SURVEYING AND STAKING
5-393.050

5-393.051 CONSTRUCTION SURVEYING

According to Specification 1508, Mn/DOT is responsible for furnishing the Contractor sufficient staking for the control points and working points as shown on the Bridge Layout sheet. Control points include benchmarks in the vicinity of substructure units. Grade points for substructure and superstructure forms and beam stool heights are also provided for the Contractor. Refer to the Surveying and Mapping Manual, Section 6-3, for detailed procedures and a sequence of activities for Construction Surveying.

5-393.052 STAKING BRIDGES

Staking a structure is a phase of the Engineer's operations which should receive very careful attention. Serious and costly delays have resulted because of stakes placed out of line and because the work was not properly checked. The Contractor should not be permitted to start work on a unit until the location of that unit has been accurately determined and verified.

Whenever possible, the entire structure should be completely staked, checked and referenced before construction operations are started. Here, again, it is important to consult with the Contractor so as to avoid placement of reference points where equipment and materials are to be stored.

Do not rely on merely two points to re-establish a line. Set enough points on each line during the original staking so that a minimum of three points can be sighted on any setup, with additional check points in the event some points are disturbed. Points should be placed on both ends of each unit so that it will not be necessary to project lines in order to re-establish a location whenever this is possible. Check angles as well as distances for each unit. Be certain that the lines and dimensions shown on the plans are correctly interpreted. A roadway centerline, for instance, is not necessarily the centerline of the bridge. The plans may use one line for superstructure details and the other for substructure units. Beware of such a condition; read the plans carefully! Check the grading plans to make sure that information is the same as in the bridge plan.

All bridge plans include a sheet entitled Bridge Layout. The purpose of this sheet is to provide a line diagram of the bridge showing only information essential for staking. Generally, one control point is shown which is established by intersection of center lines or survey lines. This would then be the point where the bridge staking would begin and the working points established. Dimensions between working points are usually shown in a tabulation at the lower left-hand part of the sheet. The tabulation also shows a number of diagonal distances between working points for checking dimensions. These measurements should be diligently made to assure that the working points have been accurately set.

Measurements will be made with either EDM (Electronic Distance Measuring) equipment or standardized steel tapes, pulled to correct tension.

Mn/DOT 2402.3 requires that, unless otherwise shown on the plans, bearing assemblies such as rockers and roller nests should be set plumb or at a designated tilt at a temperature of 7°C (45°F). The plans, also usually specify that the opening between expansion joint extrusions be a prescribed width at 7°C (45°F). To obtain the results required by the plans, i.e., specified conditions at 7°C (45°F), it is also necessary that the substructure units be staked to 7°C (45°F). Temperature corrections should, therefore, be made to a base of 7°C (45°F). If the temperature of a steel tape is higher than 7°C (45°F), it will span greater distances between its markings than at 7°C (45°F); therefore, the computed correction must be subtracted from the measured length during the staking operation. If the temperature of the tape is lower than 7°C (45°F), the correction must be added.

The amount of correction to be applied can be determined by using the following formulas:

Tc = 0.0000117Dm (7-Tt) (For temperature in °C)

Tf = 0.0000065 Df (45-Tt) (For temperature in °F)

Tc = temperature correction in millimeters

Tf = temperature correction in feet

Dm = distance to be measured in millimeters

Df = distance to be measured in feet

Tt = temperature of the tape

0.0000117 is the coefficient of thermal expansion for steel when using temperature in °C.

0.0000065 is the coefficient of thermal expansion for steel when using temperature in °F.

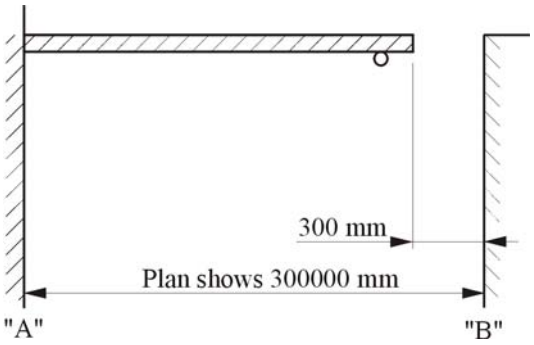
Tables 1 and 2 5-393.052 have been prepared so they may be used to check field computations and so that corrections will not be made in reverse.

Example for temperature in °C:

It is specified that the opening at Point B be 300 mm at a temperature of 7°C.

Temperature on the day of survey is 20°C.

To provide the opening of exactly 300 mm at Point B, a tape correction of 46 mm would be required for the 300000 mm true distance between A and B. A taped distance of 299954 mm would be staked.



Example for temperature in °F:

It is specified that the opening at Point B be 1.00 foot at a temperature of 45°F.

Temperature on the day of survey is 68°F

To provide the opening of exactly 1.00 foot at Point B, a tape correction of 0.15 feet would be required for the 1000.00 foot true distance between A and B. A taped distance of 999.85 feet would be staked.

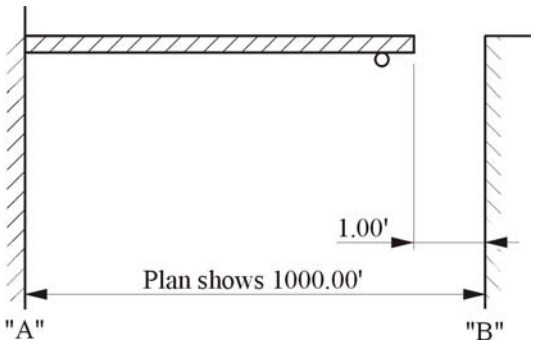


TABLE 1 5-393.052
CORRECTED DISTANCE TO BE MEASURED FOR STAKING

Distance to be staked in millimeters	Temperature of Tape in Degrees Celsius								
	-30°C	-20°C	-10°C	0°C	7°C	10°C	20°C	30°C	40°C
50000	50022	50016	50010	50004	50000	49998	49992	49987	49981
100000	100043	100032	100020	100008	100000	99996	99985	99973	99961
150000	150065	150047	150030	150012	150000	149995	149977	149960	149942
200000	200087	200063	200040	200016	200000	199993	199970	199946	199923
250000	250108	250079	250050	250020	250000	249991	249962	249933	294903
500000	500216	500158	500099	500041	500000	499982	499924	499865	499807

TABLE 2 5-393.052
CORRECTED DISTANCE TO BE MEASURED FOR STAKING

Distance to be staked in feet	Temperature of Tape in Degrees Fahrenheit							
	-20°F	0°F	+10°F	+30°F	+45°F	+60°F	+80°F	+100°F
100.00	100.04	100.03	100.02	100.01	100.00	99.99	99.98	99.96
200.00	200.08	200.06	200.05	200.02	200.00	199.98	199.95	199.93
300.00	300.13	300.09	300.07	300.03	300.00	299.97	299.93	299.89
400.00	400.17	400.12	400.09	400.04	400.00	399.96	399.91	399.86
500.00	500.21	500.15	500.11	500.05	500.00	499.95	499.89	499.82
1000.00	1000.42	1000.29	1000.23	1000.10	1000.00	999.90	999.77	999.64

5-393.053 BENCHMARKS

Benchmarks shown on the survey sheet of the plans should be checked prior to being used for setting job benches. Report any errors to the District Land Management Engineer. After job benches have been set and checked, they should be used throughout the construction of the entire bridge unless they are destroyed.

The Contractor relies upon the accuracy of benchmarks to provide grades for substructure and superstructure forms as they are needed, and it is very important that any such grades be correct. Correct grades cannot be established if the job benchmarks are in error. The resulting discrepancies are quite embarrassing, as well as costly, and can be the source of claims for both time extensions and financial reimbursement. A little extra care taken in establishing good benchmarks is the cheapest possible insurance against subsequent difficulties.

Benchmark discs are furnished by the Department and should be placed on new structures at the location designated in the plans.

A permanent record should be kept of all levels and cross sections taken. Also, records should be maintained on what process and control was used to set and check the working points or offsets. These notes may be needed if constructed work is found to be at an incorrect elevation.

Calculated elevations of tops of girders are available from the Bridge Designer (Bridge Office). The Designer's name is shown on the first sheet of the bridge plan (contact the "reviewer" for consultant plans). It is important to specify the interval at which elevations are desired (i.e., every 1.5 meters (5 feet)) and specific locations needed. Information will be furnished on a computer output sheet.