DEPARTMENT *of* INFRASTRUCTURE, ENERGY *and* RESOURCES
TASMANIA
ROADWORKS SPECIFICATION
G8 – Construction Survey
September 2010

G8.1 SCOPE

This specification sets out the requirements for construction surveys including:

- Developing and maintaining the quality management system for survey;
- Maintaining the integrity of the Survey Control Network, both primary and minor;
- Survey techniques for attaining the accuracies and tolerances detailed in the relevant DIER Standard Specifications;
- Evidence of Compliance.

All work shall be carried out in an environmentally sensitive manner and shall not cause damage to property. Any claims for damage associated with the survey work will be the responsibility of the consultant.

G8.2 OBJECTIVE

The objectives of this specification are to ensure that all surveys meet the minimum standards as defined in this specification in order for DIER projects to achieve the required construction tolerances.

Note:
The Survey Control Network and the linkages from the initial engineering detail survey through to construction set-out are pivotal to the successful installation of the constructed infrastructure to DIER requirements.

G8.3 REFERENCES

All construction surveys shall be in accordance with all DIER Specifications & Standards in particular:

- G1 General Provisions;
- G2 Contract Management Plan;
- G3 Traffic Management;
- R21 Clearing and grubbing;
- R22 Earthworks;
- R 40 Pavement Base and Subbase;
- R55 Asphalt Placement;
- T4 Planning and Design Survey.

Construction tolerances for earthworks and pavements are listed in Appendix G8A. Tolerances for other works e.g. drainage and bridge constructions are detailed in the relevant DIER Standard Specification.

Note:
The NSW RTA Guide NG71 at the ICSM web site
http://www.icsm.gov.au/icsm/tasamm/index.html
has been identified as a source of information on specific instrumentation and observing techniques used in engineering and construction surveying to achieve specified levels of measurement accuracy commensurate with DIER's construction tolerances.

G8.4 DEFINITIONS

The following interpretations apply to terms used in this specification:

- Datum
  - "GDA94" – Geodetic Datum of Australia 1994

  - "MGA" – Map Grid of Australia
  - "AHD" – Australian Height Datum (Tasmania)
- DIER's Representative – The DIER officer who has engaged the consultant, e.g. "Crown Representative" (Crown based General Conditions of Contract), "Principals Representative" (AS4122 General Conditions of Contract for Engagement of Consultants).
- "GPS" - The satellite based Global Positioning System developed by the American military in the 1970's and now used extensively worldwide by civilian users. One of the position products available is the Real Time Kinematic (RTK) system which is CAPABLE of providing real time three dimensional measurements with a Local Uncertainty of around 30mm. GPS is the original and most common Global Navigation Satellite System (GNSS) – other systems (existing and proposed) include GLONASS (Russian), GALILEO (European) and COMPASS (Chinese). In this report where GPS is used it is taken to represent any or all of the GNSS systems, individually or combined.
- "G71" and "Guide NG71" – In 2005 the NSW Roads and Traffic Authority (RTA) developed its *Quality Assurance Specifications for Road Construction Surveys* (*G71)* and an accompanying set of guidelines *Guide to G71, Quality Assurance Specifications for Road Construction Surveys (NG71*). In 2007 ICSM *and* TASAMM (Transport Authorities Surveying and Mapping Managers) commenced a review of those documents to assess their compliance with ICSM's SP1 which was completed in November 2009. The documents are available at http://www.icsm.gov.au/icsm/tasamm/index.html
- "Height of sight lines" – when used in relation to survey procedures it refers to the minimum vertical distance from the sight line to the natural surface.
- "ICSM" - The Inter-Governmental Committee on Surveying and Mapping (ICSM) is 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.
- "Local Uncertainty" – is the universally accepted measure of the quality of measurement by quoting a confidence interval about derived measurements. The ICSM defines Local Uncertainty in SP1 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".
- Models
  - GENIO – General Input/Output text file,
  - "DTM" – Digital Terrain Model of the ground surface generated from a survey,
  - "MX" – CADD Software, previously known as MOSS.
- "Minor Survey Control (MSC)" - MSC points are established as a stable point of reference for all operational survey aspects i.e. the acquisition of ground feature or cadastral boundary information, or the construction

set-out survey. It is accepted that MSC points may be destroyed during the construction process.

- "Permanent Survey Mark" – a permanently monumented survey control mark with horizontal coordinates and/or height of known accuracy adopted as a permanent mark under Section 14 of the Survey Coordination Act 1944 and included in the online register (SURCOM) maintained by the Office of the Surveyor General (http://surcom.dpiw.tas.gov.au/surcom).
- "Primary Survey Control (PSC)" – is a substantial survey control mark that is intended to survive, undisturbed, the entire life of the project– from design to construction, including all necessary compliance and audit surveys. It will either be an existing Permanent Survey Mark or a mark of an approved form described in ***Clause G8.8.1***.
- "Sight distance" – when used in relation to survey procedures refers to the length of the sight line
- "SP1" – ICSM Special Publication 1 *Standards and Practices for Control Surveys* (current version 1.7), available at http://www.icsm.gov.au/icsm/publications/index.html#news.
  NOTE:
  SP1 is currently under review and will be re-issued within 12 months in a totally new format (version 2).
- "Standard Permanent Mark (SPM)" – A common prefix used in the name of many Standard Permanent Marks in SURCOM. In this report the abbreviation SPM is used to generically refer to all of the Permanent Survey Mark types.
- "Survey Control" – a survey peg, bench mark, reference mark, or any other mark used or intended to be used for the purpose of measuring, setting out, or checking the actual or design surface.
- "Survey procedures" – methods to control parameters that affect the accuracy of survey techniques, such as a radiation procedure or height determination procedure.

G8.5 CONTRACT MANAGEMENT PLAN (CMP)

Further to Standard Specification G2 Contract Management Plan, the Contractor's Contract Management Plan shall include:

- Details of personnel including qualifications;
- Survey Management plan including
  - Equipment,
  - Work procedures;
  - Verification surveys;
  - The survey records system covering the method of storing and indexing electronic records and name of computer software for reduction of survey measurements and calculations;
- All elements as detailed in Standard Specification G2 Contract Management Plan;
  - Liaison with Service Authorities or Asset Locators to locate and expose underground services;

- Traffic Management Plans in accordance with Standard Specification G3 Traffic management.

G8.6 EVIDENCE OF COMPLIANCE

G8.6.1 General

Evidence of compliance shall include survey reports for each activity i.e. Survey Control both Primary and Minor, Set out, Compliance (As Constructed) and As-constructed Surveys.

Evidence of compliance shall be submitted at each hold point.

G8.6.2 Contract Records

All survey information generated during the contract shall be the property of the Principal and shall be included in the contract records.

Verification field book pages shall be clearly labelled, dated and signed by the surveyor with cross indexed references to equipment used and lot/component identification. All survey reports generated shall reference verification field book page numbers.

Where automatic data recording systems are used for verification surveys, a print out of both raw data and reduced data shall be retained in a similar manner as conventional filed books in addition to the electronic data.

Calibration records of survey equipment shall be included in the survey records.

G8.6.3 Audit Trail

Survey records shall be sufficient to provide objective evidence that the surveyor has completed all surveys in accordance with this specification and the Surveyor's Survey Management plan and that all surveys attain the required accuracy. The survey records system shall be indexed for easy retrieval of information and provide a clear audit trail for all surveys.

G8.6.4 Hard Copies

At the time of a survey, the surveyor shall provide signed copies of survey records verifying conformance. Paper copies of all electronically collected survey data used for set out and verification surveys shall also be provided.

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

The surveyor shall sign all paper copies of survey field measurements, data and reductions, survey reports, diagrams and sketches used to set out the works, verification or to determine quantities.

Where the surveyor radiates or determines height differences by EDM trigonometrical heighting to set out marks and uses computer software as an independent survey check, the field measurements, data and resulting computer reductions shall be included in the survey records.

G8.6.5 Machine Guidance Control Data

When grader blade laser or other automated control systems are used for the purpose of road construction, all completed layer data shall be provided with the survey records.

G8.7 SURVEY REQUIREMENTS

G8.7.1 General

It is the responsibility of the Contractor's Construction Surveyor to use appropriate survey equipment and procedures to ensure that all construction tolerances, as stated in the Specification and Drawings, are achieved.

G8.7.2 Qualification of Surveyors

All surveys shall be the responsibility of a qualified surveyor as listed in ***Table G8.1 Qualifications of Surveyors***. All surveyors are to be able to demonstrate competence in carrying out the required surveying tasks.

Table G8.1 Qualifications of Surveyors

Survey Element	Qualification
Survey Control	A person who holds a Diploma in surveying, or a recognised equivalent, from a recognised tertiary institution and possess at least three (3) years practical experience as a survey party leader on major roadworks and/or bridgeworks as appropriate.
Construction set-out and Compliance Surveys	A person who holds a Diploma in surveying, or a recognised equivalent, from a recognised tertiary institution and possess at least three (3) years practical experience as a survey party leader on major roadworks and/or bridgeworks as appropriate.

G8.7.3 Survey Standards

The technical survey standards applying to the *CLASS* of all horizontal and vertical control required under this specification are contained in *ICSM SP1*.

GPS instruments shall not to be used to derive heights for Primary Survey Control (PSC) or Minor Survey Control (MSC) in the General Survey Control Network or the Survey Control for Bridgeworks nor shall they be used for height determination of construction set-out where a construction accuracy of less than 30mm is required.

GPS instruments may be used for horizontal set out provided it is combined with another technique for vertical alignment set out.

G8.8 SURVEY CONTROL

G8.8.1 General Survey Control Network

The Principal will provide the contractor with all the survey control information necessary for setting out the works. All relevant information in the engineering Survey Report *(reference Standard Specification T4 Planning and Design Survey, Clause T4.10.3)* including datum details will be provided.

The General Survey Control network includes both the Primary Survey Control (PSC) and the Minor Survey Control (MSC) and the standards for their survey are as detailed in *Standard Specification T4 Planning and Design Survey, Clause T4.9*.

It is the contractor's responsibilities to take care of all survey control marks as well as any additional marks placed to break down/extend the survey control network.

The Contractor shall verify the integrity of all marks in the General Survey Control Network before commencing any other survey activity.

This is a HOLDPOINT.

The Contractor shall submit a Survey Report verifying the coordination and level values of the survey control marks provided. The report shall also address the issue of what will occur if any errors or anomalies are found.

If any errors or anomalies are found the Superintendent shall be informed immediately. Proposed options and actions shall be provided for approval of the Superintendent.

This Survey Report shall also detail the method by which the Contractor will implement and monitor a breakdown/extension of the survey control network, reference Standard Specification Clause G2.12.

This extension/breakdown of the general survey control network shall be as defined in this specification. The Survey Report shall identify how the Primary Survey Control (PSC) placement will survive the life of the project.

Further to *Standard Specification T4 Planning and Design Survey clause T4.9.2*, a PSC must either be an SPM or a mark of a form as follows:

- generally be placed a minimum of 2 metres outside any design earthworks;
- Any new PSC must be established by a closed survey network or traverse from a minimum of 3 existing PSC or MSC, at least two of which must be PSC;
- Any new MSC must be coordinated by closed survey network or traverse to at least 2 existing PSC or MSC, at least one of which must be a PSC;
- In the case of conventional surveying methods, an orientation angle must be observed between the existing network and the new network;

The contractor must maintain records of all new control placed that will be available at all times at the site office for the Superintendent to inspect and hard copies provided within 5 working days of control installation.

An overall report on the installation of the survey control is required at the end of the project as part of the contract records. The information is to be the same as that required in the Survey Report for the Engineering Survey (*Refer Standard Specification T4 Planning and Design Survey clause T4.10.3*) in particular:

- A Station listing of the construction set-out marks (i.e. PSC and MSC)
    - sorted according to traverse order,
    - containing station identifier,
    - corresponding SPM number (if applicable),
    - Map Grid of Australia 94 (MGA94) coordinates and AHD height,

  - the CSF at that point,
  - the type of ground mark and witness mark,
  - the source of the mark coordinates (whether adopted from SURCOM or calculated by the survey);
- Horizontal Control - a brief description of the closure adjustment and Local Uncertainty achieved;
- Vertical Control - a summary table of the of accuracies (closures) achieved in the levelling runs and values adopted, datum mark(s) adopted and discrepancies with existing SPM's with published AHD values;
- Certification that survey procedures to satisfy required accuracy standards (as per the specification) were employed.

Note:
The General Survey Control network should be all that is required for most of the construction activities: including earthworks, drainage, pavements, road furniture and most of the bridgeworks. However, in some instances survey control marks of a lower order of accuracy may be suitable for bulk earthworks whilst in other instances marks with a higher order of relative accuracy may be required for specialised work e.g. bridgeworks.

G8.8.2 Survey Control for Bulk Earthworks

When placing or verifying survey control marks for bulk earthworks the contractor may use survey procedures which result in a greater Local Uncertainty than for the general construction activities.

These activities include bulk earthworks quantities, clearing and grubbing, and initial set-out of earthworks.

The earthworks control shall not be used for construction activities that require a higher order of accuracy, such as final earthworks supporting pavement courses or the pavement courses themselves.

The *CLASS* of the Earthworks Control must be suitable for satisfying the tolerance of the construction task for which they will be used. However, the survey class of the control must be, at worst, *CLASS E* for horizontal, and *CLASS LE* for vertical, in accordance with *Part A of SP1*.

The Earthwork Control is to be clearly differentiated from the General Survey Control.

G8.8.3 Survey Control for Bridgeworks

The survey control for bridgeworks shall be known as the Bridge Survey Control. Bridge Survey Control shall use ground distances in place of grid (MGA) distances when calculating the coordinates of the control marks.

Note:
Typically, this is due to the number of pre-fabricated elements (specified in ground distances and constructed off-site) used during bridge construction.

It shall be separate to the General Survey Control, as most marks will have different two dimensional coordinates to the General Survey Control due to the different distances used.

Note:
The objective of adopting a clear documented procedure specifically for bridge control and construction is to avoid the problem of misaligned formation and bridges.

Bridge Survey control shall be on the same azimuth as the General Survey Control Network and must adopt the coordinates of at least one of the survey control marks form the General Survey Control network. It shall include at least three survey marks for each bridge, which must physically be of PSC standard.

Only the Bridge Survey control shall be used to set-out bridge construction activities, and shall be clearly differentiated on site from the General Survey Control so that the two are not confused.

The Local Uncertainty of both the Bridge Survey Control and the setting out marks placed by the Contractor from the control must be sufficient to ensure that the construction tolerances of the structures, as stated in the Specification and Drawings, are achieved.

The establishment and maintenance of the Bridge Survey Control shall be specifically addressed by the Contractor in the Survey Report.

Note:
It may not be possible to include it in the same Survey Report as the General Survey Control Network (due to site accessibility etc), although this would be preferred.

The acceptance of the Bridge Survey Control by the Superintendent is a HOLDPOINT.

G8.8.4 Machine Guidance Set out Requirements

When grader blade laser or other automated control systems are used for the purpose of road construction, such that construction pegging of the subgrade or pavement would not otherwise be provided, then the following alignment control requirements shall be established by the Contractor for the use of the Superintendent prior to the commencement of subgrade preparation or any pavement construction:

- Offset pegs shall be established on at least one side of the road formation;
- The pegs shall preferably be placed at 1.5m offset to the verge;
- Chainages shall be clearly marked on the pegs;
- The longitudinal spacing between pegs shall not be greater than 50m on straights and 20m on curves and include all curve Tangent Points;
- The pegs shall be placed vertical and within + or – 25mm tolerance to their exact location;
- The pegs shall remain undisturbed until after the Superintendent has accepted that the pavement marking complies with Standard Specification R64 Pavement Marking. Any pegs that are disturbed shall be re-established by the Contractor at no cost to the Principal;
- Construction levels are not required to be marked on the pegs;
- The pegs shall be removed by the Contractor at the completion of the Works.

G8.9 COMPLIANCE AND AUDIT SURVEYS

G8.9.1 Compliance Survey

Compliance surveys shall be undertaken by the contractor to ensure that the as-constructed product complies with the tolerances for top of subgrade and the finished compacted top of base in ***Table G8.9.2 Construction Tolerances*** and ***Table G8.9.3 Compliance Survey Requirements***, specific tolerances nominated in other DIER Standard Specifications as well as any specific project tolerances.

Note:
Table G8.9.2 *also lists other level tolerances for information.*

Table G8.9.2 Construction Tolerances

Specification	**Clause**	**Description**	**Vertical Tolerance** (mm)	
			+	**-**
Earthworks	R22.3.1 (ii)	Top of embankment (below subgrade)	0	60
Earthworks	R22.3.1 (iii)	General excavations - Top of subgrade	0	60
Earthworks	R22.3.1 (iii)	General Excavations - Insitu materials removed from subgrade zone (bottom of subgrade)	0	60
Subgrade Zone	R23.6	Top of subgrade	0	60
Pavement Base and subbase	R40 Appendix A1 (f)	Base A	10	5
Pavement Base and subbase	R40 Appendix A2 (f)	Base B	10	5
Pavement Base and subbase	R40 Appendix A3 (f)	Subbase 1	15	30
Pavement Base and subbase	R40 Appendix A4 (f)	Subbase 2	20	40
Pavement Base and subbase	R40 Appendix A5 (C.2)	Unsealed road and Unsealed shoulders wearing surface	15	10
Asphalt Placement	R55.5.2	Level of each course of asphalt	5	5
Asphalt Placement	R55.5.2	Placement against kerb and channel	5	0
Asphalt Placement	R55.C.4.3	Milled surface	5	5

Compliance surveys will usually be required on 100% of the as-constructed subgrade and pavement base surfaces.

Compliance surveys will also be required on other structures listed in the relevant DIER Standard Specification or the Project Specification.

The Compliance Surveys are to be included in the evidence of compliance for the release of the relevant pavement layer hold points.

The compliance surveys of pavements shall, where possible, adopt methods that are independent from techniques used to set-out the works. The sampling locations shall be at 20 metre intervals generally 10 metre from the set out cross sections with a minimum of three points being the centreline and edge lines.

The Compliance surveys shall include an overlap section captured from adjacent control points between observation sets. Common points to both observation sets within the designated overlap area are to be measured from each control point and the elevation differences compared in the Compliance Report prepared for the Superintendent.

Table G8.9.3 Compliance Survey Requirements outlines the requirements for the density of the compliance survey observations and the allowable height differences for each formation component.

Table G8.9.3 Compliance Survey Requirements

Pavement Surface	Maximum sampling Chainage difference	Positive height difference (+)	Negative height difference (-)	Maximum overlap height difference	Specification clause
Finished compacted base	20m	10mm	5mm	0.005m	R40 Appendix A1
Top Subgrade	20m	0	60mm	0.01m	R23.6

It is the responsibility of the compliance surveyor to ensure suitable survey practices are adopted to achieve the standards of accuracy required to adequately assess the conformance of the as-constructed surfaces to tolerance.

Note:
The NSW RTA Guide NG71 provides examples of procedures to meet specific tolerances.

G8.9.2 Joint Surveys

Joint Surveys between the Contractor' and Superintendent's Surveyors may be conducted as part of the compliance surveys on all earthworks wherever volumes are a schedule of rates payment.

G8.9.3 Audit Surveys

Audit surveys may be used to further compliment the compliance surveys if the Superintendent is still not satisfied that the construction is meeting the required tolerances.

Note:
With a consistently implemented regime of compliance surveys the need for audit surveys should lessen.

The audit may range from a desktop examination of survey information obtained from the contractors or an on-site visual inspection of techniques and records, through to a full field check of the contractor's survey control and constructed surfaces.

Field construction audits will be conducted using the contractors PSC and MSC that is verified as part of the audit process. At least two PSC must be included in every audit control survey. The audit surveyor will be required to submit, in conjunction with the surface audit results, the results of the adjustment to confirm the PSC and MSC adopted.

The field audit survey shall include an overlap section captured from adjacent control points between observation sets. Common points to both observation sets within the designated overlap area will be measured from each control point and the elevation differences compared in the Audit Report prepared for the Superintendent.

It is the responsibility of the audit surveyor to ensure suitable survey practices are adopted to achieve the standards of accuracy required to adequately assess the conformance of the as-constructed surfaces to tolerance.

The requirements of ***Table G8.9.3 Compliance Survey Requirements*** shall apply to audit survey results.

Note:
The NSW RTA Guide NG71 provides examples of procedures to meet specific tolerances.

G8.9.4 Compliance Survey Report

A compliance survey report shall be provided as evidence of compliance at completion of the survey with the hold point release request.

For compliance surveys of subgrade and pavement base layers a tabulated spreadsheet is an acceptable means of presentation of the results (required in electronic and hard copy) and should include as a minimum:

- Sample point location by easting, northing, chainage and offset
- As-constructed elevation and corresponding design elevation
- Elevation differences and a status of compliance of the observed difference to the allowed difference specified in ***Table G8.9.3***.
- Overlap Height difference where appropriate

G8.10 PAYMENT

With the exception of Audit Surveys payment for all construction surveys is deemed to be included in the contractors tendered rates and shall include the provision of all reports and information required. No payment shall be made for individual specified elements (e.g. subgrade, pavement base completion) until all relevant survey reports have been received and accepted.

Payment for audit surveys shall be as a lump sum at schedule item 8.11(a) Desk top or 8.11(b) Field.

G8.11 HOLD POINTS AND DELIVERABLES

The following hold points have been identified in this specification:

Table G8.4 Hold Points

Ref	Description of Hold Point	Nominated Work not to proceed	Evidence of Compliance
G8.8.1	General Survey Control Network	Set out for specific construction activities e.g. earthworks, drainage	Survey Report
G8.8.2	Survey Control for bulk earthworks	Earthworks	Survey Report
G8.8.3	Survey Control for bridgeworks	Bridgeworks	Survey Report
G8.8.4	Survey Control for machine guidance set out	Use of machine guidance system	Survey Report
G8.9.1	Compliance Surveys	Placement of the next layer or activity	Survey Report

Table G8.5 Deliverables

Name	Timing	No. of Copies in Format Shown		
		Hard Copies		Electronic Copies
		Bound	Unbound	
General Survey Control Network	At completion of survey	0	1	1
Survey Control for bulk earthworks	At completion of survey		1	1
Survey Control for bridgeworks	At completion of survey		1	1
Survey Control for machine guidance set out	At completion of survey		1	1
Compliance Surveys	At completion of survey		1	1

All deliverables shall include the relevant survey report.