TRANSPORT FOR NSW (TfNSW)

SPECIFICATION D&C G71

CONSTRUCTION SURVEYS

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Transport for NSW

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IC-DC-G71

VERSION FOR:
DATE:

CONTENTS

CLAUSE PAGE

FOREWORD

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BASE SPECIFICATION

This document is based on Specification TfNSW G71 Edition 2 Revision 4.

TfNSW SPECIFICATION D&C G71

CONSTRUCTION SURVEYS

1 GENERAL

1.1 SCOPE

This Specification sets out the requirements for undertaking surveys during construction. It includes the following:

(a) Quality management system for survey work, including procedures, equipment, surveying software, records and audits, complying with Specification TfNSW D&C Q6.

(b) Maintaining the integrity of the NSW Survey Control Network and Cadastre.

(c) Survey techniques for attaining the accuracies required by the tolerances specified in TfNSW Specifications.

(d) Additional survey requirements, including sampling plans for verifying spatial conformity, and Orders of Accuracy that must be complied with to achieve tolerances contained within the various road and bridgeworks specifications.

Further guidance is provided in Specification Guide TfNSW NG71.

1.2 STRUCTURE OF SPECIFICATION

This Specification includes a series of Annexures that detail additional requirements.

1.2.1 Project Specific Requirements

Project specific details of work are shown in Annexure G71/A.

1.2.2 (Not Used)

1.2.3 Schedules of HOLD POINTS and Identified Records

The schedules in Annexure G71/C list the **HOLD POINTS** that must be observed. Refer to Specification TfNSW D&C Q6 for the definition of **HOLD POINT**.

The records listed in Annexure G71/C are **Identified Records** for the purposes of TfNSW D&C Q6 Annexure Q/E.

1.2.4 Planning Documents

The PROJECT QUALITY PLAN must include each of the planning documents and requirements shown in Annexure G71/D and must be implemented.

1.2.5 Referenced Documents

Standards, specifications and test methods are referred to in abbreviated form (e.g. AS 1234). For convenience, the full titles are given in Annexure G71/M.

1.3 DEFINITIONS AND ACRONYMS

1.3.1 Definitions

The terms "you" and "your" mean "the Contractor" and "the Contractor's" respectively.

The terms "Surveying Act" and "Surveying Regulation" refer to the *Surveying and Spatial Information Act 2002 (NSW)* and the *Surveying and Spatial Information Regulation 2017 (NSW)* respectively.

The following definitions apply to this Specification:

Angle of inclination and declination	The angle of the line of sight above or below the horizontal, respectively.
Cadastral Reference Mark	A survey mark of the kind referred to in Schedules 3 and 4 of the Surveying Regulation.
Design Documentation drawings	Refer to definition in the deed.
Geoid-ellipsoid separation	The distance from the surface of an ellipsoid to the surface of the geoid, measured along a line perpendicular to the ellipsoid. The geoid approximates the mean sea level.
Global Navigation Satellite System	A collection of satellite systems developed by various countries (including USA's Global Positioning System) for navigation and positioning purposes.
Height of sight line	The minimum vertical distance from a straight line to the natural surface.
Intergovernmental Committee on Surveying and Mapping	The body responsible for coordinating Commonwealth and State agencies who contribute to surveying and mapping at a national level to ensure continued cooperation and technical standards. Its role includes developing survey standards and specifications.
Line of sight	A straight line joining the total station, or any other survey instrument, to the target.
Local Uncertainty	The universally accepted measure of the quality of measurement by quoting a confidence interval about derived measurements, and defined in SP1 v1.7 as "the average measure, in metres at the 95% confidence level, of the relative uncertainty of the coordinates, or height, of a point(s), with respect to the survey connections to adjacent points in the defined frame". In this Specification, the Orders of Accuracy for horizontal and vertical measurements are also quoted as a Local Uncertainty.

Machine Guidance System	A vehicle based system capable of providing an operator with real time feedback in relation to an electronic copy of the Design Model as reference. The system utilises sensors such as GNSS antennas, in machine and operator. It should be used only as a construction tool and not as a substitute for a survey using survey instruments such as total stations.
Model	An electronic representation of the design prepared by CADD software to produce the Design Documentation drawings. It also includes surface models for conformity verification and quantity surveys.
Order of Accuracy	A number system for relating the spatial tolerance requirements for set out and conformity surveys to a known Local Uncertainty. Orders of Accuracy for horizontal control (coordinates) are expressed using a "H" value and for vertical control (heights) are expressed using a "V" value. They are not to be confused with Class and Order as defined by SP1 v1.7.
Permanent Survey Mark	A survey control mark that is permanent by nature and uniquely defined by alphanumeric characters to store attributes of the mark in the records and systems of Spatial Services – Department of Finance, Services and Innovation (SS-DFSI). The marks provide the framework for all surveys to be brought onto the State Control Survey (refer Surveyor General's Directions No. 1).
Primary Survey Control Marks	Survey marks identified on the Design Documentation drawings as Primary Survey Control Marks and considered sufficiently stable and precise for construction setting out purposes. Primary Survey Control Marks are not limited to Approved Survey Marks as defined in Surveyor General's Directions No. 1.
Resection	A survey technique for determining the three dimensional coordinates of the total station set up remotely from survey control marks, by measurements to more than one survey control mark. Resection procedures must measure sufficient redundant data to enable a statistical adjustment, preferably by the least squares method that calculates residuals for each measurement.
Residual	The difference between the original field measurement and the adjusted measurement when carrying out statistical adjustments, e.g. by least squares, using redundant measurements.
Sight distance	The length of the sight line.
Site localisation	A method of ensuring that the World Geodetic System (WGS) values supplied by GNSS are able to be related to the on-ground survey, and therefore the design.
Standard of Accuracy	A term used to describe the precision of survey control mark values and networks. It is a function of the equipment used, observations techniques, network design, processing and the existing control. SP1 v1.7 uses a Class and Order classification system.
Survey Control Network	The Primary Survey Control Marks plus any additional survey control marks placed to extend the Survey Control Network or to replace the Primary Survey Control Marks.

Survey Infrastructure	Permanent marks and cadastral reference marks that use as reference the New South Wales Cadastre, as defined in the Surveying Regulation. This may or may not include survey marks identified on the Design Documentation drawings as Primary Survey Control Marks.
Survey mark	A survey peg, bench mark, reference mark, alignment, level mark or any other mark used or intended to be used for the purpose of setting out, checking or measuring the work under the deed.
Survey procedures	Methods to control parameters that affect the accuracy of survey techniques, such as a radiation procedure or height determination procedure.
Survey techniques	A survey method, such as radiation, differential levelling or tacheometry surveys.
Surveyor	A responsible person nominated by, and engaged by, the Contractor to undertake the surveying role on a construction site. Surveyors must possess the Surveying qualifications and experience specified in Clause 2.2.1.

1.3.2 Acronyms

EDM	Electronic distance measuring (device), i.e. total station
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
ICSM	Intergovernmental Committee on Surveying and Mapping
POSI	Preservation of Survey Infrastructure
SCIMS	NSW Survey Control Information Management System
SP1 v1.7	ICSM Special Publication No. 1 Version 1.7
SS-DFSI	Spatial Services – Department of Finance, Services and Innovation
SSM	State Survey Mark
SUI	Subsurface utility information (refer AS 5488)
WGS	World Geodetic System

2 GENERAL SURVEY REQUIREMENTS

2.1 LIAISON WITH TFNSW DIRECTOR SURVEYING OR DELEGATE

Prior to commencement of any construction activities that may affect the Survey Infrastructure (whether cadastral or state control network), contact the TfNSW Director Surveying or delegate.

Contact details for the TfNSW Director Surveying and delegates are listed in Annexure G71/E.

Liaise continually throughout the duration of the deed with the TfNSW Director Surveying or delegate.

Where necessary, you may seek further technical advice and assistance from the TfNSW Director Surveying or delegate for the survey component of the deed.

2.2 SURVEYOR

2.2.1 Qualifications

Surveyors engaged by the Contractor must hold as a minimum a Diploma in Surveying, or equivalent qualification, from a recognised tertiary institution, and have at least two (2) subsequent years of practical experience in surveying satisfactory to TfNSW.

Surveyors undertaking activities specified to be by Registered Land Surveyors must be land surveyors registered under the Surveying Act.

For surveys of Permanent Survey Marks, Bench Marks and Cadastral Reference Marks (refer Clause 3.1), comply with Section 3 of the Surveyor General's Directions No. 11.

2.2.2 Surveying Roles and Responsibilities

Detail in the PROJECT QUALITY PLAN all construction activities requiring survey work.

List those surveying tasks and responsibilities that are assigned to Surveyors and Registered Land Surveyors.

List also the personnel who will perform survey work that is not assigned to Surveyors.

2.3 QUALITY MANAGEMENT SYSTEM

2.3.1 Procedures

Provide in the PROJECT QUALITY PLAN (refer Clause 1.2.4) the procedures and equipment for carrying out the survey work, covering the measurement, calculation and recording necessary to:

(a) set out the Works;

(b) verify conformity to the Design Documentation drawings and TfNSW Specifications in relation to dimensions, tolerances and position in three dimensions;

(c) determine lengths, areas or volumes of materials or products where required for measurement of work.

The survey procedures must describe how the survey process is managed so that all the requirements of the Design Documentation drawings and TfNSW Specifications are met.

All surveying procedures must include checks to verify that coordinates of survey control marks shown in the Survey Control Mark Register are correct at the time of survey.

Survey procedures for verifying level conformity of pavement surfaces against design requirements in Specifications TfNSW D&C R82 and TfNSW D&C R83 must incorporate the requirement to use a pole with a flat base.

Provide calibration procedures for all survey equipment (refer Clause 2.4) that must be calibrated or verified.

Provide a procedure for the records system in the PROJECT QUALITY PLAN. The procedure must include the method of storing and indexing electronic records and name all computer software used for reduction of survey measurements and calculations.

Where monitoring is required, provide as part of the PROJECT QUALITY PLAN the methodology and survey process for this.

2.3.2 Management of Errors

The procedures must address all errors introduced by survey methods, including due allowance for the effects of:

(a) survey equipment capability and adjustment;

(b) integrity of the Survey Control Network and Survey Infrastructure;

(c) vertical refraction;

(d) grid scale factor;

(e) earth's curvature;

(f) geoid-ellipsoid separation.

2.3.3 Submission of PROJECT QUALITY PLAN

HOLD POINT	
Process Held:	Commencement of any work at the Site.
Submission Details:	PROJECT QUALITY PLAN for survey, including: (a) survey procedures and evidence that they are capable of achieving the specified Orders of Accuracy (refer Clauses 4 and 5); (b) strategy for the replacement of survey control marks and cadastral reference marks (refer Clause 3.1).
Release of Hold Point:	The Principal will consider the submitted documents prior to authorising the release of the Hold Point.

2.4 EQUIPMENT

2.4.1 General

Comply with the Surveyor General's Directions No. 5 in relation to all survey equipment used for work under the deed.

The equipment used must be appropriate for the attainment of the tolerances nominated in this Specification.

2.4.2 Equipment Requirements

Electronic total stations and ancillary equipment used for survey tasks must have the following (or better) features:

(a) electronic distance measuring device (EDM);

(b) error standard deviation of less than 5 mm + 5 ppm for distance measurement;

(c) error standard deviation of less than 3 seconds of arc for angular measurement of both horizontal and vertical circles;

(d) one second of arc minimum count;

(e) diametrical vertical circle reading and automatic tilt compensator;

(f) electronically record and store field data such as horizontal and vertical angles, distances, point notation, target and instrument heights.

2.4.3 Calibration/Verification

Carry out the calibration/verification of the electronic total station in accordance with the Surveyor General's Directions No. 5 prior to its use for work under the deed. Carry out similar calibration/verification after any repair, service or upgrade of firmware prior to its use.

All survey equipment used for the deed must have a current calibration certificate, with their details recorded in the equipment register.

2.5 SOFTWARE

2.5.1 General

The software used must:

(a) be the primary method for calculating design levels of pavement surfaces for both set out and conformity verification surveys of pavement surfaces;

(b) have the capability to determine design levels of the pavement surface at randomly selected points and make comparisons with constructed levels;

(c) have the capability of calculating design pavement surface levels with an error of less than one millimetre compared to the Design Documentation drawings.

Include also the name and version of the survey software in the PROJECT QUALITY PLAN.

2.5.2 Surface Modelling Software

Where so specified, determine the thickness of a pavement course by a comparison of the conformity verification surveys of the top and bottom surfaces of the pavement course. Describe in the PROJECT QUALITY PLAN the software and process for this.

2.5.3 Grid Coordinates to Chainages and Offsets

Where the work under the deed requires setting out or measurements taken on pavement courses for conformity purposes, the software must be capable of converting grid Easting and Northing to chainage and offset in relation to design control lines.

2.6 RECORDS

2.6.1 General

Survey records are quality records and must be managed and stored in accordance with TfNSW D&C Q6.

2.6.2 Data in Traditional Survey Field Books

Survey data collected manually in traditional survey field books are part of the survey records. Survey field books must be clear and legible, showing the date, purpose, and location of the survey. Each survey field book must be indexed.

The Surveyor must sign all paper copies of survey field measurements, data and reductions, field books, diagrams and sketches used to set out the work, check the product for conformity or to determine quantities in accordance with TfNSW Specifications.

2.6.3 Height Difference By EDM Trigonometrical Heighting

Where the surveyor radiates or determines height difference by EDM trigonometrical heighting to set out marks and uses computer software as an independent survey check, the field measurements, recorded data and resulting computer reductions will be part of the survey records.

2.6.4 Conformity Verification Surveys

Conformity verification field book pages (whether in paper or electronic format) must be clearly labelled, dated and signed by the Surveyor with cross-indexed references to equipment used and Lot/component identification.

Where automatic data recording systems are used for verification surveys, retain a print-out or controlled electronic copy of both raw (field) data and reduced data in a similar manner as conventional field books, in addition to the electronic data.

2.6.5 Survey Reports

At the time of survey, record the Surveyor's name, date and signature as part of the survey data, and show these details on the survey reports (whether in paper or electronic format).

The Survey Reports generated must include references to field book page numbers.

2.6.6 Assurance

Survey records must be able to provide assurance that the surveyor has carried out all surveys in compliance with the submitted procedures, and that all surveys have attained the required accuracy.

The survey records system must be indexed for easy retrieval of information and provide a clear audit trail for all surveys.

Provide paper copies of electronically collected survey data used for set out and product conformity surveys when requested by the Principal.

2.6.7 Calibration/Verification Records

Calibration/verification records of survey equipment are part of the survey records.

2.6.8 Nonconformity Register

The surveyor must maintain (or have access to) a register of any Nonconformity Reports raised on any survey work carried out to verify conformity in accordance with the PROJECT QUALITY PLAN.

2.7 INSPECTION AND QUALITY AUDITS

2.7.1 Inspections

At any time during the duration of the deed, the Principal may conduct inspections to verify compliance with this Specification. Cooperate with the Principal during any such inspections.

2.7.2 Quality Audits

Should field inspections and/or examination of survey records indicate that a condition adverse to quality may exists, the Principal may conduct a quality audit.

The Principal will give you at least 5 days written notice of impending quality audits.

Provide every assistance to the Principal, and persons nominated in writing by the Principal, for conduct of the quality audits.

2.8 WORK HEALTH AND SAFETY

2.8.1 General

Comply with Specification TfNSW D&C G22.

Provide Safe Work Method Statements for all survey activities as part of the Project WHS Management Plan.

2.8.2 Traffic Control

Provide Traffic Control Plans where required for survey activities, as part of the overall Traffic Management Plan provided in accordance with Specification TfNSW D&C G10. Include the traffic control qualifications of surveying personnel and/or Traffic Controllers proposed.

2.9 COMMENCEMENT OF FIELD SURVEY

Prior to commencement of field survey, submit the following details to the Principal:

(a) list of surveyors proposed to undertake the survey work, including their names, qualifications and details of their experience (refer Clause 2.2);

(b) list of survey and ancillary equipment proposed for use to undertake the survey work, including unique identification, calibration and verification records in accordance with the Surveyor General's Directions No. 5 and No. 9 (refer Clause 2.4);

(c) Safe Work Method Statements (refer Clause 2.8.1);

(d) Traffic Control Plans and traffic control qualifications (refer Clause 2.8.2);

(e) procedures for working around known heritage and other environment constraints at the Site.

HOLD POINT	
Process Held:	Commencement of survey field work.
Submission Details:	Documents listed under Items (a) to (e) in Clause 2.9, at least 5 working days before commencement.
Release of Hold Point:	The Principal will consider the submitted documents prior to authorising the release of the Hold Point.

2.10 JOINT SURVEYS

2.10.1 General

Where so specified, or required by the Principal, carry out a survey as a joint survey, with the Principal in attendance, unless authorised otherwise.

Provide the necessary personnel and resources to carry out, record and report the results of the survey.

HOLD POINT	
Process Held:	Commencement of each survey specified to be a joint survey.
Submission Details:	Survey date and location, surveyor's name, description of methods and equipment to be used, at least 3 working days before commencement.
Release of Hold Point:	The Principal will consider the submitted documents prior to the release of the Hold Point.

2.10.2 Submission of Joint Survey Results

Submit a report containing the results of the survey, together with relevant calculations, to the Principal within 5 working days of completion of the survey, and at least one working day before disturbing or covering up the area of the joint survey.

HOLD POINT	
Process Held:	Disturbing or covering up area of joint survey.
Submission Details:	Survey Report, including any calculations made to determine quantities, at least one working day before disturbing or covering up area of joint survey.
Release of Hold Point:	The Principal will consider the submitted documents prior to authorising the release of the Hold Point.

2.11 CARE OF SURVEY MARKS

Preserve and maintain in their true positions all survey marks.

3 SURVEY CONTROL NETWORK AND CADASTRE

3.1 PRESERVATION OF SURVEY INFRASTRUCTURE

3.1.1 General

Comply with Surveyor General's Directions No. 11 on, and take responsibility for preservation of the Survey Infrastructure and the treatment of Permanent Survey Marks, Bench Marks and Cadastral Reference Marks that may be affected by the Works in accordance with the Surveying Act and the Surveying Regulation. Refer also the Project Deed Scope of Works and Technical Criteria (SWTC).

Provide regular site induction to your workers regarding protection of Permanent Survey Marks and Cadastral Reference Marks.

3.1.2 Authorisation

Where applicable, at least 30 working days prior to the commencement of construction activities near the Survey Infrastructure, submit an application through the TfNSW Director Surveying or delegate to the Surveyor General for authorisation to remove the Permanent Survey Marks, Bench Marks and Cadastral Reference Marks that will be affected by the Works, in accordance with the Surveying Regulation.

Include with the application the following:

(a) Audit schedule (survey mark register) from a field audit of all survey marks including Permanent Survey Marks, Bench Marks and Cadastral Reference Marks within and adjoining the extent of the Works.

The audit schedule must show the mark's physical state (e.g. "found", "disturbed", "gone"), the mark's status (type, position, height and accuracy), and date of inspection.

The schedule must also show which marks will be protected and which will be replaced.

(b) Survey Project Plan outlining the strategy and methodology for onsite mark protection and reinstatement of survey infrastructure for the duration of the deed.

The Survey Project Plan must include a diagram or drawing showing the extent of the Works, all existing marks, proposed position and accuracy of each new mark, survey technique, and equipment to be used.

A Preservation of Survey Infrastructure (POSI) resource pack is available from the TfNSW internet site at: http://www.rms.nsw.gov.au/business-industry/partners-suppliers/draft-documents.html.

HOLD POINT	
Process Held:	Commencement of construction activities near Survey Infrastructure.
Submission Details:	Application for authorisation to remove Permanent Survey Marks, Cadastral Reference Marks and Bench Marks, together with Items (a) to (b) in Clause 3.1.2, at least 30 working days prior to commencement of construction activities near Survey Infrastructure.
Release of Hold Point:	The Principal and TfNSW Director Surveying or delegate will consider the submitted documents and may request further work, carry out their own site inspection and survey field measurement, prior to authorising the release of the Hold Point.

3.1.3 Protection Measures

Implement measures to prevent disturbance of the marks which are to be preserved, and any new marks placed. If practical, place 1.5 m long stakes which are painted in a conspicuous manner around these marks, to assist in their protection or alternatively, paint around these marks.

Inform the Principal immediately if there is any unplanned destruction of parts of the Survey Infrastructure, as penalties may be imposed by the Surveyor General.

3.1.4 Removal and Replacement of Survey Marks

Notify the Principal prior to removal or destruction of survey marks that have been so authorised by the Surveyor General.

Take sufficient measurements and provide sufficient information as required to comply with the conditions under the Surveyor General's approval to remove the survey marks. The conditions may include placement of new permanent marks and lodging of a Deposited Plan of Survey Information Only (DPOSIO) during and post construction period. The DPOSIO work must be undertaken by a Registered Land Surveyor.

Refer to the Surveying Regulation and the Surveyor General's Directions No. 11 and No. 12.

HOLD POINT	
Process Held:	Any activities that may cause removal, damage, destruction, or obliteration of a permanent control or cadastral mark.
Submission Details:	Surveyor General's approval under the Surveying Regulation, at least 2 days before disturbing the mark.
Release of Hold Point:	The Principal will consider the submitted approval and any conditions and may inspect the site, prior to authorising the release of the Hold Point.

3.2 SURVEY CONTROL NETWORK

3.2.1 General

The Principal will provide you with the Primary Survey Control Marks and information necessary for setting out the Works.

Take responsibility for these marks and any additional marks that form the Survey Control Network and verify their integrity before commencing any survey activity.

HOLD POINT	
Process Held:	Use of survey control marks forming part of the Survey Control Network.
Submission Details:	Survey Report verifying coordinates and level values of the survey control marks, at least 10 working days before use of the marks. Where requested, submit the procedure for replacing the affected Primary Survey Control Marks.
Release of Hold Point:	The Principal will consider the submitted documents and may inspect the marks prior to authorising the release of the Hold Point.

3.2.2 Protection Measures

Implement measures to prevent disturbance of the survey control marks defining the Survey Control Network. If practical, place 1.5 m long stakes which are painted in a conspicuous manner around the survey control marks to assist in their protection or alternatively, paint around these marks.

3.2.3 Placing Additional Survey Control Marks

Where additional survey control marks are required to break down the Survey Control Network, position such marks with due regard to maximising their use and protection against disturbance by construction activities. This includes placing survey marks that are substantially stable.

Where a survey control mark is affected by the execution of works, establish other stable marks of the same standard of accuracy that are clear of the Works prior to the commencement of work in the affected area.

3.2.4 Survey Control Network At Construction Completion

Ensure that at Construction Completion, a Survey Control Network of similar integrity as the one shown on the Design Documentation drawings, including distribution and standard of accuracy, is in place.

Comply with Surveyor General's Directions No. 11 and No. 12 when ensuring the integrity of the final State Survey Control Network.

3.3 SURVEY CONTROL MARK REGISTER AND CADASTRAL MARK REGISTER

3.3.1 General

Maintain a current Survey Control Mark Register and Cadastral Mark Register of all survey marks.

Include the schedule from the field audit of survey marks (refer Clause 3.1.2) in the mark registers.

The register forms part of the quality records and must be controlled in accordance with your Quality Management System. Retain superseded copies of the register.

Provide the Principal with an updated copy of the register whenever the register is updated.

3.3.2 Survey Control Mark Register

Include the following information, where practicable, in the Survey Control Mark Register:

(a) a unique number/identifier for each survey control mark;

(b) any other identifier such as an SSM number;

(c) Easting, Northing and Height of each survey control mark, except for marks used for reference sightings only;

(d) chainage and offset of each survey control mark in relation to a main control line, where it is practical to do so and where a main control line exists;

(e) description of the physical nature of each survey control mark, such as star picket or pre-drilled concrete nail.

3.3.3 Cadastral Mark Register

Include the following information, where practicable, in the Cadastral Mark Register:

(a) a unique number/identifier for each cadastral (reference) mark;

(b) any other identifier such as an SSM number;

(c) Easting, Northing and Height (where applicable) of each cadastral mark;

(d) description of the physical nature of each cadastral mark, such as peg or drill hole;

(e) Deposited Plan number;

(f) status (e.g. “Gone”, “Not found”, “Found”);

(g) project impact (e.g. “Safe”, “Vulnerable”, “To be destroyed”);

(h) date when reported to SS-DFSI.

3.4 MARKING LAND PROPERTY BOUNDARIES

Where the Design Documentation drawings or Design Model indicate that construction work will be carried out within 300 mm of a property boundary, determine the actual property line using the most current cadastral information supplied by the NSW Land Registry Services.

This must include a survey carried out by or under the direct supervision of a Registered Land Surveyor, in accordance with the Surveying Act.

Do not use the cadastral electronic model (or overlay), or the Digital Cadastral Database to define the property boundaries.

3.5 STANDARDS OF ACCURACY – SURVEY CONTROL NETWORK

When verifying, extending or breaking down the Survey Control Network, three Standards of Accuracy are applicable for the procedures, depending on the survey activity, as shown in Table G71.1.

Table G71.1 – Standards of Accuracy for Survey Control Network (1)

Activity	Horizontal Control		Vertical Control		
	Traditional Survey Methods	GNSS Techniques	Differential Levelling	Trigonometrical Levelling	GNSS Techniques
Bulk Earthworks	Class E	Class C	Class LE	Class D	Class C
General Construction Activities	Class C	Class B	Class LC	Class B	N.A.
Specialised Construction Activities	LU 4 mm	N.A.	Class LA	N.A.	N.A.

Note: LU = Local Uncertainty N.A. = Not applicable

(1) Classes listed in Table G71.1 are in accordance with the NSW Survey Control Information Management System (SCIMS). Refer to Surveyor General's Directions No. 12 and SP1 v1.7.

Use survey methods that will achieve the specified Classes for each Standard of Accuracy.

Provide evidence that the Local Uncertainty (refer Clause 1.3.1 for definition) for survey control developed for Specialised Construction Activities is no more than that shown in Table G71.1.

3.6 CONTROL STANDARDS OF ACCURACY – CONSTRUCTION ACTIVITIES

3.6.1 General

Use surveying procedures with accuracies that are commensurate with those of the construction activities stated under Clauses 3.6.2 to 3.6.5.

Survey control marks of a lower Standard of Accuracy may be appropriate on some occasions. Conversely, survey control marks with a higher Standard of Accuracy may be necessary for some specialised surveys, as outlined below.

Refer to Clause 3.5 for requirements.

Document the survey processes in the PROJECT QUALITY PLAN.

3.6.2 Control for Bulk Earthworks

Construction activities where survey control marks forming the Earthworks Control may be used include determination of bulk earthworks quantities, determination of the extent for clearing and grubbing, and initial set out of the earthworks.

When placing or verifying survey control marks for bulk earthworks, you may use survey procedures with a lower Standard of Accuracy than that required for General Construction Activities. Refer to Table G71.1.

The local uncertainty of the coordinates of the marks of the Earthworks Control must be less than one-third of the tolerance of the survey for which they will be used. Refer to Clause 5.1.2 for Orders of Accuracy for set out and conformity verification.

Do not include the Earthworks Control in the Survey Control Marks Register (refer Clause 3.3).

3.6.3 Control for General Construction Activities

General Construction Activities cover most of the work under the deed, and include the following:

(a) final earthworks surfaces immediately below pavement courses;

(b) pavement courses;

(c) drainage structures;

(d) other structures on top of pavement courses, such as kerbs;

(e) road furniture;

(f) some bridgeworks and other concrete structures (refer also Clause 3.6.4).

Do not use the Earthworks Control for General Construction Activities.

As soon as practical, place and survey all survey control marks to the Standard of Accuracy required for General Construction Activities. Distinguish using different markings those marks that have accuracy suitable for General Construction Activities from those marks suitable for Earthworks Control.

Verify that the Primary Survey Control Network is suitable for General Construction Activities (refer Clause 3.2).

3.6.4 Control for Specialised Construction Activities

The Principal may require you to carry out survey work to a higher Standard of Accuracy than that which is possible using survey control marks coordinated to an accuracy suitable only for General Construction Activities. Refer to Table G71.1 and Clause 4.2 for Orders of Accuracy.

This will apply to some bridgeworks, monitoring or specialised surveys.

3.6.5 Control for the Bridgeworks

Where you establish a control for General Construction Activities or Specialised Construction Activities specifically for bridgeworks, use ground distances in place of grid distances for all lines when calculating coordinates of the survey control marks (refer also Clause 5.4.1).

3.7 SUMMARY OF PROCESS

A summary of the process for developing, maintaining and extending the Survey Control Network is shown in Table G71.2.

Table G71.2 - Developing, Maintaining and Extending the Survey Control Network

Time Line	Actions by Contractor	Details	Outcome
Start of deed	Receive from the Principal the Primary Survey Control Marks.	Primary Survey Control Marks contained on the Design Documentation drawings.	Sufficient survey control marks to set out the Works
	Identify and preserve/recover Permanent Survey Marks and Cadastral Reference Marks likely to be affected by the Works.	These marks are part of the Survey Infrastructure as described in Surveyor General's Directions No. 11. Contact TfNSW Director Surveying, or delegate. Submit an application through TfNSW Director Surveying or delegate to the Surveyor General for authorisation to disturb the marks. Work involving Cadastral Reference Marks must be done by a Registered Land Surveyor. HOLD POINT on commencement of construction activities in affected area applies.	Collection of sufficient measurements and actions taken for the preservation of the NSW Survey Infrastructure. Survey information for preservation of cadastral survey marks verified and HOLD POINT released.
	Protect the Primary Survey Control Marks from construction activities.	Place stakes, markers or other means to highlight location of survey control marks for their protection.	Survey control marks protected to assist construction activities.
	Verify coordinates of the Primary Survey Control Marks before use.	HOLD POINT on use of the Survey Control Network applies.	Survey control marks verified and HOLD POINT released.
Clearing and grubbing and initial bulk earthworks activities	Initial break down of the Primary Survey Control Marks to form the Survey Control Network.	May use Earthworks Control procedures for these construction activities. Use different marking notation for Earthworks Control.	Initial construction activities are expedited by using survey control applicable to the Works.
Completion of bulk earthworks and initial pavement construction commences.	Continue to break down the Survey Control Network. Ongoing monitoring of survey control marks.	All survey control marks placed for the Earthworks Control are now surveyed for use in General Construction Activities.	The Survey Control Network becomes suitable for General Construction Activities.
Specialised Construction Activities.	Break down the Survey Control Network using higher order procedures.	Use procedures relating to Specialised Construction Activities to place extra survey marks or survey existing marks.	Tolerances stated in bridge specifications or as directed for specialised surveys can be achieved.
Construction completion	Provide the Principal with Survey Control Network of similar integrity of the Primary Survey Control Marks.	Replace survey control marks destroyed during construction of the Works in safe positions, if it was not possible to do so during construction.	The Primary Survey Control Marks are available for future TfNSW works.
	Close out outstanding actions for compliance with Surveyor General's Direction No. 11 and 12. Comply with all conditions of Removal of Survey Marks approval from SS-DFSI.	Replace destroyed permanent marks in safe positions, if it was not possible to do so during construction. Prepare and submit plans, locality sketches, data and diagrams as required by Surveyor General's Direction No. 11 and No 12.	The NSW Survey Infrastructure is preserved to assist future capital works programs and the Cadastre is protected.

4 SURVEY TECHNIQUES

4.1 GENERAL

Comply with the Orders of Accuracy for horizontal control (coordinates) and vertical control (heights) checks for the construction activities listed in Clause 5 to satisfy spatial requirements.

Use the surveying procedures in Guide TfNSW NG71 for traditional survey methods of radiation and height determination, as well as GNSS procedures, that are considered to be capable of meeting the Orders of Accuracy listed in this Clause.

You may use other procedures that you can verify as capable of meeting the required Orders of Accuracy, and providing evidence of this to the Principal for acceptance before their use.

4.2 ORDERS OF ACCURACY

4.2.1 Orders of Accuracy for Horizontal Control (Coordinates)

Table G71.3 – Orders of Accuracy for Horizontal Control (Coordinates)

Order of Accuracy (1)	Local Uncertainty (2)
1H	5 mm
2H	12 mm
3H	25 mm
4H	125 mm
5H	500 mm

Notes:

(1) A reference notation for each Order of Accuracy.

(2) 95% confidence level of relative uncertainty with respect to adjacent survey control marks.

4.2.2 Orders of Accuracy for Vertical Control (Height)

Table G71.4 – Orders of Accuracy for Vertical Control (Height)

Order of Accuracy (1)	Local Uncertainty (2)
1V	0.7 mm
2V	1.5 mm
3V	3 mm
4V	6 mm
5V	20 mm
6V	100 mm

Notes:

(1) A reference notation for each Order of Accuracy.

(2) 95% confidence level of relative uncertainty with respect to adjacent survey control marks.

4.3 EDM TRIGONOMETRICAL HEIGHTING SURVEY

Clause 4.3 applies where EDM Trigonometrical Heighting procedures are developed for vertical control Orders of Accuracy.

4.3.1 General

For EDM trigonometrical heighting procedures, minimise errors caused by determining the height of the total station, as well as determining the height difference between the total station and the surveyed point.

Where a resection procedure is used to determine the height of the total station, it must measure redundant data and calculate heights by an adjustment that calculates residuals.

4.3.2 Survey Checks

(a) By Residuals

Where a resection is used to determine the height of the total station, use the residuals calculated by resection software to verify accuracy of the height of the total station. This check is mandatory for Orders of Accuracy 2V, 3V and 4V where a resection determines the height of the total station.

For Orders of Accuracy 2V, 3V and 4V, when using a resection procedure, the difference between the residuals to any two survey control marks must not exceed 5 mm. For Order of Accuracy 5V, when using a resection procedure, the difference between the residuals for any two stations must not exceed 9 mm.

Where there is more than one sighting to the same survey control mark, use the mean of the residuals.

Where the differences exceed the limits stated above, carry out an investigation and take the appropriate corrective action.

Notify the Principal of any changes to the coordinates of the survey control marks as a result of the investigation and corrective action, in accordance with Clause 3.3.1.

(b) By Survey Control Marks

Before commencing measurements after establishing the height of the total station, determine coordinates of a survey control mark by EDM trigonometrical heighting and compare its measured height with its recorded height. This survey check applies wherever EDM trigonometrical heighting is used for vertical control.

Comply with the maximum sight distance and minimum height of sight lines when determining differences to recorded heights of control marks shown in Table G71.5 for Orders of Accuracy 2V to 6V.

Table G71.5 – Allowable Height Differences with Survey Control Marks for Orders of Accuracy

Order of Accuracy	Max Sight Distance	Min Height of Sight Line	Allowable Height Difference
2V	70 m	1.5 m	5 mm
3V	100 m	1.5 m	5 mm
4V	100 m	1.5 m	5 mm
5V	150 m	1.5 m	10 mm
6V	200 m	1.0 m	25 mm

Note: Max = Maximum Min = Minimum

(c) Timing

Carry out the survey checks for Orders of Accuracy 2V to 6V immediately after determining the height of the total station and before commencing measurements from the total station.

Carry out a further survey check hourly or at the completion of each set up, whichever is the lesser.

4.4 EDM TACHEOMETRY SURVEY

4.4.1 General

EDM tacheometry must achieve the Order of Accuracy to satisfy requirements for both the horizontal and vertical components of the survey.

Use EDM Tacheometry survey to determine horizontal coordinates and heights simultaneously.

4.4.2 Data

EDM tacheometry procedures must include recording of the following data as part of the survey records:

(a) field measurements used to determine coordinates of all resected stations;

(b) residuals of measurements used to determine coordinates of resected stations;

(c) coordinates of resected stations;

(d) coordinates of all survey control marks used for each survey, including survey control marks used to determine coordinates of the total station by a resection procedure;

(e) all raw field measurements required to carry out the survey;

(f) grid scale factor applied;

(g) survey checks to verify the accuracy of the survey;

(h) reduction of all radiated points to grid coordinates or chainage, offset and height for three dimensional surveys;

(i) purpose, location and date of survey;

(j) unique identification of each survey for traceability.

Where applicable, in areas such as pavement surveys, the survey records must also show a comparison of field coordinates of radiated points with their design position and/or height.

4.4.3 Survey Checks

When carrying out EDM tacheometry surveys, apply the survey check applicable for the Order of Accuracy for EDM trigonometrical heighting component of the survey, as given in Clause 4.3.2.

Compare its measured horizontal coordinates with recorded values to verify horizontal Orders of Accuracy given in Table G71.3.

4.5 GNSS SURVEY

For surveys using real time GNSS equipment (Real Time Kinematic) for the purpose of construction set out and conformity checking, the requirements of Clause 2.3.1 and 4.1, and the following apply:

(a) Standard GNSS equipment must have, as a minimum:

  (i) GNSS receivers capable of recording carrier waves;

  (ii) braced support for the antenna pole.

(b) For each construction activity, the applicable Orders of Accuracy must satisfy those stated in Clauses 4 or 5.

(c) Calibrate equipment and validate survey by occupying established survey control marks and comparing surveyed coordinates with recorded coordinates. Include this procedure in the PROJECT QUALITY PLAN.

(d) Keep records of all measurements including quality checks.

(e) Where possible and practical for construction set out, obtain measurements between surveyed points by traditional survey methods to verify survey.

(f) Document and validate the methodology for modelling the geoid and its effects on heights.

(g) When operating a two way radio for GNSS operations, obtain authorisation from Australian Communication Authority for the frequency to use.

Do not use Real Time GNSS procedures for height determination where construction accuracy of less than 30 mm is specified.

4.6 MACHINE GUIDANCE

4.6.1 General

Machine guidance techniques must not be used for height determination for any purpose other than to aid in real time guidance of on-site equipment.

Measurements made using machine guidance are not suitable for use in verifying conformity or determining volumes.

4.6.2 Site Start-up

A Surveyor (refer Clause 2.2.1) must approve any site localisation (site calibration) prior to use of the Machine Guidance on site. The site localisation must be recorded and updated as site circumstances changes.

After site localisation, the Surveyor must undertake a check of the Machine Guidance before making it available for use by Machine Guidance operators. Provide details of the method for checking the Machine Guidance in the PROJECT QUALITY PLAN.

Where additional survey control is required in order to correctly utilise Machine Guidance using terrestrial systems, the Surveyor must install new survey control marks and record this information in accordance with Clause 3 of this Specification.

HOLD POINT	
Process Held:	Use of Machine Guidance, for purpose of guiding work.
Submission Details:	(a) Survey Report detailing the site localisation used, and (b) Survey Report detailing the machine specific Test Sites, at least 5 working days before use of Machine Guidance.
Release of Hold Point:	The Principal will consider the submitted documents prior to authorising the release of the Hold Point.

4.6.3 Machine Guidance Data

Prepare and upload into the Machine Guidance System(s) the Design Model and any updates of which you are notified.

HOLD POINT	
Process Held:	Use of Design Model within Machine Guidance System.
Submission Details:	Machine specific files and, where applicable, instructions for uploading this information into the Machine Guidance System. Any quality assurance documents utilised in the process of generating these files.
Release of Hold Point:	The Principal will consider the submitted documents prior to authorising the release of the Hold Point.

5 SURVEY REQUIREMENTS FOR SPECIFIC WORKS

5.1 EARTHWORKS

5.1.1 General

Refer to the Standard Drawings for the position of the (set out) batter profiles in relation to the design batter planes in cuts and embankments.

Mark any placed batter stakes with their chainage, offset and slope distance to the hinge point.

5.1.2 Orders of Accuracy

Comply with the Orders of Accuracy for the earthworks activities shown in Table G71.6.

Where EDM tacheometry survey procedures are used, comply also with the survey checks to survey control marks in Table G71.6.

Table G71.6 – Orders of Accuracy and Check Measurements for Earthworks Surveys

Activity	Specification	Orders of Accuracy		Survey Checks to Survey Control Marks	
		Horizontal	Vertical	Horizontal Difference (1, 2)	Height Difference (1, 2)
Clearing and grubbing	D&C G40	5H	6V	100 mm	100 mm
Batter planes	D&C R44	4H	5V	30 mm	20 mm
Benches in cut		5H	6V	100 mm	100 mm
Cut/Fill Transitions		4H	5V	30 mm	20 mm
Cut Floor excavation (3)		3H	5V	20 mm	20 mm
Cut Floor surface (4)		See Table G71.9			
Underside of Selected Material Zone					
Top of formation					

Note:

(1) Columns titled "Horizontal Difference" and "Height Difference" contain the allowable differences from survey control marks when using EDM trigonometrical heighting techniques for each earthworks activity.

(2) Differences shown in "… Survey Control Mark" columns are the allowable horizontal and height differences between survey control mark coordinates as determined by survey when compared to the adopted values.

(3) Cut Floor excavation refers to Foundation Level as defined in TfNSW D&C R44.

(4) Cut Floor surface refers to Designed Floor Level as defined in TfNSW D&C R44.

5.1.3 Earthworks Verifications

(a) Clearing and Grubbing

Provide evidence of the verification of the plan position of the intersection of the batter plane with the natural surface when carrying out conformity verification and set out survey of clearing and grubbing.

(b) Batter Planes

Provide evidence of the verification of the plan position of the intersection of the batter plane with the natural surface when carrying out conformity verification and set out survey of batter planes. Unless otherwise specified, this Clause is also applicable to other earthworks surfaces with design levels, such as for medians.

For surveys to verify conformity of the batter plane, sample the batter plane in a defined grid pattern.

In the selection of sampling points, select those points that accurately represent the batter plane with respect to anomalies.

Define the grid by selecting sampling points along strings (cross sections) that run approximately normal to the edge of formation of the road. The distance between each cross section must be between 10 m and 15 m.

At each cross section, select one sampling point which is located at least one metre from the top, and another sampling point which is located at least one metre from the bottom of the batter plane, to negate the effects of rounding (see Figure G71.1 below).

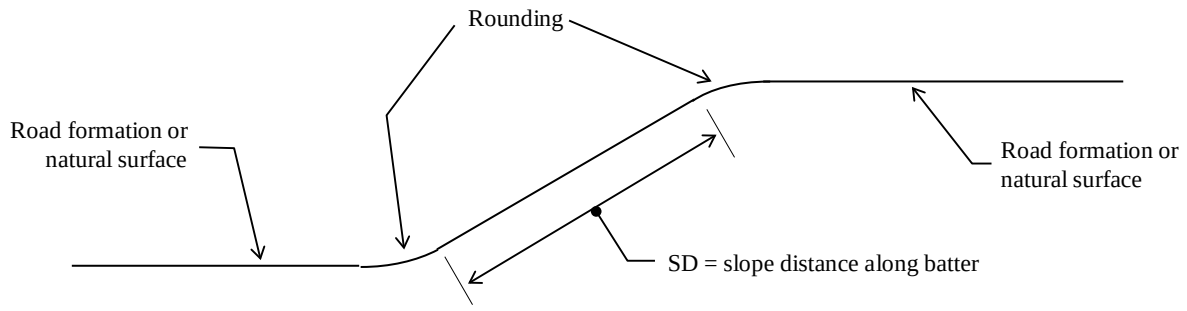

Figure G71.1 – Rounding at top and bottom of batter planes

Select additional survey points, depending on the length of the slope distance, as shown in Table G71.7.

Table G71.7 – Sampling Plan for Surveying Batter Planes

Slope Distance (SD)	Number of Sampling Points at Each Cross Section (1, 2)
SD < 5 m	1
5 m ≤ SD < 10 m	2
10 m ≤ SD < 15 m	3
15 m ≤ SD < 20 m (3)	4

Notes:

(1) Distance between each cross section must be between 10 and 15 m.

(2) For each additional 5 m (or part thereof) of SD above 20 m, add one additional sampling point.

(3) Number of points shown are in addition to the sampling points at the top and bottom of the batter.

The Survey Report must show the distance between the design and actual positions measured perpendicularly to the design batter plane unless otherwise specified.

5.2 STORMWATER DRAINAGE WORKS

5.2.1 Orders of Accuracy

Comply with the Orders of Accuracy for the stormwater drainage structures shown in Table G71.8.

Where EDM tacheometry survey procedures are used, comply with the survey checks in Table G71.8.

Table G71.8 – Orders of Accuracy and Check Measurements for Stormwater Drainage Structures Surveys

Activity	Orders of Accuracy		Survey Checks to Survey Control Mark (1)	
	Horizontal	Vertical	Horizontal Difference	Height Difference
Kerb and channel (gutter)	3H	4V	20 mm	5 mm
Gully pits and junction boxes	3H	5V	20 mm	10 mm
Lintel, covers and gratings when adjoining:				
kerb and channel (gutter)	3H	4V	20 mm	5 mm
concrete pavement	3H	2V	20 mm	4 mm
asphalt pavement	3H	4V	20 mm	5 mm
Concrete pipes, box culverts, headwalls and wing walls, energy dissipaters, inlet and outlet structures	3H	5V	20 mm	10 mm
Precast concrete box culverts	3H	4V	20 mm	10 mm
Open drains	4H	6V	50 mm	30 mm

Note:

(1) Where EDM tacheometry survey procedures are used.

5.2.2 Kerb and Channel (Gutter)

Surveys to set out kerb lines must be with reference to the horizontal position and design height of the lip line in preference to any other feature of kerb and channel (gutter), unless otherwise required by the Principal.

When carrying out conformity verification surveys, measure and record the actual position of the lip line in relation to its design position. Make allowance for the rounding of the constructed product when determining the horizontal position and height of the lip line (see Figure G71.2).

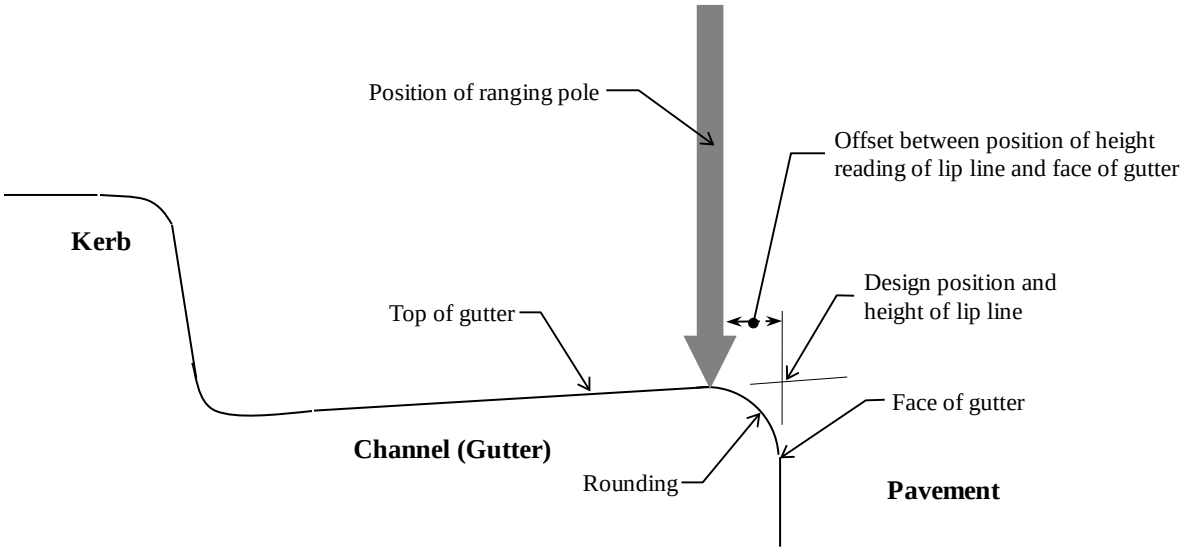

Figure G71.2 – Allowance for Lip Rounding when Determining Constructed Position of Lip Line

Refer to the Standard Drawings for standard TfNSW kerb and channel (gutter) profiles indicating where exposed edges are rounded.

Sample the kerb and channel (gutter) at a maximum interval of 10 m for conformity verification surveys. Reduce as appropriate the sampling interval for curved kerbs to ensure that design requirements are met.

5.3 PAVEMENT

5.3.1 Orders of Accuracy

Comply with the Orders of Accuracy, survey checks and conformity survey sampling requirements for pavement courses, including the underlying earthworks courses shown in Table G71.9.

Use survey procedures for setting out pavement courses to achieve an Order of Accuracy that is at least equal to that used for conformity surveys for the same surface.

Table G71.9 – Orders of Accuracy, Check Measurements and Sampling Plan Requirements for Earthworks and Pavement Courses

Earthworks or Pavement Surface [1]	Orders of Accuracy [2]		Survey Checks to Survey Control Mark [3]		Common Points Difference [4]	Sampling Plan Chainage Difference [5]	Reference Specification [6]
	Horizontal	Vertical	Horizontal Difference	Height Difference			
Cut floor excavation [7]	See Table G71.6						
Cut floor surface [8]	3H	5V	20 mm	10 mm	N.A.	10 m	D&C R44 Earthworks
Earthworks other than Selected Material Zone	3H	4V	20 mm	5 mm	10 mm	10 m	
Selected Material Zone							
Unbound and modified subbase and base	3H	3V	20 mm	5 mm	5 mm	10 m	D&C R71 Unbound and Modified Pavement Course
Heavily bound subbase and base	3H	3V	20 mm	5 mm	5 mm	5 m	D&C R73, D&C R75 Heavily Bound Pavement Course
Plain or reinforced concrete subbase and base	3H	2V	20 mm	4 mm	5 mm	5 m	D&C R81, D&C R82 Concrete Subbase, D&C R83 Concrete Base

Notes: N.A. = Not Applicable

(1) Top surface of earthworks or pavement course being surveyed.

(2) Orders of Accuracy for horizontal locations and heights assigned to each pavement surface (refer Clauses 4.2.1 and 4.2.2).

(3) Differences shown in "… Survey Control Mark" columns are the allowable horizontal and height differences between survey control mark coordinates as determined by survey when compared to the adopted values.

(4) Allowable height difference of common points by two abutting surveys before an investigation is required (refer Clause 5.3.2).

(5) Sampling Plan Chainage Difference gives the difference in chainage of points along strings for sampling the pavement for conformity with design. Table G71.10 gives the offset (transverse) distance between strings across the pavement. Uniform points along approximately parallel strings define the grid pattern for sampling the pavement surface (refer Clause 5.3.3).

(6) Reference specification containing the survey tolerances.

(7) Cut Floor excavation refers to Foundation Level as defined in TfNSW D&C R44.

(8) Cut Floor surface refers to Designed Floor Level as defined in TfNSW D&C R44.

5.3.2 Survey Checks Using EDM Trigonometrical Heighting

Where procedures for pavement surfaces use EDM trigonometrical heighting, in addition to the survey checks described in Clause 4.3, apply the following check for pavement surveys, including those of the underlying earthworks courses.

Where surveys abut, at the next setup of the total station, take measurements to the last cross section marked or measured from the previous set up location.

For set out surveys, take measurements to the nearest set out marks placed from the previous set up of the total station. For conformity surveys, spot mark on the pavement the location of measurements at the final cross section of the previous survey.

Investigate the cause of differences in heights of set out marks or measurements of the pavement surface to the same spot, from the two total station set ups, if these differences exceed the values shown in column titled "Common Points Difference" of Table G71.9.

For the purpose of this Clause, abutting surveys may be carried out on separate days.

5.3.3 Sampling Plan for Conformity Verification Surveys

Select sampling points from a defined grid pattern. Form the grid using equally spaced points in strings that run approximately parallel to the centreline of the constructed pavement. Select sampling points in each string at the intervals shown in column titled "Sampling Plan Chainage Difference" of Table G71.9.

Determine the number of strings across the pavement for different pavement widths from Table G71.10.

Table G71.10 – Sampling Plan for Pavements

Pavement Width (W)	Number of Strings
$W \leq 1.5$ m	1
1.5 m $< W \leq$ 6.0 m	2
6.0 m $< W \leq$ 11.0 m	3
11.0 m $< W \leq$ 16.0 m (1)	4

Note:

(1) For each additional 5 m (or part thereof) of W above 16.0 m, add one additional string.

For pavements sampled by a single string, run the string along the approximate centreline of the constructed pavement. For pavements sampled by two strings, place each string between 0.5 m and 1.0 m from each edge of the pavement. For pavements sampled by more than two strings, place each of the two outer strings between 0.5 m and 1.0 m from the pavement edge, and arrange the remaining strings so that the transverse distances between adjacent strings are approximately equal.

The maximum distance between strings across the pavement for any pavement width is 5 m.

Select sampling points to within 0.7 m of the location defined by this Clause and determine actual field coordinates by survey.

Include the sampling plan for conformity verification surveys of pavement surfaces in the PROJECT QUALITY PLAN.

5.4 BRIDGES

Clause 5.4 also applies to structures such as noise walls.

The Surveyor (refer Clause 2.2.1) must verify the tolerances shown in Tables G71.11 and G71.12 which are reproduced from other TfNSW Specifications and Australian Standards.

5.4.1 General

The survey control network for the bridge, known as the Bridge Survey Control Network, must be separate to the main Survey Control Network. Most marks will have different two-dimensional coordinates to the main Survey Control Network due to the different distances used to calculate coordinates for the controls.

Calculate the coordinates of survey control marks used for bridge surveys using ground distances and not grid distances as applied to road works. In addition, use ground distances when measuring from survey control marks for all survey work on bridges.

5.4.2 Bridge Survey Control

Procedures for determining coordinates of the Bridge Survey Control must comply with Clause 3.6.

Bridge Survey Control Network must include at least three survey control marks for each bridge. Include a procedure describing the methodology in the PROJECT QUALITY PLAN.

Submit details of the Bridge Survey Control prior to commencing survey work for the bridge.

The Bridge Survey Control must change only the horizontal coordinates and must adopt the heights of the survey control marks used from the main Survey Control Network. Submit a separate Bridge Survey Control Marks Register for each bridge in accordance with Clause 3.3.

HOLD POINT

Process Held:	Use of the Bridge Survey Control for setting out the bridge works.
Submission Details:	Plan of the Bridge Survey Control including coordinates, and the measurements and calculations used to determine the coordinates.
Release of Hold Point:	The Principal will consider the submitted documents and may inspect the survey control marks and review the calculations prior to authorising the release of the Hold Point.

5.4.3 Cast-in-place Concrete Members (to Specification TfNSW D&C B80)

Survey records must state estimated allowances for deflection of concrete formwork before and during concreting on bridges.

Carry out checking and verification for cast-in-place concrete members of the following characteristics:

(a) As planned:

(i) design characteristic (level, dimension, position) at a particular point on the structure shown on the Design Documentation drawings;

(ii) calculated or estimated deflection/settlement of the formwork prior to and during concreting;

(iii) target characteristic for the formwork (allowing for deflection/settlement);

(iv) specified tolerance on final location of structure at that point.

(b) As measured:

(i) characteristic (level, dimension, position) as set out;

(ii) characteristic as verified;

(iii) difference between the verified value and the target value;

(iv) magnitude of any out of tolerance measurement (i.e. the amount by which the measured difference exceeds the specified tolerances).

Set out all fitments and embedments with sufficient accuracy to prevent any misfit or misalignment between mating components.

5.4.4 Incrementally Launched Girders (to Specification TfNSW D&C B152)

Comply with the survey control requirements of TfNSW D&C B152.

Provide a survey certificate for the Reference Point, which must be stable to within ± 0.5 mm, including details of the physical structure of the reference mark.

5.4.5 Tolerances and Orders of Accuracy for Bridge Components or Other Structures (to Specification TfNSW D&C B80)

Table G71.11 lists the tolerances and survey Orders of Accuracy for concrete components of bridges for setting out concrete formwork and verifying conformity of the finished concrete (reproduced from TfNSW D&C B80).

Table G71.11 - Tolerances and Orders of Accuracy for Bridge Components or Other Structures (to Specification TfNSW D&C B80)

Item	Bridge Component or Other Structures	Tolerance (mm)	Orders of Accuracy	
			Horizontal	Vertical
(a)	Footings and pile caps:			
	Plan dimensions for, formed footings and pile caps surface (1)	–10 to +50	3H	N.A.
	Plan dimensions, unformed footings	0 to +150	3H	N.A.
	Thickness < 300 mm	–5 to +25	N.A.	4V
	Thickness ≥ 300 mm	–10 to +50	N.A.	5V
	Top of footing or pile cap reduced level	–25 to +25	N.A.	5V
	Deviation from plan position in any direction	50	3H	N.A.
(b)	Columns, piers, headstocks, slabs other than deck slabs, walls, beams and similar components (but excluding deck slabs and barrier end posts):			
	Cross sectional dimensions < 3 m	–5 to +15	Tape (2)	N.A.
	Cross sectional dimensions ≥ 3 m	–10 to +25	Tape (2)	N.A.

Item	Bridge Component or Other Structures	Tolerance (mm)	Orders of Accuracy	
			Horizontal	Vertical
(c)	Columns, piers, headstocks, slabs, walls, beams, and other similar components:			
	Deviation from plan position at any level	25	1H	N.A.
	Relative displacement of adjoining components	10	Tape (2)	N.A.
	Centreline of bearings	5	1H	N.A.
(d)	Rows of columns, faces of piers or walls Deviation from alignment	10	1H	N.A.
(e)	Columns, piers, walls, and barriers:			
	Deviation from vertical of specified batter, unexposed concrete	12 mm in 3 m (1/250)	2H	4V
	Deviation from vertical of specified batter, exposed concrete	6 mm in 3 m (1/500)	1H	4V
(f)	Piers and headstocks:			
	Top surface, reduced level, with pedestals	–10 to +10	N.A.	4V
	Top surface, reduced level, without pedestals	–5 to +5	N.A.	4V
	Difference in level across width of headstocks	5	N.A.	4V (3)
(g)	Bearing pads and pedestals:			
	Top surface, reduced level	–2.5 to +2.5	N.A.	3V
	Deviation from grade across width of individual pads and pedestals	1 in 200	N.A.	4V (4)
	Deviation from flat surface	–1.0 to +1.0	Straight edge & tape	N.A.
(h)	Deck slabs:			
	Thickness (5)	–5 to +15	N.A.	4V
	Top surface, reduced level (5)	–10 to +5	N.A.	4V
	Flatness of top surface in any direction (6)	3 mm in 3 m (1/1000)	Straight edge & tape	
(i)	Deck joints:			
	Width of slot	–3 to +3	1H	N.A.
(j)	Barrier end posts: Cross sectional dimensions	–5 to +5	Tape (2)	N.A.
(k)	Kerbs and barriers:			
	Deviation from design grades	3 mm in 3 m (1/1000)	2H	4V
	Height above deck slab	–5 to +10	N.A.	4V
	Deviation in plan position from straight or curved horizontal alignment	5 mm in 3 m (1/600)	1H	4V
	Steps in plan and elevation	5	1H	4V
	Flatness of front face of kerbs and barriers	3 mm in 3 m (1/1000)	Straight edge & tape	
(l)	Barriers and handrails:			
	Deviation from a 3 m straight edge held longitudinally on all surfaces	6	Straight edge & tape	
	Vertical and horizontal alignment between adjacent barrier segments	6	Straight edge & tape	
	Deviation from alignment for handrails, faces of handrail posts, and barriers	5	1H	N.A.
(m)	Maximum allowance for irregularities in exposed concrete surfaces:			
	Sections less than 1 m in dimension when measured with a straight edge across the dimension of the section	2.5	Straight edge & tape	N.A.
	Sections greater than 1 m in dimension when measured with a straight edge across the dimension of the section, except that when sections are greater than 3 m in dimension, a 3 m straight edge must be used	5	Straight edge & tape	N.A.
	Deviation from design kerb and barrier dimensions	–2.5 to +2.5	Tape (2)	N.A.

Notes: N.A. = Not applicable

(1) For all formwork, D&C B80 requires a survey certificate on the formwork prior to placing concrete.

(2) Careful use of a calibrated steel tape provides sufficient accuracy.

(3) May use differential levelling procedure where measurement of the relative height difference across the headstock is required and not AHD values.

(4) May use a builder's spirit level or differential levelling procedure.

(5) After allowing for corrections for camber or hog and variations in design loads, forces and load effects.

(6) After allowing for superelevation and vertical curvature or grade.

5.4.6 Tolerances and Orders of Accuracy for Bridge Components or Other Structures (to Other Specifications)

Table G71.12 lists the tolerances and Orders of Accuracy for other bridge components and verifying conformity of other bridge components.

The tolerances shown in Table G71.12 under D&C B201 "Steelwork for Bridges" are only partial extracts from Appendix F4 of AS 5131. Refer to Appendix F4 of AS 5131 for a complete set of tolerances.

Table G71.12 – Tolerances and Orders of Accuracy for Bridge Components or Other Structures (to Other Specifications)

D&C Spec. No.	Specification Title	Work Activity	Refer. or Std.	Tolerance [3]	Orders of Accuracy		Certificate	Joint survey
					Horiz.	Vert.		
	Piling							
B50	Driven Reinforced Concrete Piles	Position:						
B51	Driven Prestressed Concrete Piles	(a) For a pile installed from land, with a cut-off level no more than 2 m below piling platform level [1]		(a) ±75 mm horz. and for vertical piles: ≤ 4% of specified inclination for raked piles: ≤ 7% of specified inclination	3H	5V		
B53	Driven H Section Steel Piles							
B54	Driven Tubular Steel Piles							
B57	Driven Cast-in-place Concrete Piles	(b) For a pile installed from land, with a cut-off level at or more than 2 m below piling platform level	AS 2159 Cl. 7.2	(b) ± [75 + 20(h - 2)] mm horz. and for vertical piles: ≤ 4% of specified inclination for raked piles: ≤ 7% of specified inclination where h is the depth to cut-off in metres	3H	5V	Yes	No
B58	Bored Cast-in-place Reinforced Concrete Piles (With Permanent Casing)							
B59	Bored Cast-in-place Reinforced Concrete Piles (Without Permanent Casing)	(c) For a pile installed from a floating plant		(c) ±150 mm horz. and for vertical piles: ≤ 4% of specified inclination for raked piles: ≤ 7% of specified inclination	4H	6V		
B61	Driven Composite Piles							
		(d) For a non-circular pile section, where orientation of the major axes		(d) ≤ 10° rotational deviation from specified alignment	3H	N.A.		
		Cut-off levels:		±25 mm	N.A.	5V		
B63	Continuous Flight Auger (CFA) Piles	As above for rest of piling specs, except that items (c) and (d) under "Position" do not apply for CFA piles.		As above for rest of piling specs, except that for "vertical piles", tolerance ≤ 2% of specified inclination and "raked piles" do not apply for CFA piles.				
B110	Pretensioned Precast Concrete Members		Table B110.1	Piles / Planks / Girders			Yes	No
		Overall dimensions						
		Any linear side dimension in cross section:						
		≤ 2 m		±4 mm / ±4 mm / ±4 mm	Tape [2]	N.A.		
		> 2 m		N.A. / N.A. / ±7 mm	Tape [2]	N.A.		
		Overall length, *L*		±20 mm / Greater of ±0.06% *L* or ±10 mm	2H (Piles), 1H (Girders)	N.A.		
		Squareness of corners						
		Any diagonal dimension:						
		≤ 2 m		±7 mm / ±4 mm	1H or Tape [2]	N.A.		
		> 2 m, ≤ 4 m		±7 mm / ±5 mm	1H or Tape [2]	N.A.		
		> 4 m		±7 mm / ±7 mm	1H or Tape [2]	N.A.		
		Twist						
		Angular rotation		½° over length of member	1H or Tape [2]	N.A.		
		Profile						
		Bow in horizontal plane		Greater of ±0.06% *L* or ±8 mm	1H or Tape [2]			

D&C Spec. No.	Specification Title	Work Activity	Refer. or Std.	Tolerance [3]			Orders of Accuracy		Certificate	Joint survey
							Horiz.	Vert.		
B110	Pretensioned Precast Concrete Members (cont'd)	Hog in vertical plane		N.A.	±0.05% *L*	Greater of ±35% of design value or ±20 mm				
		Cored holes and openings								
		Location		N.A.	±7 mm		1H	N.A.		
		Diameter or side dimensions		N.A.	±4 mm		Tape [2]	N.A.		
B115	Precast Concrete Members (Not Pretensioned)		Table B115.1	Piles	All Other Members				Yes	No
		Overall dimensions								
		Any linear side dimension in cross section:								
		≤ 2 m		±4 mm	±4 mm		Tape [2]	N.A.		
		> 2 m		N.A.	±7 mm		Tape [2]	N.A.		
		Overall length, *L*		± 20 mm	Greater of ±0.06% *L* or ±10 mm		2H (Piles), 1H (Girders)	N.A.		
		Squareness of corners								
		Any diagonal dimension:								
		≤ 2 m		±7 mm	±4 mm		1H or Tape [2]	N.A.		
		> 2 m, ≤ 4 m		±7 mm	±5 mm		1H or Tape [2]	N.A.		
		> 4 m		±7 mm	±7 mm		1H or Tape [2]	N.A.		
		Twist								
		Angular rotation		½° over length of member			1H or Tape [2]	N.A.		
		Profile								
		Bow in horizontal plane		Greater of ±0.06% *L* or ±8 mm			1H or Tape [2]	N.A.		
		Deviation from design profile in vertical plane		Greater of ±0.06% *L* or ±8 mm			1H or Tape [2]	N.A.		
		Cored holes and openings								
		Location		N.A.	±7 mm		1H	N.A.		
		Diameter or side dimensions		N.A.	±4 mm		Tape [2]	N.A.		
B150	Erection of Pretensioned Precast Concrete Members	Pre-alignment underside member must marry with bearings. D&C G71 joint survey and conformity survey for girders.	B150 Cl. 4.3	Member bearings must comply with D&C B284			See D&C B284		Yes	Yes
		Profile Diagram before placing cast-in-situ concrete supported by precast members. D&C G71 joint survey and conformity survey for girders.	Cl. 8							
		(a) Deviation from correct position	Cl. 6.4	< 20 mm in any direction					Yes	Yes
		(b) Deviation from plumb or design inclination between any two points		< $1/200$ times distance between points or 10 mm, whichever is less.						

D&C Spec. No.	Specification Title	Work Activity	Refer. or Std.	Tolerance [3]	Orders of Accuracy		Certificate	Joint survey
					Horiz.	Vert.		
B152	Incrementally Launched Prestressed Concrete Girders	Reference Point Procedure for establishing, verifying and maintaining survey control and for certification of accuracy of control marks, plus set out from control marks.	B152 Cl. 6.1	Reference point must be stable to within ±0.5 mm in position & level	Establish control with LU of 4 mm and use 1H and 1V procedures from control marks		Yes	No
		Installation of launching bearing:					See comments immediate-ly below	
		(a) Position:	Cl. 5.3					
		(i) Measured in a direction parallel to bridge centreline		±3 mm	1H	N.A.		
		(ii) Measured in a direction normal to bridge centreline		±1.5 mm	1H	N.A.		
		(b) Level:						
		(i) Launching bearings within the casting bed	Cl. 5.3					
		- Levels relative to the Reference Point		±2 mm	N.A.	2V		
		- Levels relative to the soffit sliding surface adjacent to the launching bearing		±0.5 mm	N.A.	1V		
		(ii) Launching bearings between the casting bed and the launching abutment and braking saddle plates					Yes, certificate for levels and alignment of side guides for first three segments and then every third segment.	No
		- Levels relative to the Reference Point		±2 mm	N.A.	2V		
		- Levels relative to adjacent launching bearings or braking saddle plate		±0.5 mm	N.A.	1V		
		- Levels relative to launching bearings or braking saddle plate located at the same cross section		±0.5 mm	N.A.	1V		
		(iii) All other launching bearings						
		- Levels relative to launching bearings on adjacent piers or abutments		±1.5 mm	N.A.	2V		
		- Levels relative to launching bearings located on the same pier or abutment		±0.5 mm	N.A.	1V		
		(c) Deviation from specified plane:						
		Deviation from the specified plane, both longitudinally and transversely		< 1 mm in 1000 mm	1H	2V		
		Sliding surfaces on casting yard	Cl. 7.4					
		Soffit:						
		(a) Vertical tolerance (relative to Reference Point)		±2 mm	N.A.	2V		
		(b) Vertical tolerance (relative to other soffit sliding surface)		±1 mm	1H	1V	No	No
		(c) Slope tolerance (deviation from specified slope)		< 1 mm in 1000 mm	1H	2V		
		Lateral Sliding Surfaces:						
		(a) Horizontal tolerance (relative to girder centreline)		±1.5 mm	1H	N.A.	No	No
		(b) Slope tolerance (deviation from specified slope)		< 1 mm in 1000 mm	1H	2V		

D&C Spec. No.	Specification Title	Work Activity	Refer. or Std.	Tolerance [3]	Orders of Accuracy		Certificate	Joint survey
					Horiz.	Vert.		
B152	Incrementally Launched Prestressed Concrete Girders (cont'd)	Installation of top attachment plates for permanent bearings (a) Measured in a direction parallel to the bridge centreline. (b) Measured in a direction transverse to the bridge centreline	Cl. 8.4	 ±10 mm ±3 mm	 1H [3] 1H [3]	 N.A. N.A.	No	No
B153	Erection of Precast Concrete Members (Not Pretensioned)	Pre-alignment of temporary and permanent supports on girder bridges (a) Deviation from correct position (b) Deviation of point from a straight line (c) Deviation of vertical members from plumb between any two points	B153 Cl. 6.4	 < 20 mm in any direction < $1/250$ times length or 10 mm, whichever is less < $1/250$ times vertical distance or 10 mm, whichever is less unless specified otherwise in D&C B80 or drawings	Consult bridge drawings		Yes, profile of completed work where member is erected on girder bridges	No
B170	Supply and Installation of Void Former	Position of void	B170 Cl. 5.1	±7 mm	1H	N.A.	No	No
B201	Steelwork for Bridges	Anchor bolts within anchor bolt group [4] (a) Centre-to-centre deviation between - any two bolts within a rigidly cast-in anchor bolt group - any two bolts within a sleeved anchor bolt group (b) Centre-to-centre deviation between adjacent anchor bolt groups (c) Deviation from centre of any anchor bolt group to established column line through that group (d) Maximum accumulated deviation along an established column line of multiple anchor bolt groups Column base Position: Essential tolerances Class 1 & 2 [5] Functional tolerances Class 1 [5] Functional tolerances Class 2 [5] Level: Essential tolerances Class 1 & 2 [5] Functional tolerances Class 1 & 2 [5]	AS 5131 Appx. F4	 ±3 mm ±10 mm ±6 mm ±6 mm ±6 mm per 30 m, to max ±25 mm ±6 mm along either axis ±10 mm along either axis ±5 mm along either axis ±10 mm of the underside of steel base ±5 mm of the underside of steel base	 1H 1H 1H 1H 1H N.A. 	 N.A. N.A. N.A. N.A. N.A. 3V 		

D&C Spec. No.	Specification Title	Work Activity	Refer. or Std.	Tolerance [3]	Orders of Accuracy		Certificate	Joint survey
					Horiz.	Vert.		
B201	Steelwork for Bridges (cont'd)	Column						
		Deviation from plumb		Not exceed height/500 mm, or the lesser of:				
				Up to 60 m height: 25 mm	1H	4V	Yes	No
				Above 60 m height: 25 mm + 1/3(total height – 60) to max 50 mm	1H	4V		
		Beam	AS 5131					
		Beam level and relative beam level:	Appx. F4		N.A.	3V		
		Essential tolerances Class 1 & 2 [5]		±10 mm				
		Functional tolerances Class 1 [5]		±10 mm				
		Functional tolerances Class 2 [5]		±5 mm				
		Alignment:			1H	N.A.	Yes	No
		Essential tolerances Class 1 & 2 [5]		±3 mm of its horizontal to other members				
		Functional tolerances Class 1 [5]		±5 mm of its horizontal to other members				
		Functional tolerances Class 2 [5]		±3 mm of its horizontal to other members				
		Slope of beam – deviation in level of one end of beam relative to the other:				3V		
		Essential tolerances Class 1 & 2 [5]		± Length/500 mm, but ≤ 10 mm				
		Functional tolerances Class 1 [5]		± Length/500 mm, but ≤ 10 mm				
		Functional tolerances Class 2 [5]		± Length/1000 mm, but ≤ 5 mm				
		Profile of temporary falsework supporting steelwork		Consult bridgeworks drawings and falsework design				
B261	Erection of Structural Aluminium	Profile of installed aluminium		Consult bridgeworks drawings and falsework design			Yes	No
		Profile of temporary falsework supporting aluminium					Yes	No
B264	Erection of Barrier Railing and Minor Components	Setting out hold down bolts	B264 Cl. 7.1					
		Railings		≤ 3 mm deviation from line and grade	2H	4V	Yes, set out diagram.	No
		Lighting columns		N.A.	3H	5V		
		Conformity reports						
		Railings			2H	4V		
		Light columns			3H	5V		

D&C Spec. No.	Specification Title	Work Activity	Refer. or Std.	Tolerance [3]	Orders of Accuracy		Certificate	Joint survey
					Horiz.	Vert.		
B284	Installation of Bridge Bearings	Elastomeric bearings	B284				Certificate to verify set out position and certificate to verify the final position of the bearings	Yes
		(i) Position						
		- Elastomeric strips		±5 mm transversely and ±15 mm longitudinally	1H	N.A.		
		- Elastomeric pads		±3 mm transversely and ±3 mm longitudinally	1H	N.A.		
		(ii) Level	Cl. 6.1.1					
		- Elastomeric strips (*on headstock*):		±2.5 mm	N.A.	2V		
		- Elastomeric pads (*usually on mortar pad*):		±2.5 mm	N.A.	2V		
		- Difference in level between adjacent pad bearings		±2.5 mm	N.A.	2V		
		All other types of bearings	B284					
		(i) Position	Cl. 6.1.2	within 3 mm	1H	N.A.		
		(ii) Level:						
		- For bridges with simply supported girders		±5 mm	N.A.	2V		
		- For bridges with continuous superstructure		±0.0001 x *sum of adjacent span lengths*, but not > ±5 mm	N.A.	2V		
		- Bearing inclination		$\pm 1/200$	N.A.	2V		

Notes: D&C Spec. No. = D&C Specification number Refer. or Std. = Reference or Standard Cl. = Clause Horiz. = Horizontal Vert. = Vertical LU = Local Uncertainty Appx. = Appendix

(1) Where a pile projects above the ground, a tighter inclination tolerance may be required.

(2) Careful use of a calibrated steel tape provides sufficient accuracy.

(3) Where the tolerances shown in Table G71.12 conflict with those shown in the referenced Specification or Australian Standard, the latter takes precedence.

(4) "Anchor bolt group" refers to a set of anchor bolts which receives a single fabricated steel member.

(5) References to Classes 1 and 2 are as defined in AS 5131.

5.5 (NOT USED)

5.6 PRODUCT CONFORMITY SURVEY

5.6.1 General

Adopt methods for product conformity surveys that ensure independence from the methods used to set out the Works. Where possible, take measurements directly from survey control marks.

Avoid taking measurements from subsidiary survey marks established to set out the Works. If the use of subsidiary survey marks is unavoidable for verification purposes, re-establish their positions and levels.

5.6.2 Random Sampling

Do not restrict sampling of the Works for conformity verification to the locations used to set out the Works but carry out sampling in accordance with Clause 5 or in a random or unbiased manner at any location of the Works to verify conformity with the Design Documentation drawings and this Specification.

Take sufficient sampling points to provide a valid representation of the product's spatial qualities.

5.6.3 Timing

Perform conformity verification surveys for the bound pavement layers, concrete subbase and concrete base as soon as practicable, but in any event not later than one working day after the pavement Lot has become accessible for survey, unless otherwise agreed by the Principal.

5.6.4 Pavement Layer Thickness

Detail in the PROJECT QUALITY PLAN the method of determining the thickness, with adjustment. Calculate the mean thickness for each Lot using all results for the Lot.

Determine the thickness of pavement courses by comparing two surveyed points on top of each other with a tolerance of 0.5 m and calculating the thickness as the difference between the finished top surface level and the underlying surface level. Adjust the calculated thickness to allow for the design surface longitudinal and transverse slopes between the two surveyed points.

Alternatively, you may use other methods such as comparing points to triangulated surfaces. Details of the methodology must be submitted to the Principal for acceptance, with appropriate test data results, prior to its use.

5.6.5 Survey Report

Submit a Survey Report for each Lot or component where design levels, position and/or tolerances have been specified. The Survey Report must show the actual value versus the specified value for position (defined either by grid coordinates, or chainage and offset) and level, and the applicable tolerance as appropriate.

Submit survey reports for pavements showing values for calculated thickness as detailed in the PROJECT QUALITY PLAN.

The report must be certified by the Surveyor responsible for the verification survey and highlight any results that are outside of tolerance (nonconformities).

5.6.6 Submission of Survey Report

HOLD POINT	
Process Held:	Covering up of work subject to a conformity verification survey.
Submission Details:	Survey Report verifying conformity.
Release of Hold Point:	The Principal will consider the submitted documents prior to authorising the release of the Hold Point.

5.7 SUBSURFACE UTILITY INFORMATION (SUI)

5.7.1 General

Carry out a survey of new subsurface utilities (whether new installations or relocations of existing utilities) before backfilling of the trenches.

Comply with TfNSW D&C G22 when working near live utilities.

5.7.2 Quality Level

Record the position and level of subsurface utilities for input into the Works-As-Executed survey models and schedules at Quality Level A (QL-A) in accordance with AS 5488.

SUI QL-A survey is required where there is:

(a) change of direction of a new utility;

(b) change of grade of a new utility;

(c) change of size or configuration of a new utility;

(d) at access pits or buried junctions;

(e) points where each utility crosses other new or retained utilities;

(f) locations where utilities deviate from their design allocation;

(g) minimum horizontal interval of 20 m.

At locations where subsurface utility information (SUI) cannot be recorded to QL-A, such as where utilities have been installed using trenchless technologies, record the SUI at Quality Level B (QL-B). Use only accredited Utility Locators to locate underground utilities.

5.7.3 Orders of Accuracy

Subsurface utility location surveys (whether for new installations or relocations of existing utilities) must comply with the Orders of Accuracy shown in Table G71.13.

Where EDM tacheometry survey procedures are used, comply also with the survey checks shown in Table G71.13.

Table G71.13 – Orders of Accuracy for SUI Surveys

Activity	Orders of Accuracy		Survey Checks to Survey Control Mark	
	Horizontal	Vertical	Horizontal	Height
SUI Surveys QL-A	3H	5V	20 mm	10 mm
SUI Surveys QL-B	4H	6V	30 mm	100 mm

The Survey Control Network for General Construction Activities as specified in Clause 3.6.3 applies for establishing subsurface utility survey position and level, plus any associated quality checks.

5.7.4 Point Sampling Requirements

Record, for each point, the SUI attributes to AS 5488 shown in Table G71.14. As successive points share the same attribute values, the value of a previous point can be assumed to carry forward to the next.

Table G71.14 –SUI Point Attributes (to AS 5488)

Attribute	Description
Point ID	A unique identification reference for this point within the schedule. May also be annotated on the plan
Easting	MGA coordinate, to 2 decimal places
Northing	MGA coordinate, to 2 decimal places
RL	AHD RL, to 2 decimal places
Quality Level	QL-A or QL-B
Date Of Capture	Date that information was surveyed
Source Of Information	Name of Surveyor (and if QL-B, name of locator)
Material	External material as installed, e.g. PVC conduit white
Size	External dimensions. If only one number is specified, it is assumed to be a cylinder. If rectangular configuration, specify W x H, e.g. 450 mm x 150 mm
Configuration	How the utility is configured, e.g. 2 W x 3 H 100 mm PVC conduits laid in trench
Survey Control Information	Survey Datum and Survey Control Stations used to verify accuracy of survey (checks must be performed to these stations)
Surveyed Point	Top Centreline / Invert / Obvert / Edge of bank
Photo Reference	Filename link to jpg file (optional)
Notes	Any other notes
Owner	Entity which is the owner of the asset

5.8 WORK-AS-EXECUTED DRAWINGS AND MODEL

5.8.1 Work-As-Executed Drawings

Comply with the SWTC for requirements on Work-As-Executed (WAE) drawings.

5.8.2 Work-As-Executed Model

If a WAE survey model of the finished surface and other features is specified in Annexure G71/A to be required, comply with the surveying technical requirements under Clause 3 of Specification TfNSW G73.

The WAE survey model must be compatible with the TfNSW CADD software applicable to the deed and utilises the TfNSW Survey Pick Up Codes.

The standard TfNSW CADD software applicable to the deed and TfNSW Survey Pick Up Codes are stated in Annexure G71/A.

Where necessary, contact the TfNSW Director Surveying or delegate to obtain further technical advice and assistance on compliance with TfNSW G73.

ANNEXURE G71/A – PROJECT SPECIFIC REQUIREMENTS

Refer to Clause 1.2.1.

NOTES TO TENDER DOCUMENTER: (Delete this boxed text after customising Annexure G71/A)

Complete the table below by deleting whichever option is not applicable.

Further advice on how to complete the table may be obtained from the TfNSW Director Surveying or delegate, whose phone numbers are listed in Annexure G81/E.

Clause	Description	Requirement
2.5, 5.8.2	TfNSW CADD software applicable to deed	MX GENIO / MX major option SURVEY / MX compatible / Not applicable
5.8.2	Survey Pick Up Codes for TfNSW NSW	2009 Detail Style Set / 2010 Cadastral Style Set / 2015 Work As Executed Style Set (3D Utility) / Not applicable
5.8.2	Work-As-Executed survey model required	Yes / No

ANNEXURE G71/B – (NOT USED)

ANNEXURE G71/C – SCHEDULES OF HOLD POINTS AND IDENTIFIED RECORDS

Refer to Clause 1.2.3.

C1 SCHEDULE OF HOLD POINTS

Clause	Description
2.3.3	Submission of PROJECT QUALITY PLAN
2.9	Commencement of field work
2.10.1	Joint survey
2.10.2	Submission of joint survey results
3.1.2	Application for authorisation to remove survey marks forming part of Survey Infrastructure
3.1.4	Surveyor General's approval to disturb survey marks
3.2.1	Submission of survey report verifying coordinates and levels of survey control marks
4.6.2	Use of Machine Guidance System for use for guiding work
4.6.3	Use of Design Model within Machine Guidance System
5.4.2	Use of the Bridge Survey Control for setting out the bridge works
5.6.6	Submission of Survey Report verifying conformity

C2 SCHEDULE OF IDENTIFIED RECORDS

The records listed below are Identified Records for the purposes of TfNSW Q Annexure Q/E.

Clause	Description
2.3.1	Survey Reports and other records of monitoring surveys, as specified in other specifications
2.4	Equipment register and calibration documents
3.1	Locality sketches, network drawings and lodgement details of new permanent survey marks
3.1	POSI drawings, strategy, survey mark registers, approvals from Surveyor General and, if required copies of DPOSIOs
3.2.1	Survey Report verifying survey control marks
3.3	Survey Control Mark Register and Cadastral Mark Register
5.4.4	Survey certificate for Reference Point for incrementally launched girders
5.6.6	Survey Reports verifying conformity
5.7.3	SUI point attributes
5.8.2	Work-As-Executed survey model

ANNEXURE G71/D – PLANNING DOCUMENTS

Refer to Clause 1.2.4.

The following documents are a summary of documents that must be included in the PROJECT QUALITY PLAN. Review the requirements of this Specification and others included in the deed to determine any additional documentation requirements.

Clause	Description of Document
2.2.2	Details of all construction activities requiring survey work, and list of all surveying tasks and responsibilities that are assigned to Surveyors and Registered Land Surveyors, and list of personnel who will perform survey work that is not assigned to Surveyors
2.3.1	Procedures and equipment for carrying out the survey work as detailed in Clause 2.3.1
2.5.1, 2.5.2	Name and version of pavement survey software
2.5.2	Procedure and software for determining pavement course thickness
2.10.1	Method of joint survey
3.1.2	Survey Project Plan and drawings outlining the strategy and methodology for onsite mark protection and reinstatement of survey infrastructure
3.6.1	Survey procedures for controlling Standards of Accuracy for bulk earthworks, general construction activities and specialised construction activities
4.5	Procedure for validating GNSS survey equipment
4.6	Method of site localisation and checking Machine Guidance System(s)
5.3.3	Sampling plan for conformity verification surveys of pavement surfaces
5.4.2	Details of Bridge Survey Control
5.6.4	Method of determining pavement course thickness

ANNEXURE G71/E – TFNSW SURVEY CONTACT DETAILS

TfNSW Survey contact details:

Position title	Phone number
Director Surveying	02 8837 0440
Maritime - Manager Survey	02 9563 8538
Manager Survey Certification & Compliance	02 8837 0422
Sydney Region – Manager Geospatial Technologies	02 8837 0433
Sydney Region – Manager Cadastral Survey	02 8837 0443
Sydney Region – Manager Utility Locations	02 8837 0450
Hunter Region – Survey Manager	02 4908 7656
Northern Region – Survey Manager	02 6604 9306
South West Region – Survey Manager	02 6923 6534
Southern Region – Survey Manager	02 4221 2762
Western Region – Survey Manager	02 6861 1432

ANNEXURES G71/F TO G71/L – (NOT USED)

ANNEXURE G71/M – REFERENCED DOCUMENTS

Refer to Clause 1.2.4.

TfNSW Specifications

TfNSW D&C G7	Utility Adjustment
TfNSW D&C G10	Traffic Management
TfNSW D&C G22	Work Health and Safety (Construction Work)
TfNSW D&C G40	Clearing and Grubbing
TfNSW G73	Detail Survey
TfNSW D&C Q6	Quality Management System (Type 6)
TfNSW D&C B50	Driven Reinforced Concrete Piles
TfNSW D&C B51	Driven Prestressed Concrete Piles
TfNSW D&C B53	Driven H-Section Steel Piles
TfNSW D&C B54	Driven Tubular Steel Piles
TfNSW D&C B57	Driven Cast-in-place Concrete Piles
TfNSW D&C B58	Bored Cast-in-place Reinforced Concrete Piles (With Permanent Casing)
TfNSW D&C B59	Bored Cast-in-place Reinforced Concrete Piles (Without Permanent Casing)
TfNSW D&C B61	Driven Composite Piles
TfNSW D&C B63	Continuous Flight Auger (CFA) Piles
TfNSW D&C B80	Concrete Work for Bridges
TfNSW D&C B110	Pretensioned Precast Concrete Members
TfNSW D&C B115	Precast Concrete Members (Not Pretensioned)
TfNSW D&C B150	Erection of Pretensioned Precast Concrete Members
TfNSW D&C B152	Incrementally Launched Prestressed Concrete Girders
TfNSW D&C B153	Erection of Precast Concrete Members (Not Pretensioned)
TfNSW D&C B170	Supply and Installation of Void Formers
TfNSW D&C B201	Steelwork for Bridges
TfNSW D&C B261	Erection of Structural Aluminium
TfNSW D&C B264	Erection of Barrier Railings and Minor Components
TfNSW D&C B284	Installation of Bridge Bearings
TfNSW D&C B349	Precast Concrete Noise Wall Members (Not Pretensioned)
TfNSW D&C R44	Earthworks
TfNSW D&C R73	Construction of Plant Mixed Heavily Bound Pavement Course
TfNSW D&C R81	No Fines Concrete Subbase
TfNSW D&C R82	Lean Mix Concrete Subbase
TfNSW D&C R83	Concrete Pavement Base
TfNSW D&C R271	Design and Construction of Noise Walls

TfNSW Guides

TfNSW NG71	Guide to TfNSW G71 – Guide to Construction Surveys

Australian Standards

AS 2159	Piling - Design and installation
AS 5131	Structural steelwork - Fabrication and erection
AS 5488	Classification of Subsurface Utility Information (SUI)
AS/NZS ISO 9001	Quality management system - Requirements

NSW Government Legislation

Surveying and Spatial Information Act 2002

Surveying and Spatial Information Regulation 2017

Intergovernmental Committee on Surveying and Mapping (ICSM)

Special Publication No. 1 Version 1.7	Standards and Practices for Control Surveys

Surveyor General's Directions

No. 1	Approved Permanent Marks
No. 2	Preparation of Locality Sketch Plans
No. 5	Verification of Distance Measuring Equipment
No. 9	GNSS for Cadastral Surveys
No. 11	Preservation of Survey Infrastructure
No. 12	Control Surveys and SCIMS