall be corrected to conform to 12 millimeters (1/2 inch) for proper tolerance.
11. Check bridge slab thickness when header elevations are set. Check camber in screed.

12. Check projection of shear studs into slab.
13. Slope protection berm width should be computed prior to slope staking the ends of the bridge fills. The toe of the slope protection should be staked to insure that alignment and grade will conform with that of the roadway.
14. It is usually good practice to establish a temporary bench mark on a substructure as soon as it is completed. This is usually accomplished by setting one temporary benchmark on a wing wall of each end bent.
15. Check top of pavement elevations against bottom of beam elevation at flyovers during stakeout and compare difference in elevations to vertical clearance shown on plans to insure it is sufficient.

SUGGESTED PROCEDURE FOR GRADING BUILD-UPS ON CONTINUOUS OR SIMPLE SPAN BRIDGES

Final bottom of slab elevations at tenth points between centerline of bearings are furnished by the Structure Design Unit. The elevations are given along the centerline of each girder and are used in computing the height of the build-ups.

Build-up height is fixed at the centerline of bearing and would be constant throughout the length of a span if the actual girder camber was exactly as shown, the build-ups will normally vary in height between bearings.

Tops of girders should be marked with paint at each tenth point. (For longer spans 20th or 30th points may be required – see construction elevations provided from the Structure Design Unit.) After camber has been checked, necessary corrections made and diaphragm connection bolts tightened, elevations should be determined on top of girders at each tenth point and used computing build-up heights. The effect of the sun can significantly change girder camber. Levels should be run either early in the morning or on a completely overcast morning. Deflections shown in the deflection tables are used in the required computations. Build-up height at a tenth point is computed as follows:

+ final bottom of slab elevation
+ deflection due to weight of slab
+ deflection due to weight of parapet, rail, and F.W.S.
- top of girder elevation (determined in field)

The algebraic sum of these values equals the height of build-up above the top of girder. In some cases, this value will be minus indicating the girder flange projects into the slab.

The build-up heights for the entire bridge can be computed and listed in a field book well in advance of any forming operation. These heights can be marked on the top of girder at the proper tenth point.

The Contractor should be made aware that the computed height is at the centerline of girder and will vary at each side of the build-up depending on the crown slope and flange width.

Theoretical construction elevations should not be used to grade overhangs.

Overhangs can be graded very efficiently by using the overhang typical section and adjusting by a small amount of form settlement and compensating for build-ups on the top of the exterior girders or beams.

It should be noted that bridges with normal crown and similar overhangs on both sides can be graded using one typical section with the algebraic difference between the bottom of slab over the exterior girder or beam and the outside bottom edge of the overhang. A structure with constant superelevation will require two typical section computations. A structure with variable superelevation or varying width overhangs such as those found on horizontally curved bridges with straight girders will require a different typical section computation at each grade point if the superelevation or overhang width changes.

With this method, it is suggested 1/20th points be used on exterior girders or beams for build-ups where spans are greater than 15 meters (50 feet) in length to keep grade points spaced reasonably. **Regardless of grade point spacing, all overhang brackets or jacks should be graded**. A quick interpolation between grade points with adjustment for top flange thickness when it changes can be readily accomplished.

Following is an example in English Units of using this method to grade overhang formwork: See Figure 1.

Step 1 - Compute algebraic difference between bottom of slab and outside bottom edge of overhang:

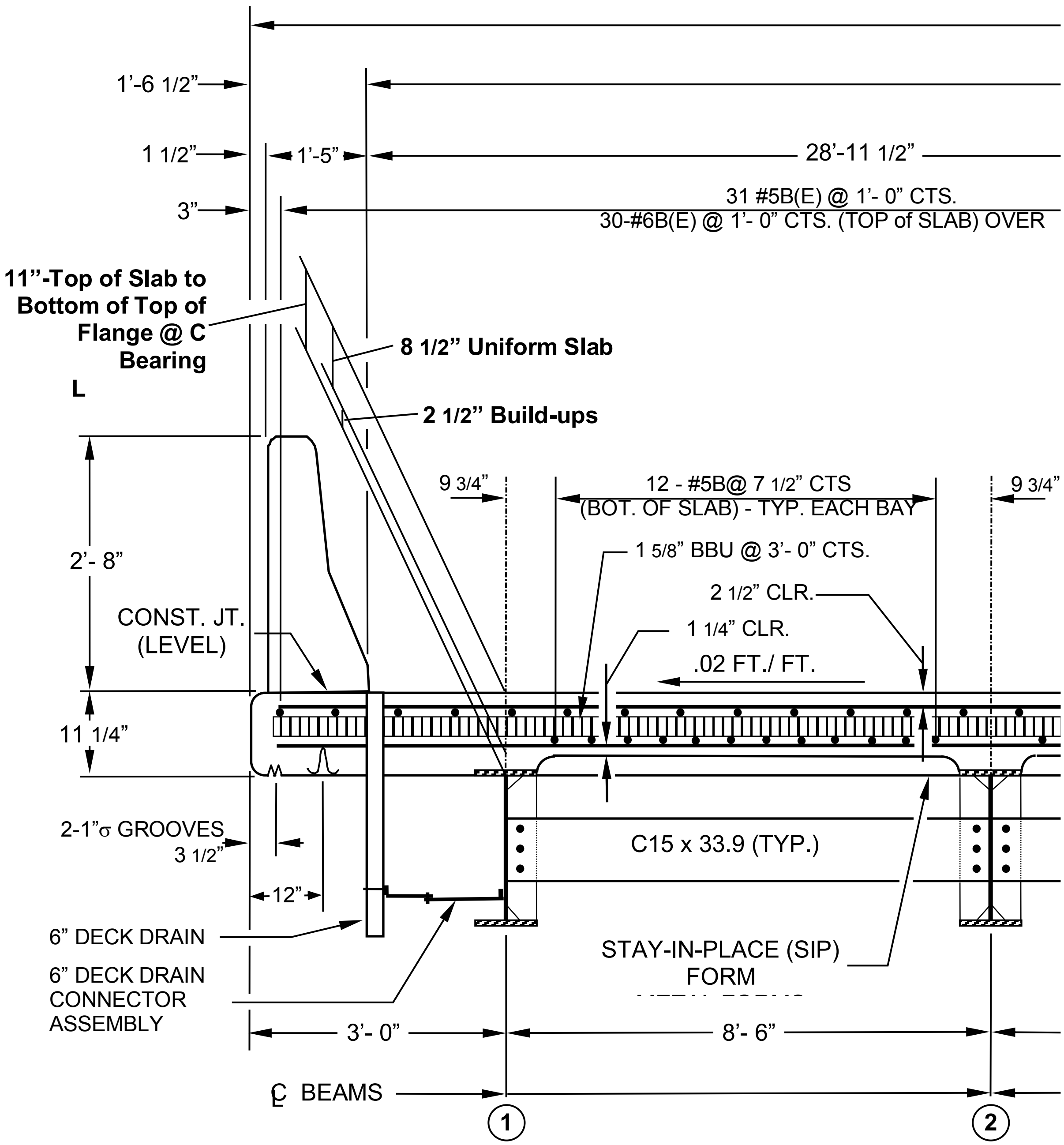
+ 0.71	8-1/2 inch slab
- 0.03	to gutter line
- 0.00	level under barrier rail
- 0.94	outside slab dimension
+ 0.02	form settlement
- 0.24	algebraic difference including form settlement

Therefore, grade for an overhang point opposite a field build-up of +0.12 = -0.24 + 0.12 = -0.12 below the top of beam or girder.

Step 2 - Show overhang grades in structure workbook opposite build-up grades and adjusted to level over from top of beam or girder with the use of an engineering level and rod or a carpenter level and rule. Interpolate in between grades to adjust each overhang bracket or jack to assure uniform grade.

It should be noted this method eliminates additional levels being run on edge of exterior girders or beams and eliminates laying out grade points according to construction elevations. All grades can be computed and checked in the structure workbook well ahead of time.

The reason construction theoretical grades should not be used is to eliminate variable slopes on bottom of overhangs due to temperature changes and the constant movement of girders or beams. Using typical sections will assure all overhangs are relative to the girder or beam and therefore a constant slope will be attained on the bottom of overhangs. In an extreme case, it would be possible to have a reverse slope on the overhang bottom if the girder or beam has moved sufficiently down and a theoretical elevation is used.



TYPICAL HALF SECTION

SHOWING INTERIOR BENT AND
INTERMEDIATE DIAPHRAGM

Figure 1

SUGGESTED PROCEDURE FOR GRADING HEADERS

The Structure Design Unit furnishes a computer listing of final top of slab elevations along each header line. These elevations can be used as listed when grading headers located over bearing points.

When a header is located out on a span, movement of the header will occur as the beams deflect during the deck casting operation. This type of header is known as a "floating" header. Floating headers are best graded by measuring up the deck thickness from the bottom of slab elevation at each point the header crosses a beam. When the header does not cross a beam at a previously calculated build-up, interpolation should be used. The header must reflect any changes in the transverse slope of the deck which may occur between beams.

SUGGESTED PROCEDURE FOR GRADING SCREEDS

A. Transverse Screed

After overhang forms have been graded, the screed rail can be adjusted to some predetermined constant height above the bottom form at the outside edge of overhang. A gage stick and carpenter's level can be used in adjusting the screed rail to the proper elevation.

The screed carriage must be graded to conform to the transverse slope of the deck, taking into consideration the weight of the operator and trowel mechanism.

Dry runs should be made to assure proper operation and slab thickness. The dry run procedure for transverse screeds is located at the end of this section.

B. Longitudinal Screed

Longitudinal Screeds are rarely used due to limited span length capability and the ease of grading transverse screeds. If a longitudinal screed is proposed to be used, contact the Bridge Construction Engineer to determine if it is an acceptable application and for assistance with reviewing the setup.

Dry Run Procedure for Transverse Screeds

1. Screed Rails can be set initially by measuring up a constant distance from the overhang form, but this is only preliminary. Final adjustments must be made during the dry run.

2. Before beginning, the carriage rail should be straightened. At all four corners of the screed the distance from the screed rail up to the carriage rail should be the same. Place a four (4) foot level under the front of the finish rollers, snug against the rollers. Measure from the carriage rail to the top of the level. If the screed is set correctly the measurement should be the same at all four corners of the rollers. This measurement will be referred to as the constant (C). (see figure)

3. Begin on one of the exterior girders. At each 10^{th} point measure up from the top of the girder to the carriage rail. The carriage should be located as close to the beams as possible and still allow for easy measurement. This measurement will be referred to as the shot (S).

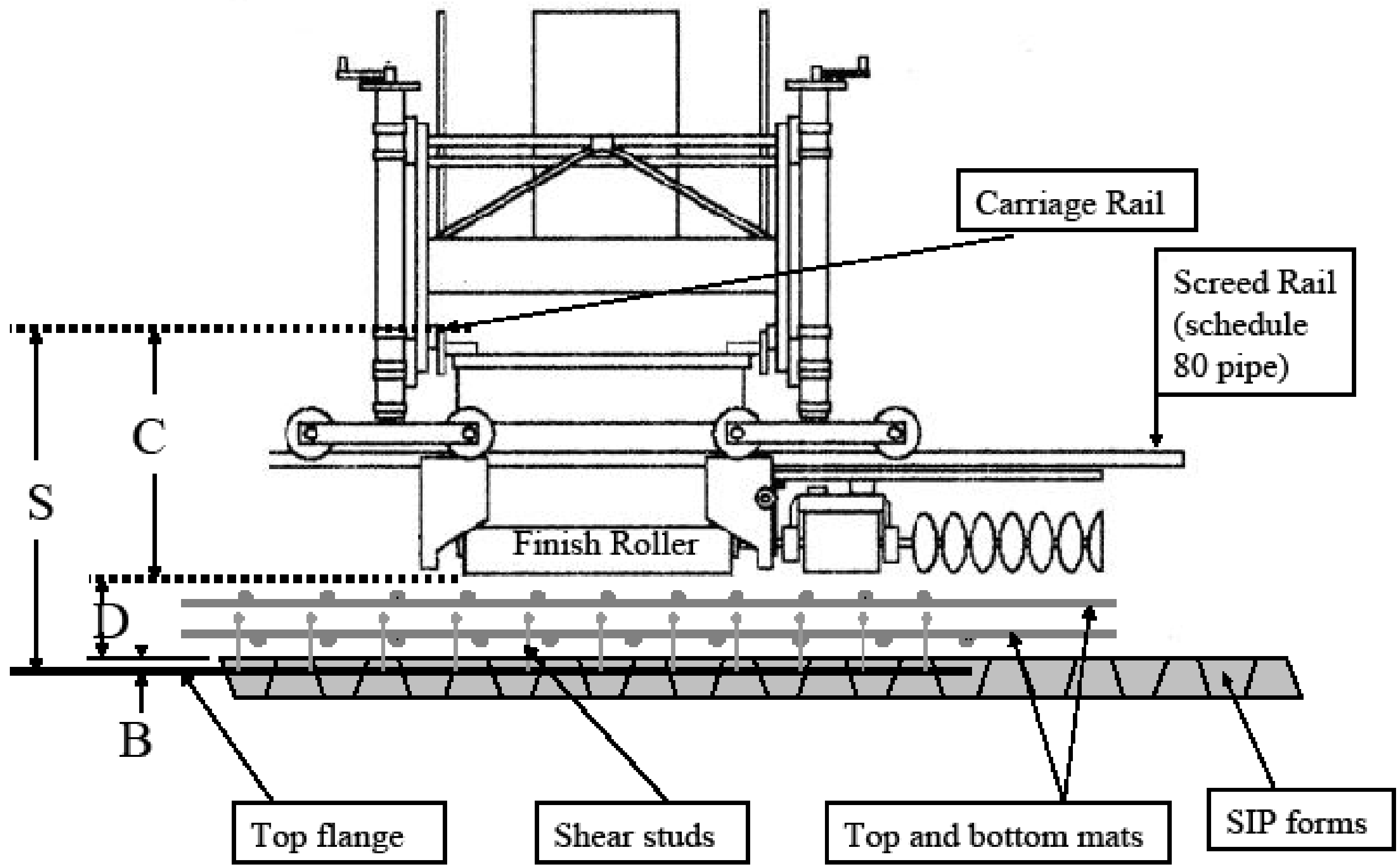
4. Subtract the buildup (B) and the constant from the shot and you will be left with the deck thickness (D).

   S-C-B=D

   Where: S=Shot form carriage rail to top of girder
   C=Constant from carriage rail to bottom of finish rollers
   B=Calculated buildup
   D=Deck Thickness

5. If the deck thickness is greater that the plan thickness, the screed rail should be lowered until the plan thickness is achieved. Conversely, if the deck thickness is less than the plan thickness, the screed rail should be raised until the plan thickness is achieved. Also check for proper clearance from the deck pans and the top mat to the finish rollers.

6. Steps 3-5 should be repeated for each tenth (10^{th}) point on the exterior girders before checking the interior girders. Any errors found on the interior girders at that point should be minor variations due to incorrect pan elevations.



Carriage Rail
Screed Rail
(schedule
80 pipe)
C
S
Finish Roller
D
B
Top flange
Shear studs
Top and bottom mats
SIP forms

Figure