Why is it that scale, accuracy and precision cause so many problems for architects and designers when we surveyors know all about it; or do we? Andy Roberts unravels these critical factors as they affect measured building surveys.

Survey Drawings – an Oxymoron?

By Andy Roberts

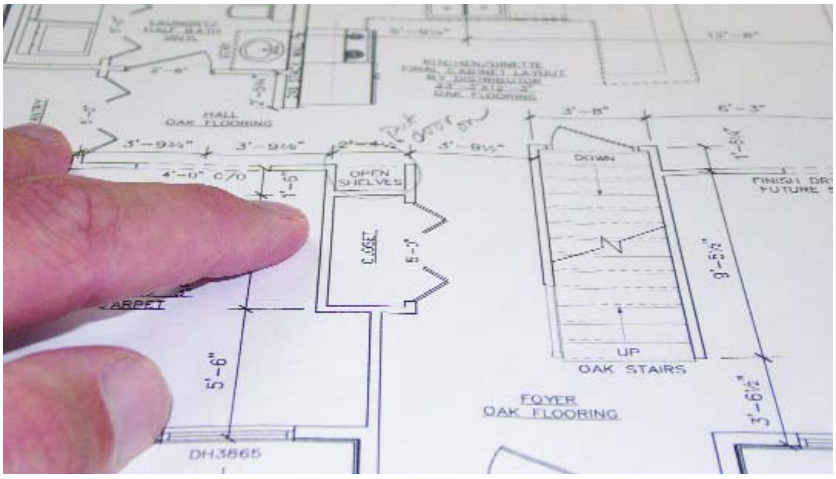
There seems to be a difference in the levels of understanding of what is meant by scale and accuracy in today's construction industry. These varying levels of understanding (or mis-understanding depending on which construction professional you are dealing with!) are playing a large role in how measured surveys of all descriptions are being specified, commissioned, undertaken and subsequently interpreted. This is a serious matter for the professionals who read this publication, because misunderstanding by the client leads to surveys being undertaken by "amateurs" who compete with us on price alone.

To some it comes as a surprise to learn that scale and accuracy go hand in hand in geomatics and it is usually measured building surveys that come under close scrutiny as opposed to the smaller scale topographical surveys. This is probably because clients feel they can "check" the larger scale surveys themselves (apparently purchasing a handheld measuring device automatically qualifies you as a surveyor these days!). It is for this reason that I'll concentrate on measured building surveys, particularly floor plans.

It may be appropriate before we go any further to define some appropriate terms:

"To some it comes as a surprise to learn that scale and accuracy go hand in hand in geomatics. . ."

- ***Scale*** is a proportion used in determining the dimensional relationship of a representation to that which it represents.
- ***Accuracy*** is the nearness of a measurement to its true value.
- ***Precision*** is the consistency of a group of measurements.
- ***Discrepancy*** is the difference between two measured values of the same quantity.



Let us deal with the issue of scale. What do we mean by scale? To us, as measurement professionals, this determines *two* issues of fundamental importance in how we tender and undertake professional measured surveys. Firstly, scale determines the level of accuracy at which we undertake survey work, and secondly the level of detail that should be surveyed – a 1:100 survey differs both in terms of accuracy and detail from a survey undertaken at 1:50. To some construction professionals the scale is determined by what can be plotted on a particular paper size.

Firstly, it is widely accepted that a floor plan is a representation of a building floor at 1.5m above the floor level. Taking measurements at 1.5m is not always easy, or even possible, due to obstructions, so measurements tend to be taken at different heights throughout the survey. Differing thicknesses of plaster, compounded with verticality issues can produce errors.

Secondly, no measurement is exact, and all measurements will contain some degree of error. The instrumentation that should be adopted when conducting a measured building survey includes total stations, handheld laser distance measurers and steel tapes. All of these instruments, including tapes, work to a tolerance, be it a very small one. In theory every measurement has an error, or tolerance. It is therefore practically impossible to survey at a scale of 1:1.

It would seem appropriate at this point to explode the myth of the 1:1 survey. There is no such thing! Whilst theoretically possible using a Mekometer (hands up all those who have one), a 1:1 survey has issues relating not only scale, but also to the practical nature of the job. These issues go some way to explaining why a 1:1 survey is unrealistic.

There are three types of errors in measurement:

Blunders – these are fundamental errors that occur in the measuring process, usually caused by human error. Blunders are mistakes which occur in the process of taking, reading, transcribing or recording survey data (recording 5.20m instead of 5.02m, for example).

Systematic Errors – these occur when something causes a constant and consistent error throughout the measuring process. Systematic errors can be compensated for once the factor producing the error (temperature or ground slope, for example) has been identified.

Random Errors – these are generally small errors

that have no apparent cause but are a consequence of the measuring process itself. They result from the fact that it is impossible to get absolutely perfect measurements each time an instrument is read, for example, because of personal limitations of sight and/or touch. They tend to be compensating by nature (i.e. they are both positive and negative) and can be dealt with by statistical methods (see below).

All of these errors are dealt with through the issue of scale. The Royal Institution of Chartered Surveyors (RICS) has produced a document entitled "Surveys of Land, Buildings and Utilities at Scales of 1:500 and larger", which is designed to be used by the client as a guide to the tender process, and by the surveyor as a guide to the undertaking of such work. This document goes some way towards explaining the issues of scale and accuracy for surveys of 1:500 or larger (surveys undertaken at scales smaller than this are covered by a different document as they are generally undertaken using different survey techniques such as aerial surveys).

The RICS also produce a document entitled "Code of Measuring Practice" which is useful when identifying what should be measured, and what does and does not need to be taken into account when defining "Net Internal Areas". Rather annoyingly the same document mentions the word "accuracy" and attempts to define it in a wholly inappropriate way. Thus the 99,000 Chartered Surveyors who do not use "those funny things on top of tripods" have a simplistic view of what constitutes an accurate survey. "You use a device that can measure to an accuracy of 5mm? That's good enough for me!"

"The biggest influence in the misconception of scale and accuracy is without doubt the invention of CAD."

Over the last two years, David Maltby and myself have given upwards of 100 CPD Seminars on this very topic, aimed specifically at architects under the auspices and accreditation of the RIBA (I cannot help thinking that our Undercurrents correspondent may be able to find some humour with this gentle irony!) and in all that time, there has been only one architectural practice that we have come across where anyone has even heard of the document, never mind has a copy on the shelf! It is probably just as surprising to learn that the Code of Measuring Practice can be found in between 30% and 40% of the architectural practices we have presented to. Although to be fair, this probably says more about us as a profession, than it does of them.

Before explaining accuracy, it is important to understand that there are three types of measured building survey that a professional surveyor can undertake:

- ***Unconnected*** – using simple methods which do not enable one part of the survey to be related to another.

- ***Semi-Connected*** – one floor (normally the ground floor) is surveyed with all parts connected by instrumental control. Other floors are matched by assuming verticality of common features.

- ***Fully Connected*** – all floors are instrumentally related to a common survey control framework.

Each of the above survey types has their uses. However, accuracy is explained within the "Surveys of Land, Buildings and Utilities at Scales of 1:500 and larger" document as follows:-

"In general, when accuracies or tolerances have been specified, they refer to vector errors and are defined statistically as root mean square errors (r.m.s.e.) or maximum tolerances. The r.m.s.e. is equivalent to a 67% tolerance, and a 90% tolerance is 1.65 times the r.m.s.e. when a representative sample of points is tested. Thus an r.m.s.e. of ± 0.1m indicates that in a representative sample of 100 points, not less than 67 shall be correct to better than ± 0.1m, and not less than 90 points shall be correct to better than ± 0.16m. Any errors exceeding three times the r.m.s.e., in this case ± 0.3m, may be regarded as mistakes."

So, what exactly does this mean? It may be better explained in layman's terms. Further on, the document simplifies the above statement:

Accuracy of Detail

"On semi-connected surveys the accuracy given will apply only within the immediate survey area - thus the ground (controlled) floor will meet the accuracy requirement, but on other floors the position of room detail will only be accurate relative to other detail within the same room.

Dimensions between points which cannot be directly measured can be computed only from a fully controlled survey. Accuracy will be affected by the size and complexity of the building. The Surveyor can state his estimate of the accuracy achievable.

The accuracy of surveyed detail shall fall within the following limits:

- ***Plans*** - on fully-controlled surveys the absolute plan position of well defined detail shall be accurate to ± 15mm at 1:50 scale or ± 30mm at 1:100 scale, when checked from the nearest survey control station on that floor.
- ***Dimensions*** - directly measured figured dimensions shall be quoted to the nearest centimetre. The Surveyor's estimate of the achievable accuracy for dimensions which can not be directly measured should be sought.
- ***Levels*** - the quoted level of any feature relative to the nearest bench mark on that floor shall be to ± 5mm."

It is important to note that this does not mean any measurement taken "will only be good for ±30mm at 1:100". Errors and tolerances should be applied to the "measurements" you can't take (i.e. between two positions in a building, both of which are not inter-visible) as well as those that you can.

The biggest influence in the misconception of scale and accuracy is without doubt the invention of CAD. Everyone seems to have forgotten what used to happen pre-CAD, in the days of the humble drawing board. Surveyors these days are no more accurate than the previous generation. The instrumentation and software that is available today exists to provide and improve efficiency, not

". . . the accuracy of the data is not linked to the zoom factor of the wheel mouse!"

necessarily to improve accuracy.

Surveys (not drawings!) are accurate at the scale at which they are mapped / surveyed. As we all know, Ordnance Survey data is now available in digital format for use within a CAD system, with the mapping generally derived at a scale of 1:2500 for rural areas and 1:1250 for urban areas. What comes as a shock to a lot of people is that the respective accuracies are ± 2.4m and ± 1.0m (these are worst case).

It is generally accepted that OS data is inaccurate, a statement which is in itself inaccurate, as the data is accurate at the scale at which it was mapped. This is the same for any surveyed data, whether at 1:1250 or 1:100. CAD allows the data to be plotted at any scale the user wants – even at 1:1. Unfortunately the accuracy of the data is not linked to the zoom factor of the wheel mouse!

It is probably fair to say there isn't a surveyor anywhere in the world who has undertaken a building survey at a scale of 1:1 – the practicalities prevent it, the instrumentation limits it and the client can't afford it. It should be remembered that the design may be digital, but the building is not!

Designers and architects design at 1:1 – surveyors map existing data. The construction process involves tolerances. Surveying is no different. At MBS Software we spend a great deal of time actively trying to educate clients (and in some cases surveyors!) in this area. Is it not time that everyone jumped on this bandwagon?

A large amount of issues exist between surveyor and client due to a lack of communication (and in a lot of cases, a lack of understanding of each parties requirements). There is a lot of truth in the notion of "asking the right questions takes as much skill as giving the right answers". Specifiers of measured building surveys believe they understand about scale and accuracy, but generally speaking they don't! It is up to us as a profession to educate our client base accurately (pardon the pun!) and consistently, not necessarily from supplying the right answers, but in asking the right questions!

References and acknowledgements

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Surveys of Land, Buildings and Utilities at Scales of 1:500 and larger Second Edition 1996 published by the RICS. ISBN: 0854065393

Code of Measuring Practice 5th Edition published by the RICS. ISBN 1842190601

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