A National Survey Standard for Road and Bridge Construction in Australia and New Zealand

Jim OLLIS, Australia

Key words: Road **c**onstruction, surveying specifications, Australia, standards,

SUMMARY

This paper deals with the development of Construction Survey Specification G71 and its companion document Guide NG71, by the Roads and Traffic Authority of New South Wales (RTA) and its ongoing development to become a national standard.

The specification addressed serious concerns raised by senior RTA management about the impact of perceived poor survey practices affecting their infrastructure. The specification was able to address their concerns and also raise awareness about the importance of good survey practices and how survey contributes to the over all life cycle costs of projects.

This specification made several break-throughs, including for the first time specifying the accuracy of surveying procedures when surveying different road/bridge components. The application highlights the intellectual challenge of rigorously defining the standards of accuracy that reflect the capability of construction processes and surveying procedures. For the RTA it is the first stand-alone construction survey specification and is written by surveyors. This allowed the specification to reflect their concerns about issues that affect survey in road/bridge construction projects.

The specification is now loaded onto the Inter-governmental Committee of Surveying and Mapping (ICSM) website as a national standard for road construction surveys in Australia and New Zealand. This is recognition of the specification's contribution to improving surveying standards. The paper also describes this process.

Annual expenditure on Australian road infrastructure is approximately 6 billion dollars. This specification is seen as a tool to make significant contribution to reducing the cost and improving the efficiency and lifespan of the infrastructure.

A National Survey Standard for Road and Bridge Construction in Australia and New Zealand

Jim OLLIS, Australia

1. BACKGROUND

The genesis of Construction Survey Specification G71 comes from the Roads and Traffic Authority (RTA) of New South Wales (NSW), which spends almost $2B yearly on the state's road infrastructure. An RTA review of maintenance costs of roads built during the 1990's showed that expenditure was greater than what designers had predicted. A letter from the RTA Infrastructure Contracts Branch, sent to road construction contractors operating in NSW, in December 2004 concerning excessive maintenance costs advised that;

> *"One cause can be contributed to pavement dimensions that do not always conform to design, possibly the result of deficient survey practices"*

Pavement thickness of RTA roads is critical to pavement life and hence, maintenance costs. Concrete pavements constructed 10% less than their design thickness will reduce its life cycle by 90 percent. The effect of pavement thickness on bound flexible pavements (the more traditional bitumen roads) is similar.

The causes for pavements being constructed less than design thickness are complex and can not be attributed to surveying procedures only. However, surveillance audits during the 1990's demonstrated that surveying practices and procedures by contractors on RTA road construction projects were variable and sometimes questionable.

Nevertheless, the fact that spatial tolerances were not met meant that surveying was one of factors that the RTA needed to address. The concern by RTA senior management also highlighted the need for surveyors to project a more positive image and a need for better control to reflect the significant contribution of Surveying to road construction projects.

1.1 RTA survey specifications prior to G71

RTA engineers have traditionally prepared specifications for RTA construction projects, as have engineers in most organisations that are responsible for capital works. They sought and depended upon input from technical experts for disciplines such as surveying. While surveyors may have worded parts of the specifications, engineers remained the custodians and owners of the specifications. Where engineers do not seek sufficient survey input they can specify an outcome without an understanding of survey inputs for different outcomes. This has led to vague survey requirements which do not always translate simply to specific survey tasks, often leaving the surveyor to second guess what the project manager really wants.

In addition, RTA surveying requirements were not controlled in one specific survey specification but as a part of other technical requirements and contained in several RTA contract documents. This meant that the wording of survey requirements had to match other parts of these documents and limited the ability of surveyors to express survey requirements as they would have liked.

Some specifications gave spatial tolerances that did not reflect the capability of the construction process to achieve the tolerance. This meant surveys of a higher accuracy for setting out the works and conformance measuring than what was possible by commercially accepted construction processes, thus adding undue survey costs and time to construction.

2. DEVELOPMENT OF SPECIFICATION

2.1 Philosophy

2.1.1 Ownership of G71

As a result of the RTA review into excessive infrastructure maintenance costs, senior RTA management met with the RTA Surveying Section in December 2000 with a list of issues that they felt a surveying specification should address. The meeting agreed that the Surveying Section would to prepare a standalone surveying specification for RTA construction projects that would address the list of issues and other matters that may arise. The Surveying Section would be responsible for maintaining the specification and its ongoing review.

This gave ownership of the surveying specification to RTA surveyors, meaning that the specification would be written by surveyors, about surveying, for surveyors, but at the same time protecting the RTA infrastructure. It also allowed RTA surveyors engaged on construction projects to raise construction surveying issues through the Surveying Section instead of through Engineering Contracts Branch. This less formal approach enabled the Surveying Section to express the issues in a language familiar to Engineering Contract Branch before forwarding revisions to them for final approval in accordance with RTA model specification guidelines.

2.1.2 Estimate of process capability and surveying capability

The meeting also discussed how to strengthen control of the survey element and providing clearer direction to contractors on the outputs required by surveyors. This included defining orders of accuracy for different survey tasks and applying those different orders of accuracy to different components of the project, such as pavements, drainage and earthworks.

Applying the appropriate order of accuracy when surveying a construction component means the variability (or accuracy) of the survey would not add any significant variability to the constructed component. This requires knowledge of construction processes and their capability, then assigning the survey accuracy appropriate to that construction process.

Estimating process capability is a significant paradigm shift from traditional surveying specifications.

2.2 Structure of G71

Specification G71 contains five sections to address the critical issues for setting standards for survey on road and bridge construction projects.

2.2.1 Section 1 - General requirements

Section 1, General Requirements, similar to other contract documents, describes the scope and structure of the specification. In additional, G71 also contains a list of surveying terms and definitions for clarification for contract surveyors. The definitions are also beneficial to project managers who may not have surveying expertise or knowledge.

Quality assurance specifications are now accepted practice in Australia for all government contracts. G71 specifies compliance with international standard ISO 9001, *"Quality Management System Requirements"*, to address quality assurance requirements for survey. Section 1 provides direction on how surveyors may comply with ISO 9001 in the specific areas of qualification of surveyors, development of procedures, control of records and equipment calibration.

Previous specifications have relied upon membership of professional institutions as evidence that the surveyor has sufficient capability to take responsibility of survey for the project. However, at the time of developing the specification professional surveying bodies in Australia were in a state of reform, which made specifying bodies by name a problematic exercise. It was therefore felt that defining qualifications and practical experience was more appropriate and less affected by change. Two years practical experience after completion of a Diploma in Surveying from a recognised institution defines the qualifications for the surveyor responsible for survey. However, where property boundaries must be defined, the contractor must use qualified boundary/property surveyors in the jurisdiction where the project is being constructed. Property boundary definition is critical where structures are intended to be placed near a private property boundary.

ISO 9001 requires development of procedures where absence of procedures may have an adverse effect on quality. Specification G71 specifies that contract surveyors must prepare surveying procedures, thereby removing the ambiguity that some contractors may feel exists. The companion Guide to the specification, NG71 provides some direction for compliance with ISO 9001, including factors to address.

Records provide evidence that the end product has met specified requirements and adopted procedures have been followed. Surveying procedures should show how the product was set out and the survey conformance report should show the level of conformity with spatial tolerance. Where products fail to comply with spatial requirements surveying records must be sufficient to immediately remove quality surveys as a possible cause. Surveyors traditionally have taken pride in their survey records. However, with the introduction electronic data capture, some surveyors are not as diligent maintaining records as when they collected information by hard copy field notes.

G71 directs the surveyor to comply with Clause 7.6 of ISO 9001, *"Control of monitoring and measuring equipment"*, for control of survey equipment. Clause 7.6 addresses such issues as calibration procedures and records, care, protection and maintenance of equipment, and tagging equipment. However, these requirements are not onerous as survey regulations in jurisdictions in Australia and New Zealand currently require surveyors to address these issues. G71 also specifically states that the surveyor must apply these requirements to all survey equipment, not just the EDM, to which the surveyor usually addresses most of these issues.

2.2.2 Survey control network

Surveys to establish and maintain the survey control network is the only surveying activity not directly linked to an engineering component of the project. Surveys for components of the project, such as pavements or earthworks, add to the cost of delivering those components to the project. Whereas the survey control network is a hidden cost that is spread over all the components constructed during the project. Because this a hidden cost, project managers and specification writers have not appreciated the importance of the survey control network and have not given it the attention it deserves.

However, as surveyors are aware, the accuracy of all survey activities on a project is limited by the integrity of the survey control network: unless due care and diligence are applied to setting up and maintaining the survey control network, then all future surveys are compromised. Specification G71, written by surveyors, gives the survey control network the importance that surveyors appreciate.

The specification allows three standards of accuracy for procedures for the survey control network depending on the survey activity and the stage of the project. The Earthworks Control is lowest standard of accuracy. This allows the contractor to place control through the project at the start-up of phase when access may be limited and the contractor wishes to start clearing and grubbing as soon as possible. RTA surveillance surveyors appreciated the impracticality of forcing the contract surveyor to establish a rigorous surveyor control network for clearing, grubbing and initial bulk earthworks when the accuracy was not required and, in all probability, the marks would be destroyed by the these activities.

The General Construction Activities control provides control for the majority of the project, including pavements, drainage, final earthworks, road furniture and fencing. As a rule of thumb the accuracy of this control is similar to the control for cadastral surveys. The specification requires all residual marks of the Earthworks control be resurveyed to General Construction Activities control standard as soon as practical.

However, there are occasions where the accuracy of the General Construction Activities control is not capable of meeting the tolerances specified in clauses of the RTA model specifications. This applies to some bridgework clauses such as incrementally launched concrete girders. The Specialised Construction Activities control has been established for this purpose.

The ICSM publication SP1, *Standards and Practices for Control Surveys*, provides the standards of accuracies for the survey control network as shown in Table 1.

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

Table 1 – Standards of Accuracy for the Survey Control Network

The Classes shown in the table are from SP1. The standard for the Specialised Construction Activities is not shown as a Class in accordance with SP1, as the higher accuracy controls of SP1 usually address parameters that affect longer lines. However, for tight engineering tolerances absolute error is more critical than the ratio of the error to the length of the lines, as used by SP1. Therefore, in consultation with Geosciences Australia, a local uncertainty of 4 mm for all control points was adopted.

Specification G71 assigns the responsibility of the survey control network to the contract surveyor. While the RTA, or any other road construction authority, may take all due care and responsibility to establish a control for an investigation/design survey, it is not possible for them to guarantee that the integrity of the survey control network will remain the same when construction work commences.

Construction activities associated with road and bridge projects can affect the survey infrastructure, both cadastral marks and the State Control Survey marks. Legislation in some jurisdictions now recognises this and aims to minimise it. G71 highlights these requirements and gives direction on compliance.

The specification also requires the contractor to provide site surveillance with a survey control mark register to ensure that surveillance check surveys use the same coordinate values as the contract surveyor.

2.2.3 General survey requirements

Section 3 clarifies survey issues that are not addressed by other sections, including software, joint surveys, product conformance surveys and marking land property boundaries.

Joint surveys between site surveillance surveyors and contract surveys may be used for quantity surveys for payment purposes to minimise the risk of disputes. They may also be used for critical components of the project with tight tolerances. The specification specifies where joint surveys are required but also allows the construction authority to request one wherever there is deemed to be an unacceptable risk.

This section also provides some general directions on product conformance surveys, such as sampling, timing of conformance verification surveys and release of Hold Points.

Cadastral overlays provide an indication of position of property boundaries for designers to assist location of design features on the project. However, it is not economically viable to precisely define all cadastral boundaries during the investigation survey as some or most boundaries may not be affected by the work. Therefore, the cadastral overlay should be used as a guide for design purposes only and a more precise survey, using the latest cadastral information and qualified surveyors, should be used only after those boundaries affected by the work have been determined. However, designers will normally assign design coordinates to the cadastral overlay, which may indicate to some people that the cadastral overlay is the correct position of the property boundary.

Clause 3.4 of G71 is specifically to address this issue and to minimise the risk of the infrastructure encroaching onto private property and the added costs that would cause the project.

2.2.4 Survey techniques

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

Table 2 – Orders of Accuracy for Horizontal Control

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

Table 3 – Orders of Accuracy for Vertical Control

Notes for Tables 2 and 3

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

(2) **Ninety five percent confidence level of relative uncertainty with respect to adjacent survey control marks.**

Specification G71 makes a significant departure from previous survey specifications controlling survey by the application of tables of Orders of Accuracy for horizontal coordinates (two dimensional) and vertical coordinates (the third dimension) as shown in tables 2 and 3. A schedule of Orders of Accuracy was one of the recommendations from the December 2000 meeting between Senior RTA Management and the Surveying Section.

The standard deviation of the accuracy of a measurement is multiplied by 2.45 to establish its 95% confidence level of local uncertainty (LU) for two dimensional coordinates, whereas for one dimensional coordinates, the standard deviation is multiplied by 1.96 for the LU. It is common practice to quote surveying accuracy as a confidence interval of one standard deviation. Therefore, the values listed in Tables 2 for the accuracy under the Local Uncertainty column may appear large on first inspection. However, dividing those values by 2.45 gives values that experienced construction surveyors may expect.

The notations, H for horizontal coordinates and V for vertical coordinates is the same as SP(1). Similarly, the use of the 95% confidence level of relative uncertainty as a measure of accuracy is the same as SP(1) and is in line with international standards for expressing the uncertainty (or accuracy) of measurement.

The purpose of the tables is to provide a range of surveying Orders of Accuracy and then applying the appropriate Order of Accuracy when surveying specific components of the project. For example, spatial tolerances for clearing lines through forestation are much more generous than tolerances for bridgeworks. Therefore, the surveyor would have to choose a higher Order of Accuracy when surveying a bridge component than if setting out a clearing line.

The specification requires the contract surveyor to prepare procedures that are capable of achieving each of the Orders of Accuracy listed in the tables for both horizontal and vertical coordinates or as required for a particular project. The companion document, NG71, *Guide to Construction Surveys*, provides sample procedures which the contractor may adopt or, develop his/her own procedures that are capable of achieving the specified Orders of Accuracy.

It is important to note that G71 specifies Orders of Accuracy; not the procedures or methods for achieving the Orders of Accuracy. The procedures in the Guide may represent good survey practice at the time of releasing of the specification, however, they also may not be. The other problem with specifying procedures is that it inhibits innovation: who can say what technology may deliver to the surveying industry in the coming years? Government agencies prefer Performance Specifications in preference to Recipe Specifications, which give directions on how the work is to be carried out. Specifying Orders of Accuracy makes G71 a Performance Specification.

While G71 does not specify methodology, it does recognise that current construction surveying procedures rely heavily on EDM trigonometrical heighting. It therefore specifies survey checks where EDM trigonometrical heighting is used. These include where to carry out the checks, surveying techniques applied for each check, timing and the acceptance criteria for each Order of Accuracy. Maintaining records of these checks provide evidence of the quality of the survey and compliance with procedures.

The specification also recognises the expanding use of GNSS in road and bridge construction; it also recognises that there are limitations and standard procedures to follow when using GNSS. G71, therefore, has sets some minimum requirements and limitations when using this technology.

2.2.5 Construction activities

Section 5 ties the Orders of Accuracy listed in Section 4 to construction processes by estimating the capability of the construction process and selecting an Order of Accuracy that will not add significant variability to construction process.

By expressing both the capability of construction processes and surveying accuracy as a standard deviation, it is possible to estimate the effect of survey variability on construction accuracy (Ollis, 1997). This then leads to finding the maximum allowable variability in the surveying procedure before it has a significant effect on the construction process.

For example: the construction process that constructs concrete road pavement surfaces to the correct height is estimated to have a variability with a standard deviation of about 4 mm.

The effect of surveying procedures on the final variability of the pavement surface height can be expressed as:

$$\sigma^2_{pavement} = \sigma^2_{process} + \sigma^2_{survey} \qquad (1)$$

Where:

$\sigma_{pavement}$ is the standard deviation of the constructed pavement

$\sigma_{process}$ is the standard deviation of the construction process

σ_{survey} is the standard deviation of the surveying procedure (Ollis, 1997)

Substituting values into equation (1), and allowing 0.1mm for the effect of survey variability, determines the required surveying accuracy. Therefore, the required surveying accuracy can be expressed as:

$$\sigma^2_{survey} = \sigma^2_{pavement} - \sigma^2_{process}$$

$$\sigma_{survey} = \sqrt{4.1^2 - 4.0^2}$$

$$= 0.9\,\text{mm}$$

Therefore, when surveying concrete pavement surfaces, the surveying procedure must have a height accuracy with a standard deviation of 0.9 mm, which is achievable with proper survey controls. However, the Orders of Accuracy listed in Table 3 are expressed as a local uncertainty at 95% level of confidence (LU). The height standard deviation of 0.9 mm is multiplied by 1.96 to convert to the LU list in Table 3, which gives a LU of 1.75 mm.

Therefore, surveyors must adopt 2V Order of Accuracy (LU = 1.5 mm) when surveying concrete pavement surfaces.

Applying a similar approach to other construction processes enabled G71 to give a list of Orders of Accuracy for different phases of the processes of earthworks, drainage, bridges, pavements as well as quantity surveys.

Table 4 show how the Specification applies Orders of Accuracy to the process of constructing drainage structures. For example, when setting out kerb and gutter lines the surveying procedure must have an Order of Accuracy of 3H for horizontal and 4V for height. From Table 2, 3H equates to LU of 25 mm and from Table 3, 4V equates to LU of 6 mm.

Columns 4 and 5 of Table 4 contains the acceptance criteria for survey checks to survey control marks where the surveyor uses EDM trigonometrical heighting procedures, as outlined in Section 2.2.4 above.

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

Table 4 – Orders of Accuracy for Surveys of Drainage Structures

Section 5 also contains some specified requirements for bridgeworks, including the survey bridge control and survey records to be maintained.

The bridge survey control is distinct from the project survey control network in that it uses ground distances in preference to grid distances adopted by the project control. The reason for this is due to some bridge components being constructed off-site and others constructed in-situ.

Large components such as girders that are constructed off-site and brought to the site for placement will be constructed using the plan dimensions, that is, ground distances. However, if the position of the bearing pads on each headstock, to which the girders must fit, were surveyed using grid distances then the distance between them would not be the same as the relevant distances on the girders. Where the grid scale factor is significant, as is possible with MGA, then this difference could cause significant non-conformance resulting in significant rework and cost.

It was decided for consistency to apply a scale factor of one (1) to all bridge survey controls, even though some bridges are constructed completely in-situ and other sites may have a grid scale factor approximating one (1), thereby causing negligible effect.

The specification requires the surveyor to record all calculations used to position formwork for concrete cast in-situ. This is to ensure that the allowances calculated by designers, for such factors as settlement of the formwork, post-stressing and concrete creep, have been correctly applied. This is to assist engineering in the event of the concrete not settling as predicted by designers.

3. COMPANION DOCUMENT NG71 - GUIDE TO ICSM QA SPECIFICATION G71

The companion document, NG71, is presented in two parts: Part 1 contains a guide to developing procedures for compliance with the G71 as well as sample procedures; and Part 2 takes the form of G71, greyed out, with the addition of commentary notes in italics where ever an explanation of the specification is felt appropriate.

The advantage of a guide is that it does not carry the same contractual weight as a specification. This allows more informal language to be used than is possible in a specification where any ambiguity raises the possibility of contractual conflict.

The guide to developing procedures in Part 1 deals with the scope of survey, procedures for each surveying activity, capability of procedure to meet the required accuracy, survey checks and preparation of different procedures for setting out a product and the conformance surveys. International standard ISO 9001 provides the basis for the guidance in this section.

3.1 Sample procedures

Procedures for the three standards of accuracy for the survey control network are taken from ISCM's document SP(1) and the NSW Surveyor General's Directions. The General Construction Activities Control complies with Class C and the Earthworks Control complies with Class E of SP(1). Procedures for the Specialised Construction Activities control were originally based on Class B of SP(1) but were refined after consultation of Geosciences Australia to tighten the absolute errors of control marks. Geosciences Australia also provided the criteria for statistical testing of observations to verify that the local uncertainty is less than 4 mm.

GNSS procedures for the survey control network were derived from the Surveyor General's Directions (NSW) and from procedures developed by the RTA control survey group.

Procedures for survey techniques for horizontal and vertical coordinates were based on SP(1) and research by the RTA, with radiation procedures providing horizontal coordinates and height determination procedures for vertical coordinates. These procedures cover the Orders of Accuracy listed in Tables 2 and 3 above. EDM tacheometry surveys are radiation and height determination surveys carried out simultaneously, such as quantity surveys. Procedures for these must satisfy the Orders of Accuracy for both horizontal and vertical coordinates.

4. ACCEPTANCE OF THE SPECIFICATION BY ICSM

The RTA released specification G71 for road/bridge construction contract in NSW in February 2005. Feedback from site surveillance and the construction industry lead to the first revision of the specification in March 2006.

TASAMM (Transport Authority Surveying and Mapping Managers) is a group which comprises the "Chief Surveyors" of State Government roads authorities in Western Australia, South Australia, Victoria, Queensland and New South Wales. It also has occasional representation from New Zealand and Tasmania. About the time of release of G71, ICSM and TASAMM were developing a relationship to develop consistency of surveying standards.

In this context, the RTA Manager Surveying tabled G71 and the Guide NG71, for consideration as a national standard in surveying for road and bridge construction. This was accepted and TASAMM requested that ICSM liaise with AUSTROADS to develop a process for the adoption of a national standard.

AUSTROADS is the association of Australian and New Zealand road transport and traffic authorities. Its members are the six Australian state and two territory road transport and traffic authorities, the Department for Infrastructure, Transport, Regional Development and Local Government, the Australian Local Government Association (ALGA), and the New Zealand Transport Agency (NZTA). The AUSTROADS website lists amongst its purposes:

- undertaking nationally strategic research on behalf of Australasian road agencies and communicating outcomes;
- promoting improved practice by Australasian road agencies;
- facilitating collaboration between road agencies to avoid duplication;
- promoting harmonisation, consistency and uniformity in road and related operations.

In order to achieve consistency with other national standards, in late 2007 RTA surveyors liaised with Geosciences Australia, who prepared and are responsible for SP(1). The meeting looked mainly at orders of accuracy and acceptance criteria to ensure alignment with SP(1). One of the changes from this meeting was the adoption of the expression of accuracy as a local uncertainty instead of one standard deviation, as shown in the 2005 version of G71.

RTA senior contracts management agreed to G71 and NG71 becoming national standards and saw no need to have RTA versions of the specification different to the national versions. Future RTA contracts will reference the ICSM documents, which hence forth will be known as *ICSM QA Specification G71 – Road Construction Surveys* and *ICSM Guide NG71 – Guide to ICSM QA Specification - G71 Road Construction Surveys*. , .

However, the original issue of G71 requires compliance with NSW legislation, such as bodies responsible for registering or licensing surveyors. Therefore, all references to NSW legislation have been removed from the national version of G71. In their place, the specification directs its users to insert, in a series of annexures, the name(s) of the governing body(ies) or legislation(s) relevant to jurisdiction where the contract is being undertaken. NSW users will re-insert the original NSW legislative requirements; Queensland users insert Queensland legislations, etc.

The NSW version also contained a series of tables for bridge surveys aligning Orders of Accuracies with spatial tolerances contained in RTA bridge specifications. This has now been moved to an annexure. However, AUSTROADS have carried out work to develop national standards and guidelines for bridge construction, which has lead to some consistency in bridge specifications between states. Therefore, other states may use the G71 bridge surveying tables contained in the annexures, if appropriate.

5 CONCLUSION

The development of Specification G71 began with a meeting between the RTA's Surveying Section and the Contracts Quality Branch in December 2000 and ended with the release of the Specification and Guide in February 2005. This further strengthened the RTA's project delivery procedures and provided greater emphasis to the importance of survey in road and bridge construction. The specification provides more clearly defined survey requirements to reduce site conflict and more consistent survey quality, which in turn will lead to improved product quality.

The Inter-governmental Committee Surveying and Mapping, in its role as the national body of surveying and mapping to ensure consistency of standards, has adopted the RTA documents to provide surveying standards that reflect current best practice. It is felt that the focus of the surveying standards expressed in ICSM G71 and ICSM NG71 reflect the ICSM focus on quality and this will enhance the surveyor's role and status nationally in road and bridge construction.

ICSM Documents

REFERENCES

Ollis, JE, 1997, *Statistical Tolerances for Concrete Road Pavement Surfaces*, Hons Masters thesis in Total Quality Management, University of Wollongong.

BIOGRAPHICAL NOTES

Retired as Manager Survey Technology and Practice, Surveying Section of RTA in May 2008 after 37 years with the Authority. Graduated with Bachelor of Surveying from the University of NSW in May 1973 and Registered by the Board of Surveyors of NSW in April 1974. Member of the Institution of Surveyors NSW and Main Road Surveyors Association.

In 1993 undertook a Post Graduate Diploma in Total Quality Management at the University of Wollongong which lead to publication of the thesis *Statistical Tolerances for Concrete Road Pavement Surfaces* in 1997 to complete an Honours Masters in Total Quality Management. The RTA recognised the thesis by awarding it the Scholastic Achieved Award for 1996/97 (plus $1000 prize money). The Institution of Surveyors recognised the work with an Excellence in Surveying award in 1998 (Specification G71 received the same award in 2006). Along with my the two supervisors of the thesis (Dr David Griffiths and Dr Chandra Gulati) published a peered reviewed article, *Statistical Control for Road Pavements*, for the June 2003 edition of the professional journal, Australian and New Zealand Journal of Statistics. Also presented the peer reviewed paper, *Scientific Approach to Acceptance Sampling of Concrete Pavement Surfaces*, based on the thesis, at the 1998 Australian Road Research & Transportation Board Conference in Sydney. Published and presented joint paper (*Monitoring Pavement Construction Processes*) with DR Ross Sparks (CSIRO) at the 2001 Advances in Statistics, Combinatirics and Related Areas conference at the University of Wollongong.

In April 2000 appointed to the position of Quality and Statistical Control Officer of Survey Section of RTA, from the previous position of Registered Surveyor Class 3. In this position I was responsible for developing, implementing and maintaining the Survey Section's quality system for Certification by SAI Global to ISO 9001. This included developing and writing surveying procedures and auditing RTA surveyors as well as contract surveyors carrying RTA work.

In addition to RTA specification G71, was also heavily involved with the implementation of survey specification G71, *Detail Surveys in CADD Format*, in June 2001, also, responsible for its major review in August 2005. Oversaw procedures for improving partnerships/relationships with private sector surveyors for the delivery of detail/investigation surveys during 2005 to 2007.

CONTACTS

Mr Jim Ollis
Roads and Traffic Authority (NSW) (retired)
41 Kathleen Crescent
Woonona, 2517
Australia
Home phone 42 833951 mobile 0432 564 701
Email: jrlmollis@1earth.net