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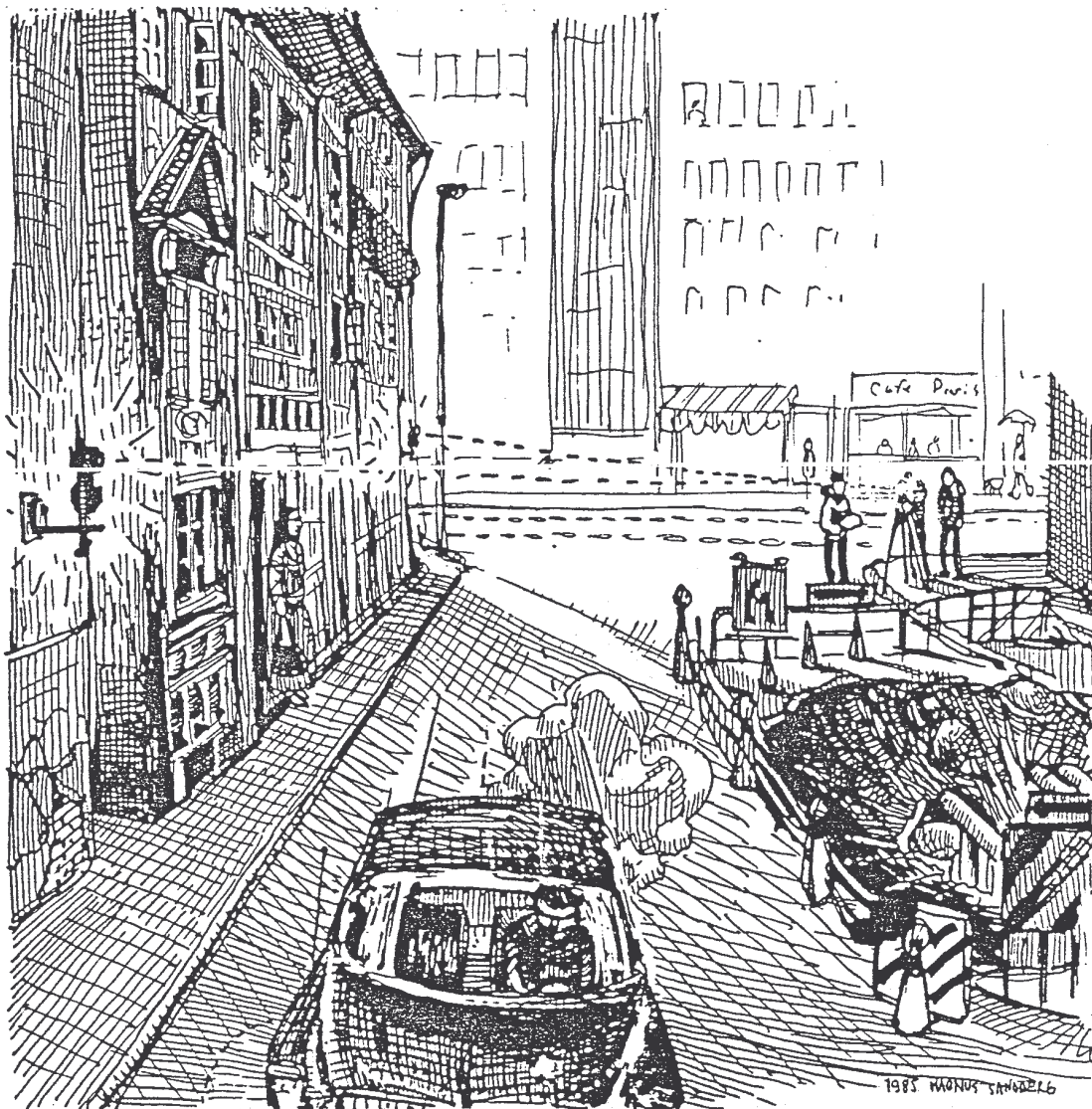
Tekniska skrifter - Professional Papers

LMV-RAPPORT 1986:2

ISSN 0280-5731

SWEDISH EXPERIENCE OF WALL-MOUNTED TARGETS

by Clas-Göran Persson



Gävle 1986

Förteckning över utgivna rapporter 1986

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Lantmäteriet
Samhällsmättnings-
funktionen vid LMV

RAPPORT

Datum

1986-01-01

Rapport nr

1986:2

Dnr

Kg Mätningsteknik

Titel

Swedish Experience of Wall-Mounted Targets.

Huvudinnehåll

I rapporten sammanfattas de erfarenheter som i dag finns i Sverige av s k "väggmarkerade stomnät" eller "väggpunktsnät".

Clas-Göran Persson

KG - Geodetiska Ut-
vecklingsenheten

Utarbetande av tekniska rapporter ingår som ett led i den s k Samhällsmättningsfunktionens verksamhet. Tillkomsten av denna funktion är ett uttryck för en ökad satsning på samhällsmätning vid LMV. Den utgörs av de enheter som har sitt verksamhetsfält inom detta område, och har som sin huvudsakliga uppgift att samordna och befrämja metodutveckling samt informera om metoder och instrument.

LDOK

Kg Mätningsteknik Stommätning

Beställs hos



Lantmäteriverket
Blankettförrådet
801 12 GÄVLE



Liber Förlag



Swedish experience of wall-mounted targets

by Dr Clas-Göran Persson, National Land
Survey, Gävle, Sweden.

Invited paper to be presented at:
XVIII International Congress of Surveyors
June 1-11, 1986, Toronto, Canada.

SUMMARY

This article constitutes a subreport from a project, the long-term goal of which is to devise suitable methods for planning, surveying, adjustment and utilization of control networks with wall monumentation.

The experience gained hitherto in different places in Sweden, and to some extent also earlier experience from other countries, is presented and analysed - in an attempt to present a description of the state-of-the-art in this field.

BACKGROUND

Today, greater interest in questions concerning control networks is clearly discernible. It is evident that now, after the building rush of the 1970s, time has once again become available for control surveys.

In all probability, the control networks have also started to deteriorate in consequence of poor maintenance during the time when the main occupation was setting out and check measurement and therefore they require maintenance.

In conjunction with these overhauls, a greater awareness has materialized in many places of the benefits of wall markers - benefits such as:

- * They allow use of modern surveying technique, applying the so-called free station point method (free positioning) in detailing and setting out. This is particularly important when detailing in conjunction with utility line running.
- * The survey can then always be carried out from the most appropriate station point - out of the way of the traffic and with no obstacles to obstruct the view.
- * There is no risk of survey points being dug away - this loss is otherwise one of the greatest problems encountered in conventional ground monumentation. Moreover, the wall markers are cheaper and simpler to mark.
- * They are also easier to find, particularly during the winter months, which prolongs the surveying season in northern Sweden.

The advantages are particularly beneficial in areas where some kind of action is being carried out, for example in exploitation and clearance areas, i.e. where the control points are utilized most diligently.

In this article, a summary is presented of the experience gained hitherto in Sweden with regard to wall markers and control networks with wall monumentation. To some extent, previously reported foreign experience has also been included, to enable the state-of-the-art in this field to be described as comprehensively as possible. The presentation is supplemented with results from simulation studies of network adjustment and positioning of free station points.

The experience gained in Sweden has been described by Bengt Hellman (Sandviken), Bertil Källström (Uppsala), Jan Virking (Västerås) and Torsten Oldenmark (the Land Survey Administration in Västerbotten).

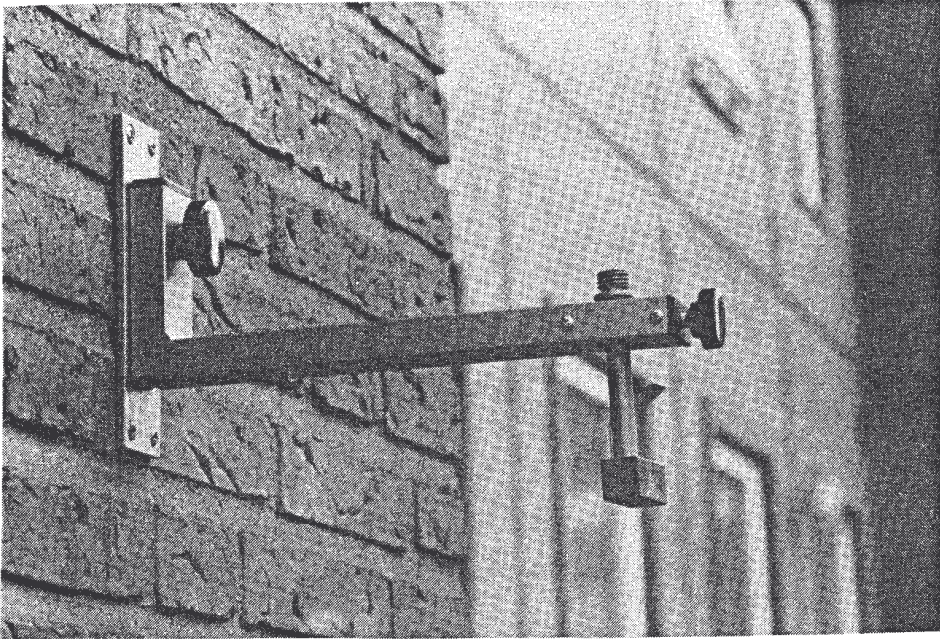


Fig. 1: Wall plate with marker bracket of the Geostandard make.
(Photo: Jan Virking)

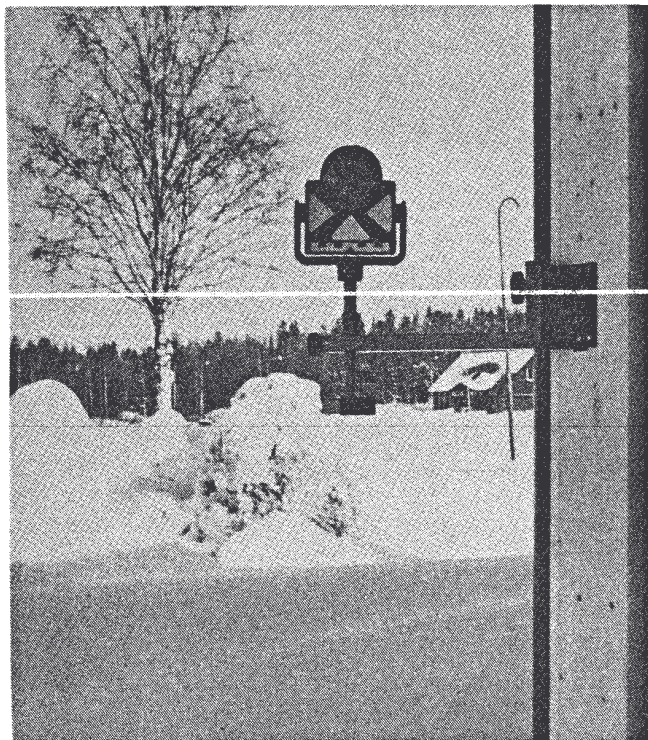


Fig. 2: Monumentation in house corner - corner plate, marker
bracket and prism. (Photo: Torsten Oldenmark)

NETWORK DESIGN

Networks with wall monumentation have been established both in city centres and in sparsely built-up areas. As a rule, both wall markers and ground markers are included - the latter permanently or temporarily marked. In principle, three different types of network can be distinguished:

- 1) Networks with wall markers "flocked" around conventional traverse stations.
- 2) Networks with ground control points in the street intersections and wall markers set out one by one in the middle of the sides of the block.
- 3) Networks with ground markers in street intersections and wall markers in the corners of the block.

The first type requires a fairly large number of markings and moreover one has actually "stopped half-way" so to speak, because the philosophy of traversing has not been entirely relinquished.

Marking in the middle of the sides of the block gives fewer wall control points than type 1, but nevertheless roughly twice as many as in type 3 (i.e. marking in the corners of the block). The measuring-in geometry is usually favourable.

Type 3 requires the smallest number of markers but naturally also gives the sparsest network. This, however, is not so critical with the current range of EDM instruments. As a rule, the measuring-in geometry is good - almost perpendicular measurements. Occasionally, however, it is not possible or inappropriate to mark in the corners. House bevels, entrances, shop windows etc. may make it difficult both to drill holes in the wall and to see the point from several directions.

Types 2 and 3 are also to some extent conservative in the sense that they still include ground markers - even though they, as a rule, are only provided for purposes of measuring in. A network entirely without conventional markers could be built up in the following manner:

- * Monument in the corners of the block.
- * Measure-in from "free" station points in the street intersections - both the markers in the intersection concerned and those in adjacent intersections (see Fig. 3).
- * Tie to the higher-order network in the customary manner.
- * Adjust the network simultaneously (using a rigorous method).

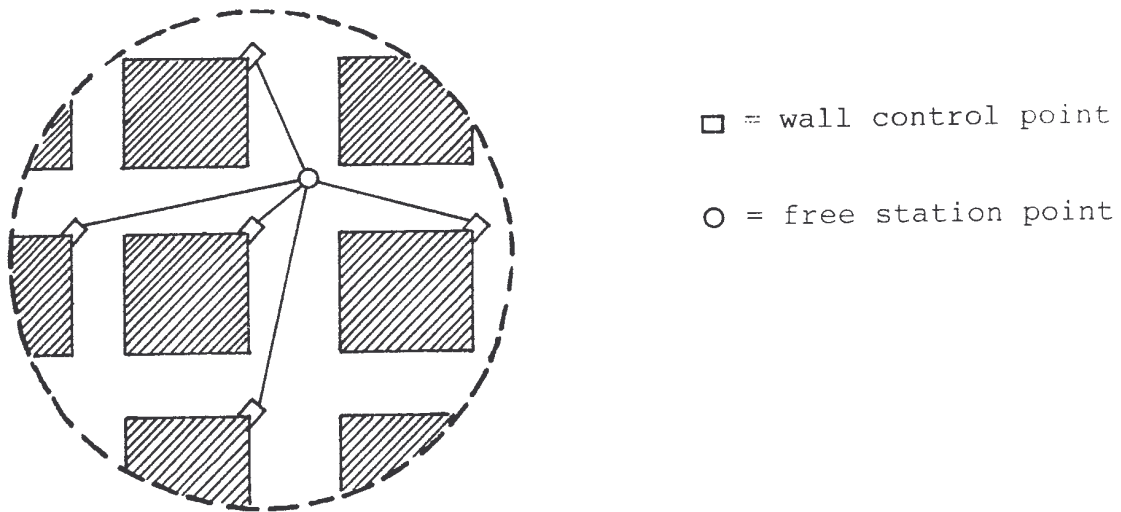


Fig. 3: Measuring-in of wall markers from an unmarked "free station"

This method would be a rapid and efficient way in which to design a wall marker network, particularly in combination with motorized surveying. Moreover, the quality will be high. True enough, no measurements are made between the ground stations, but in recompense the wall markers are measured in from far more stations than in the network types above. Note that marking in the middle of the sides of the block are more difficult to deal with in this manner.

The most practicable method of designing a network, however, is to permit the envisaged utilization and not the surveying technique or a routine method control the setting out of the markers. In all probability, a combination of conventional ground markers and wall markers - in the corners of the block, in the middle of the sides of the block and inside the block - is best. The proportion of markers of each type may also vary with the character of the area and also with time. In a development area, for example, it may be appropriate to commence with conventional markers and to switch successively to only wall markers as the use become obstructed owing to the construction work.

"Modern" control surveying also implies that consideration must be given to the exigency of all densification. Control nets are quite decidedly not ends in themselves and the setting out of control points without justification is indefensible. In areas where it is known that in all probability nothing will happen within a foreseeable time, a very sparse network is therefore established - just as much as is needed in order for densification to be possible if a need should nevertheless arise, and in order for the network to hang together over a larger area.

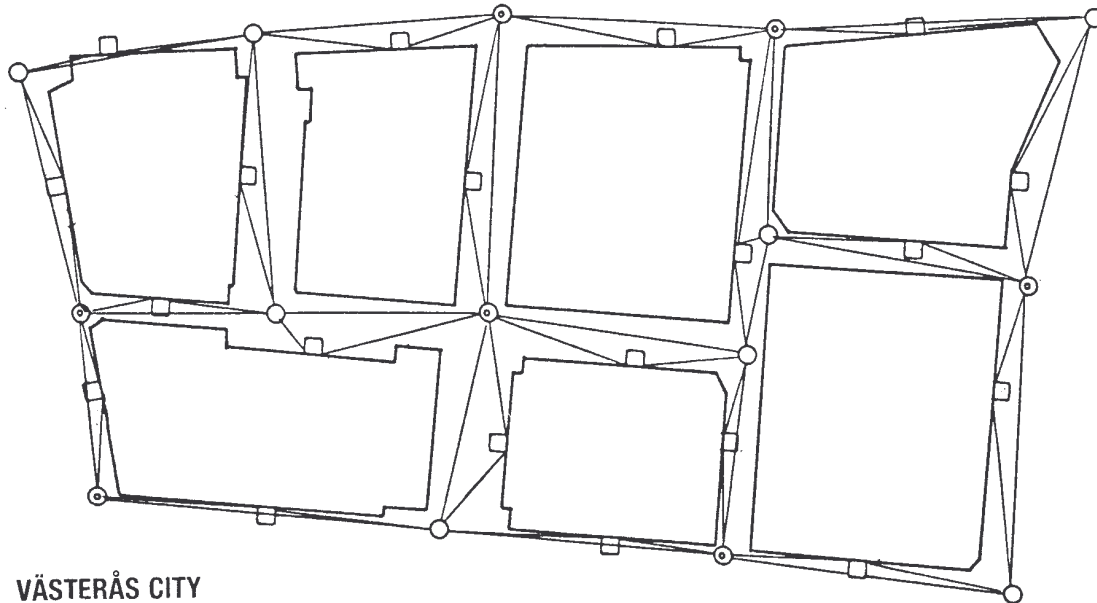


Fig. 4: Low-order control network with wall monumentation.
The City of Västerås (city centre)

What has been said hitherto concerns the establishment of new control networks. The demands imposed when working in areas with existing networks are to some extent different. In particular proper action must be taken during planning to ensure that the measurement suffice both for determination of new monuments (wall markers) and for checking the older monumentation. This also applies to the higher-order points in new construction.

The wall markers should be distinguished from other control points via the point numbering system, since they require special equipment and to some extent a different method when being used - which should be directly evident. Topographical descriptions (in the form of sketches) should be drawn: this is extremely simple in this case and can, in principle, be done in the office.

MONUMENTATION

The wall points have been set up throughout roughly two metres above ground excepting Västerbotten, where the demand for being

able to use conventional levelling has made it necessary to bring them down to roughly chest height.

The actual marker consists of a wall plate which is secured to the wall of the house. When the surveying work is being carried out, a bracket and target prism are placed on it. The detailed elaboration nevertheless varies. Today, wall plates are available for both monumentation in house corners and on house façades in the middle of block sides, but in all probability the last word about monumentation has not yet been said.

Points to be borne in mind when choosing type of monumentation:

- * Simple to monument.
- * Causes a minimum of damage.
- * Of good quality - but nevertheless cheap.
- * Easy to use/target; different types of signal must be installable.
- * Suitable target point for EDM instruments and theodolites.
- * Protected from damage - both contrast damage and damage caused by the weather and wind.

As a rule, monumentation has been done in houses with a façade of brick, stone or concrete, but in Västerbotten wall markers have also been set up on wooden houses. Needless to say, the permission of the property owner must be obtained before monumentation is performed.

If the temporary ground control points are also marked in one way or another, not only are they available for a while for utilization but they can also be used in error detection in conjunction with the adjustment of the network.

MEASURING IN

The wall control points are measured in using the polar method, i.e. with the aid of direction and length from the ground markers. The coordinated point is, as a rule, located on the removable bracket and not on the wall plate. This makes it essential for all users to use the same type of bracket.

All control points should be over-determined by measurements from several stations. The simulation studies show that measurements from two ground stations suffices. This is only true, however, for establishment of new networks. In areas with old ground control points, more measurements may be needed to check existing points.

Measuring in is appropriately carried out with a precision theodolite (two sets and rotation of the horizontal circle between the sets) and an EDM instrument or, alternatively, with an electronic tacheometer.

Whether, and if so how, height determination of the wall points shall be carried out is a question to which no univocal answer can be given. Height determination by means of trigonometric levelling is nevertheless a method with great appeal. Unfortunately, this method has acquired a rather poor reputation. Properly applied, however, it gives excellent results and when using an electronic tachometer the heights are actually obtained more or less automatically. Moreover, accurate calculation of horizontal control networks necessitates correction of measured distances for the elevation above the reference ellipsoid, and the height information is then essential.

NETWORK ADJUSTMENT

In principle, there are two methods of adjustment:

- * Simultaneous adjustment; calculation of both wall points and temporary or permanent ground points in one step - as a miniature triangulation network.
- * Adjustment in two steps; the ground points are first determined in a separate adjustment, whereupon the coordinates of the wall points are calculated one by one using the polar method and simple averaging.

Both these procedures have their pros and cons. Simultaneous adjustment is optimal from the theoretical point of view, but the result is somewhat difficult to check for anyone unaccustomed to this kind of computation. Moreover, it is easy to include extra measurements and check measurements in the adjustment. For adjustment in two steps, exactly the opposite applies: it is easy to check but is not optimal and offers fewer opportunities to deal with extra measurements.

The simulation studies nevertheless indicate that from the standpoint of accuracy there is no greater difference between the methods. Simultaneous adjustment is only marginally better. In this context, therefore, it does not really matter which method is used and the choice of method should be dictated by the available software and the experience of the user. In areas with existing networks, however, the usual technique is to determine one wall point at a time from the older points, which in principle is an adjustment in two steps, the first of which has been completed far earlier on.

With the computer programs available today, it is usually necessary for determination of the horizontal location and the height determination to be carried out separately in different adjustment programs. Moreover, the capacity does not suffice and the networks are often too large to be handled in one single adjustment. Finally, the error detection routines are not up to date - more effective routines based on statistical methods are now available.

For this reason, new programs will have to be developed to allow streamlined processing of this type of control net.

These shall be capable of coping with all types of measurements, network configurations and network sizes. Moreover, the results shall be easily checkable even by individuals lacking much experience of network adjustment.

UTILIZATION

As a rule, networks with wall monumentation have been used in compiling utility line maps and in conjunction with new development. They are also used, however, in other contexts such as in project planning work.

They can be included in a district heating project in roughly the following manner:

- * Establishment of a network with wall monumentation on the basis of existing ground points.
- * Measuring in of existing utility lines, borders etc. for establishment of projecting documentation.
- * Projecting.
- * Setting out from a free station point determined from the wall markers.
- * Trenching and laying of the utility lines: several of the ground points disappear but the wall markers nevertheless remain.
- * Measuring in of the finished utility line - using free positioning once again.
- * Compilation of utility maps, whereafter the wall markers serve as points of reference for future utility service.

The free positioning mode, then, is the universally prevailing method of utilization. The different variants available for calculating the coordinates of the free station are analysed below.

Strict adjustment, i.e. adjustment according to the method of least-squares. This method gives optimum results, since the distance and direction measurements can be weighted correctly in relation to their respective accuracies. This, moreover, makes the survey itself highly flexible: an arbitrary combination of observations can be used and the number of measurements is not limited. The results, however, are difficult to evaluate with the methods used hitherto. The least-squares residuals, the only quantity directly available for checking, sometimes give completely misleading error indications. As already mentioned, however, nowadays statistical checking methods have been developed. They are a bit complicated to understand in detail, but simple to use and to interpret. The major disadvantage of this rigorous method is that it calls for a large amount of computing capacity, particularly if the statistical tests for error detection are to be included.

Simple averaging. The station is determined as the arithmetic mean of all the resections, tying-ins, etc. that can be constructed from the surveying material. This procedure makes for simple calculations, but the results are not optimal since equal weight is given to all individual determinations despite their geometry being of different quality. There will also be many variants if the number of measurements is large. The deviations between the determinations provide an impression of the possible occurrence of gross errors (outliers), but it is by no means always so easy to decide whether large differences are actually due to errors or are simply a consequence of an unfavourable configuration. From the standpoint of error detection, however, this method may be preferable to strict adjustment without statistical checking. With statistical checking, strict adjustment is always to be preferred provided that sufficient computation capacity is available.

Coordinate transformation. Theoretically, this method can be regarded as semi-strict - somewhere in between the two methods described above. In terms of computing technique, it is uncomplicated and can be supplemented with the modern methods available for gross error detection, (which are also very simple in this context). Here, then, we have an admirable compromise: a method that requires little computing capacity, is easy to check and virtually optimal. Its only real disadvantage is that it is conditional upon both direction and length being measured towards all targets. This, however, does not really involve any limitations in conjunction with wall control points.

If a free station is to be really usable, it must be possible for the computation to be performed in the field in certain contexts. When measuring in (detailing), this is not so essential. There, the coordinates of both the station and the detail points can be calculated afterwards. In setting out, however, it is preferable for both the location of the station and the setting-out data to be calculatable on the site. This also requires provisions for storing coordinates and bringing them out in the field.

In itself, extensive calculation work in the field is fully possible today, but field computers are nevertheless expensive and many of the less sophisticated computational aids do not have the requisite capacity. Consequently, field calculations do involve certain difficulties. The presentation below is an endeavour to describe an optimal utilization of the wall targets for different available calculating equipment. In all cases, it is assumed that a computer is available at the office and that the necessary software for field computations has been developed.

Field computer (or access to a mainframe computer, e.g. via telephone contact): high computing and storage capacity. In detailed surveys, station measuring-in is computed and checked in the field, while all calculation of the detail points is done afterwards. In setting out, both the free station and the

setting-out data are calculated on the site. A strict adjustment method is used, which includes statistical tests for gross error detection.

Sophisticated pocket calculator/data logger: powerful but nevertheless of limited capacity. In principle, the same procedure as above, but in positioning of the station adjustment through transformation of coordinates is applied instead, (in combination with statistical tests) which occupy less space than a strict adjustment.

Simple pocket calculator: only small computations and no storage. In measuring in, the station is roughly checked in the field in the simplest possible manner, but all definite computation takes place subsequently. In setting out, the station is first measured in and marked temporarily. Calculation of both the coordinates of the free station and setting-out data is then carried out in the office, whereupon the surveyor will have to go out into the field again to complete his task. This latter procedure will work if the trips are short and/or if several stations can be measured in simultaneously. If the number of setting-out points is small, then obviously it is always appropriate to do the computations in the field - manually, dealing with one point at a time.

And now a final word about free positioning. Our simulation studies indicate that measurement of direction and length should take place towards three targets or more. There should be at least two overdeterminations. The method with two lengths and one angle (= 1 overdetermination) is in most cases uncontrollable on account of the poor measuring-in geometry - particularly in conjunction with measuring towards wall control points along a street.

The principle that "one measurement is no measurement" should thus be modified in connection with free stations to "one overdetermination - no overdetermination".

CONCLUSION

Control networks with wall monumentation results on the whole in lower establishment costs, more efficient utilization and simpler maintenance.

The experience gained hitherto is solely positive. Nevertheless, the method cannot be regarded as completely ready as yet. The development work must go on: on the field calculation side there is a lot more to be done and more practicable programs for network adjustment are required. Since there is a very great need of standardization, uniform guidelines are also required for establishment and use of control networks with wall monumentation.

Note: A Swedish version of this paper has been published in Svensk Lantmäteritidskrift 1985.

