A Historical Review of Measurement and Marking Techniques for Cadastral Surveying in New South Wales

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Abstract

A historical review is made of the measurement and marking of cadastral surveys in New South Wales. The development of linear and angular measurement techniques has been considered in the following time periods: 1788-1873; 1873-1970; and 1970-present. The review concentrates on historical techniques and not recent practices.

Introduction

An investigation of the development of techniques in cadastral surveying, such as equipment used, marking practices and accuracies achieved, has a number of benefits. Firstly, it gives an appreciation of the accuracy of early surveys and the consequent survey descriptions. This helps appreciate differences in comparisons between early dimensions of boundaries and measurements made today using current technology. Secondly, an understanding of accuracy leads to a better insight into the weight that should be placed on early occupations.

As has been mentioned in a previous article (Williamson, 1984), there has been no major change in survey practice in New South Wales for over 100 years. The "isolated" survey system has, however, developed significant problems over this period. Due to early survey techniques, such as barometric levelling and errors in chaining, which were more common in the past, surveys have a greater chance of being inaccurate due to these factors. Without introducing a coordinated system, the only way open to the State to help overcome these problems was to increase the relative accuracy of individual parcel surveys and then improve the system of referencing and marking surveys, together with improved administrative controls and checking of cadastral surveys. This "isolated" survey system has spanned the whole history of cadastral surveying in New South Wales.

In reviewing the development of techniques in cadastral surveying, three eras are considered: 1788-1873; 1873-1970; and 1970-present. The three periods relate to the equipment used during each period and, in turn, had a direct effect on the standard of surveys of that time. During the first period, the Gunter's chain was generally used for linear measurements and the co-ordinate or compass was used for angular measurements. The second period saw the introduction of the steel ribbon, or long wire, for linear measurements and the theodolite for angular measurements. During the first period, most boundaries were surveyed on the cardinal directions, which made calculation of areas simple. The second period saw a refinement of calculations and the introduction of inverse and logarithmic tables, together with mechanical calculators towards the latter part of the period. The third period saw the introduction of short range electronic distance measurement (EDM) and of small hand-held calculators and computers. In summary, the accuracy of linear measurements in the first half of the 19th century was approximately 1:100 to 1:200 (Audeley, 1866, p. 70). Today, all individual measurements with EDM equipment usually have a potential accuracy better than 1:50,000 (after allowing for a small constant error), with most cadastral EDM traverses closing better than 1:120,000. Therefore, the potential accuracy of the equipment used for survey measurements in a little more than one hundred years has increased by over one hundred times. For further information on early surveys, reference should be made to Hallmann (1975), pages 3-6. Also, for an interesting review relating to early survey practice in Tasmania, refer to Lewis and Lee (1980).

Linear Measurement

Linear measurement between 1788-1873 was almost solely carried out by the Gunter's chain, although, in the early part of the period, other less accurate methods were used. For example, Oakes (1875) claims that Mr. Hanlan was still using a parrandolator or measuring wheel as late as 1840. Darby (1881) claims that they were used as late as 1840. Usually, distances measured with such equipment were rounded off to the nearest chain. If distances were measured with a Gunter's chain, the distance would usually be rounded off to one link. Bayliss (1956) quotes an extract from a letter to a rural surveyor, "... the first Chief Clerk... under no obligation to measure too little in the country in particular, and advised me in rough country to allow 1 chain to a mile, and half a link to a church in all town allotments to allow a fence between two points". Bayliss (1956) claims that, when District Surveyor and later Surveyor General mentions in a report the need to re-survey many large grants due to old surveying being "out of alignment" and the usual practice of adding an extra link to the chain, "As mentioned previously, the accuracy of measuring distances during this period was 1:100 to 1:200, with areas calculated to one or two percent. Truscott (1895), in referring to the practice between 1830-1850, claims that, on level ground, chaining gave an excess and, in hilly country, often a deficiency.

The first known recorded regulations for measurement are found in the 1848 Regulations for Licensed Surveyors (Legislative Assembly of N.S.W., 1848, p. 158), which were as follows: "The survey and measurement, which are to be performed in the usual manner by taking angles with a theodolite, bearings with a circumferentor, and measurement of the lengths of the several boundary lines with a Gunter's chain, verified by comparison with the standard measure". It appears that this latter requirement was introduced as early as 1840 into South Australia, where "every Surveyor should be provided with a standard measure, by which to lay down at each station marks, for the daily comparison of his working chains, the errors of which must be noted in the Field Book, and allowed for" (Prime, 1840, p. 6). It appears unlikely that the practice was enthusiastically carried out in N.S.W.

The use of the steel ribbon for linear measurement was first utilised by Mr. F. B. W. Woolrych in 1872 and was in general use by the Survey Department by 1873 (Adams, 1886); however, in the 1872 Instructions to Surveyors, the Gunter's chain was still the standard for linear measurement (Darby, 1981). The 1884 Surveyors' Instructions first introduced the riband and also set the first regulations for linear accuracy, i.e., for two links per mile for level country (1:4000), reducing to four links per mile for mountainous country (1:2000). The Gunter's chain was still used in 1886, for the "Surveyors' Pocket Book" by Adams, published in that year, still describes the use of the chain, even though steel tape was the recommended instrument of measure.
ment. Interestingly, regarding the use of the Gunter’s chain, Adams recommends: “That in subdivision of land it is desirable that the working chain should be from 1/4 to 3/8 of an inch longer than standard, as some compensation for loss which must accrue through inequalities of surface and minor obstacles”.

The Regulations for licensed surveyors in 1914 introduced the present standard accuracy of 1:8000 (one link per mile). Weingart (1913, p. 72) comments on the methods used in the latter part of the 19th century: “Our fathers probably did the best they could with the implements they had, and it is apparent that even the Government Departments took small notice of the Standard of Measurement lying at the Treasury. The surveys of the old grants show this”. The present standards for survey were introduced in the Survey Practice Regulations, 1933. These regulations introduced a limit on traverse closures for both distances and angles. As before, the most stringent requirement for traverse closure in level country is a tolerance of 1:8000. The probable error for linear measurement is 1:12,000 in level country.

Angular Measurement

As stated in the 1848 instructions, bearings were to be measured with the circumferencer (i.e., magnetic bearings) and angles with a theodolite. It appears that, up to about 1870, circumferencers were used almost exclusively for grant surveys. Usually, if a plan shows bearings to less than 10 minutes of arc, then a theodolite was used (Darby, 1981). Mitchell, in evidence to the 1855 Royal Commission (Legislative Council of N.S.W., 1856) claimed, however, that some government theodolites could read to three minutes of arc. He claimed that, prior to 1855, circumferencers were universally used where suitable for some river traverses. Audley (1866, p. 70) praised the circumferencer, claiming the theodolite was too slow. He claimed magnetic bearings were observed to 1 or ½ degree. Truscott (1895) commented on the use of the compass in 1830-1850: “My experience goes to show that each surveyor’s compass gave a different magnetic north; and not only so, but lines run by the same surveyor, in the same locality, and often in the identical portion, do not agree”. The Regulations for the Guidance of Licensed Surveyors, 1864, state that there was a standard needle in the Survey Department to which all circumferencers should be adjusted. These regulations also required that “a note should be inserted on each plan, stating whether the theodolite or circumferencer, or both, have been used in the survey”.

In the 1872 Instructions for Surveyors (Darby, 1981), the use of the circumferencer was prohibited. From this time onwards, all angular measurements should have been carried out by theodolite. As mentioned, the present regulations for angular misclosures were introduced in the Survey Practice Regulations, 1933. They state that the angular misclosure of a traverse shall not exceed 30 seconds plus .6/n seconds where “n” is the number of traverse angular stations.

Marking of Surveys

The marking of surveys prior to 1873 was not dissimilar to today, although the system was not as sophisticated. All original Crown land was marked with a “blazed” corner, with corner trees being “blazed” on four sides. This practice had been adopted as early as 1811, since Hallman (1973, p. 30) claims to have sighted the statement: “A leaning apple tree marked four sides” in Meehan’s field book of that year. Bayliss (1956) states this was the practice in 1830 but corner trees were not numbered. Truscott (1894) claims this was the practice from 1830 to 1850, although he claims that many of the surveys of the period were “seldom measured and rarely marked”. Where marking was carried out, he claims the blazed bore little resemblance to today’s practice. Mitchell, in evidence to the 1855 Royal Commission, also confirms the practice. The 1848 Regulations for Licensed Surveyors state that: “In extensive and continuous chaining, conspicuous marks on the trees are to be made of sufficient height to render them distinguishable from a distance”. The present method of “blazing” lines was first formally regulated in the 1853 Instructions for marking Crown Land by Government surveyors (Legislative Assembly of N.S.W., 1859, p. 158). The 1853 directions for Government surveyors refined these instructions still further (Legislative Assembly of N.S.W., 1858, p. 651).

Corners were marked with green stakes certainly as early as 1830 (Bayliss, 1956; Truscott, 1894). Prior to 1850, rock marks were occasionally used, but no standard was adopted. The 1848 regulations stated that corners were to be marked with stakes or in rock with broad arrows, crosses, triangles or square. In 1852, an act was passed directing that the official mark for surveys conducted for the Government was the broad arrow (Assembled to 19th August, 1852). The 1853 instructions required stakes to be 18 inches long and to be driven 12 inches into the ground.

The 1859 and the 1864 regulations required stakes to be 2 feet 6 inches long, driven 18 inches into the ground. The 1864 regulations introduced lockspike similar to the type we know today, a form of lockspire which was subsequently modified in 1858. The 1864 regulations also required that “rocks which lie across upon a boundary line are, wherever the character of the rock will admit of it, to be marked with a pick line; and where at a corner of a portion, with a broad arrow”.

The first specific reference to “marking out towns””, as distinct from the marking of farms or surveys in rural areas, is in the 1853 instructions to Government surveyors. Basically, all corners in towns had to be marked with a stake and lockspire. The 1858 directions, “to be observed in marking Building and Suburban Allotments within Town Boundaries”, were a considerable refinement of the 1853 instructions. They included more specific directions for the clearing of boundaries, marking trees on a boundary line or on a corner, lockspitting, the “branding” of corner “stakes” and the placing of “two strong posts, not less than 6 inches square and 6 feet in height . . . set 2 feet in the ground, in the brick line (12 feet from the building line) of the principal street of the Town”, such posts being intended “to form a basis with which future surveys in the Town may be connected” (Legislative Assembly of N.S.W., 1858, p. 653). The 1864 regulations, mentioned previously, continued the practice of describing the marking of boundaries in towns and rural areas separately, although the regulations were marginally different.

The first requirement for referencing corners came about in 1836 (Beaver, 1980; also see Richards, 1925). The reference at this time was from the corner to the reference tree. The reference tree was most probably blazed on four sides. The 1853 instructions required a broad arrow and numbers of the portion to be chiselled into the base and facing the corner. This regulation retained the reference from the corner to the tree. The 1864 instructions refined the above directions — of particular interest, references now had to be from the reference tree to the corner.

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Evidence to the 1835 Royal Commission includes a statement by a surveyor named Shone that, in general, survey marks of that era disappeared after 15-20 years. A private surveyor, Browning, also gave evidence. He was very critical of the methods of government surveyors, particularly the use of a circumferometer — he claimed he always used a theodolite.

The “blazing” of boundaries remains to this day in the present directions for the survey of Crown lands — it does not apply to surveys of freehold or alienated land. The marking of surveys has been refined since the 1864 instructions, but only as much as a greater number of survey marks are placed and more permanent marks are used. For a detailed discussion of such marks, refer to Beaver (1980). Also see Williamson (1982).

Two other systems of marking have had a very significant effect on boundary definition this century — both concern the marking of road alignments. The first relates to the power of the Surveyor General or Municipal Councils under various Acts to fix the alignment of streets or other public places within the State. Such alignment surveys have now been carried out for most public roads in the State. The alignment of each road has been marked using a variety of survey marks, such as steel pins, stones and wooden posts. All alignments are marked at the kerb line. Alignment surveys generally only apply to roads dedicated prior to 1920 (also see Hallmann, 1973, p. 102).

The second system came about with the introduction of Ordinance 32 under the Local Government Act, 1919, in 1920. Under this ordinance, permanent marks are required to be placed in any public road opened under the Local Government Act. Over the years, the location of these permanent marks has changed but the basis of the system has remained the same.

Hallmann (1973, p. 32) summarises the value of these two forms of marking: “The transitory boundary markings generally as compared with the markings of road surveys has gradually convinced surveyors and survey investigators that the latter present a more reliable and practical means by which boundaries may be controlled for retracement purposes”. Hallmann further states (p 33): “...the basis of the reference marking system for land boundaries in New South Wales is to establish in each fresh survey a set or sets of intervisible survey marks and other acceptable monuments in roads and streets to serve as terminal points of azimuth lines for future retracement surveys”.

In summary, it can be stated that a major weakness of the N.S.W. cadastral system is the poor monumentation. A large number of all survey marks disappear within several years of placement. The most common survey mark is the wooden peg, which is used to mark boundaries. This mark is easily removed, or disturbed, particularly by fencing, and is often destroyed by fire: quite often, the peg simply rots away. A large number of alignment marks have been destroyed over the years by road works. The placing or maintenance of services in the footpath reserve has caused a considerable percentage of reference and permanent marks to disappear. In rural areas, corner trees usually have only a limited life span due to fire, clearing or their value as timber. Certainly, the best marks in the N.S.W. system are rock marks, which appear to have an unlimited life span and are very difficult to destroy. Fletcher (1969) summarises the position: “Much money, time and effort expended in making surveys have been lost because the monumentation or marking of such surveys has been destroyed. From the author’s experience, it is considered that the majority of all original marks placed in N.S.W. have disappeared.

HISTORICAL REVIEW OF MEASUREMENT & MARKING TECHNIQUES

As mentioned, the third era, 1970—present, saw the introduction of short-range EDM equipment and portable hand-held calculators and computers to cadastral surveying. The EDM equipment has made it possible to measure a distance to an accuracy of ±50,000 or better under most conditions, at the press of a button. The major advantage of this new technology has been an improvement in the efficiency of carrying out cadastral surveys, particularly regarding measurement and marking techniques in large surveys. This equipment, however, together with modern computing techniques, has made it possible and easy to introduce new and improved survey methods into the cadastral system. Unfortunately, the present survey regulations are not designed for such methods and the profession is restricted in not being able to take full advantage of this new technology. This is not an argument for increased accuracy within the “isolated” survey system — such moves are not, and most probably will never be, compatible with the existing legal framework. The present survey system can only be improved by applying the technology to the cadastral system as a whole.

Conclusion

The standard of cadastral surveying instrumentation and techniques in N.S.W. is comparable to anywhere in the world. Since the turn of the century, and particularly since the introduction of the Survey Practice Regulations, 1933, standardised steel bands have been used, with temperature and sag corrections being applied in most cases to ensure accuracy standards. In the last decade, short-range EDM equipment has been the order of the day, with many surveyors even using “total stations” for cadastral surveys. Unfortunately, the use of these accurate systems has not increased the overall efficiency of the cadastral system to any large extent. They do, however, reduce the chance of errors in surveys and improve the efficiency of making measurements.

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