TYPES OF SURVEY CONTROL – ETHEKWINI MUNICIPALITY

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Introduction

Surveyors from the Ethekwini Municipality working in the Survey and Land Information Department have to on a daily basis undertake various types of surveys depending on the client requirements. These will vary from detail surveys, monitoring surveys, setting out data, carry out checks on site, as built surveys etc. However every surveyor has to start from a known or co-ordinated control point or benchmark in order for their survey to be on the national co-ordinate system. Once a survey is carried out on this system it can be imported and added to almost any existing drawing on this same system in order to start a design or compare to it to previous surveys. A control point is a point on the ground or any permanent structure whose horizontal and vertical location/position is known. Control points are used as a starting point of all types of surveys.

Additional control points or working points are fixed on site if required ensuring they are accurate and also tie-in to the national grid system. All surveyors also use this same fundamental control in order to start their survey and they will also create their own additional control points. Our main focus will be to discuss the following types of survey control that are used:

*Trigonometric Beacons (Trig Beacons)*

*Minor Control Points*

*Town Survey Marks (TSM’s)*

*Benchmarks*

*GPS Control*

*Reference Marks*

In this article we will discuss how these control points are used and explain their origin, accuracy and maintenance and how we as surveyors use them in order to undertake our surveys.
**Trigonometrical Beacons (Trig Beacons)**

The trigonometric beacons (trig beacons) in South Africa originated from the Western Cape, Cape Town to be exact and they were based on star observations and precisely measured baselines. Maclear between 1833 and 1870 and Sir David Gill between 1879 and 1907 whose initial geodetic objectives were to verify the size and shape of the earth in the Southern Hemisphere and later to provide geodetic control for topographic maps and navigation charts. From these beginnings the network was extended to eventually cover the entire country and comprises about 29000 highly visible trigonometric beacons on mountains, high buildings and water towers.

Trig beacons are built and maintained by the Chief Directorate Surveys and Mapping with known coordinates and elevations published. They are constructed on mountain tops, high buildings and water towers using concrete and the stability of the soil in that area has to be checked, this is done to make sure that the trig beacon will not move with time.

Figure 1: on a mountain top (Cape Town), figure 2: on a water reservoir, figure 3: on top of a building.

The trig beacons were fixed mainly by angle observations for the horizontal position and trig heighting was used to determine the heights. The position of the trig beacon is at the centre of the pillar and the height is mainly at the top of the pillar and their heights are based on Mean Sea Level (MSL). Trig beacons are grouped together to form a network of triangulation and are grouped together according to their positions on earth with the reference to the degree squares e.g. those that are in degree square 2930 will be grouped together and those in degree square 3030 will be grouped together. The degree squares are defined by the lines of Latitude and Longitude.

Information about trig beacons is kept by the department of Rural Development and Land Reform, National Mapping Organization in Mowbray – Western Cape. It is this department that is responsible for the maintenance of trig beacons, but every one that uses the trig beacons has the responsibility for their well being and also to report to the Chief directorate if there’s a trig beacon that is damaged or destroyed.
The challenges that exist with trig beacons is that the community sometimes damages them especially children and sometimes the vanes are removed for the purpose of selling them at the scrap yards. Sometimes the pillar is damaged and it’s hard to setup a base plate on it for surveying purposes.

**Minor Control Points**

Minor control points are the extension of the survey network and are based on trig beacons and town survey marks or from any working point with a survey record number (SR). As development take place, trig beacons are sometimes not as visible as before and that’s how the idea of minor control points came about.

Minor control points are usually set up by a registered professional Land Surveyor and they have a known coordinate, elevation and sometimes with no elevation published. They are usually vanes on water towers, cellphone antennas or any structure that is elevated and visible. They are fixed by angles for the position and trig heighting for the heights and with the development of technology they are also fixed by GPS (Global Positioning System). The minor control points are referenced with an SR number that is received from the Surveyor General Office e.g. SR 2004/63.

Information about minor control points is kept with Surveyor General Office in that province. Ethekwini Council has the records of the ones that are within the municipality. Most of the minor control points are not accessible and are not easily destroyed.
**Town Survey Marks (TSM’S)**

Town Survey Marks are survey stations erected by or under the direction of the *Chief Directorate: National Geo-Spatial Information.*

The cover is made of a 228mm diameter cast iron cylindrical box which is 200mm long. The Town Survey Mark is a 60mmx12mm diameter brass peg inside a 915mmx150mm diameter concrete column. They are normally found in the middle of the roads, intersections, sidewalks and road Islands.

In terms of section 3A (1) (d) of Land Survey Act (Act 8 of 1997), the Chief Directorate: National Geo-spatial Information is mandated to ‘Establish and maintain a national control survey network’.

*Section 42(4)(a) states that, “A local authority shall within its area of jurisdiction be responsible for the maintenance to the satisfaction of the Chief Director, of any town survey marks erected in terms of this section, and should the local authority fail to maintain any town survey mark the Chief Surveyor-General may undertake any necessary work at the expense of that local authority.”*
**Functions of the TSM’S**

As the surveyors in Ethekwini Municipality we use these TSM’s to base our Cadastral surveys, put up extra controls points and to undertake our engineering surveys. TSM’S are more useful inside the CBD areas and places with tall trees. We cannot use GPS in these areas because of the effect trees and other structures have on the quality of the satellite signals.

The positional accuracy of TSM’S is within 10mm and the height is accurately leveled to within 1mm (0.001m). This makes them more suitable for engineering and cadastral survey.

**What is our responsibility with these TSM’S ?**

As the Ethekwini Municipality, especially the Surveying and Land Information Department, we are mandated by law to safeguard and maintain all the TSM,S which are within our boundary. We are currently undertaking an audit of all TSM’s in eThekwini Municipality. Originally we had 3238 TSM’s. Out of approximately 1000 TSM’s that have been checked, 200 of them have been destroyed.

Of those destroyed, 90% of TSM’s were destroyed by road construction and maintenance. As most TSM’S are constructed in the road area, they are destroyed during road rehabilitation. This is not supposed to be happening because TSM’s can be easily raised or lowered like other services that can be found in the road area.
The other 10% of those destroyed or damaged have been vandalized by the general public who sell the steel covers.

**Benchmarks (BM)**

The term Benchmark describes an inscribed / chiseled horizontal mark that surveyors made on stone / concrete structures, into which an angle-iron could be placed to form a ‘bench’ for a leveling rod / staff, thus a staff could be accurately positioned at the same place in the future. These marks were usually indicated with a chiseled arrow below the horizontal line. Benchmarks are used for leveling.

From the figure above we also observe the now widely used benchmark symbol

The term benchmark is now widely applied to any item used to mark a point as an elevation reference. Brass or stainless steel pegs are set in stone / concrete or on rods driven deeply into the earth to provide a stable elevation point.
**Benchmark Heights**

The words height and elevation are interchangeable, but do have different specific meanings. Height commonly refers to a local or relative difference in vertical, ie height of a building. Elevation refers to the difference in vertical distance from a selected / nominated reference surface, ie mean sea level.

The height of any benchmark is calculated / derived relative to the height of nearby benchmarks in levelling networks extending from the *fundamental benchmark*. The fundamental benchmark is a point with a precisely known relationship to the level datum of the area, typically ‘mean sea level’

This is done by taking tidal measurements to determine the mean sea level and linking them to primary / fundamental benchmarks. These are built six months before they are leveled, and are spaced approximately 65km apart at intersections of primary or secondary routes.

In Durban the nearest fundamental benchmark is found in bed rock in a disused quarry in Umgeni road. It is situated under a circular steel manhole cover and it consists of a brass stud set in the rock. It ‘s height was calculated using precise leveling methods and is based on mean sea level as determined in the early part of the last century.
Sometimes benchmarks are buried quite deep as a result of changing ground levels.

The benchmark in the picture above is accessed via a large circular manhole.

The Fundamental Benchmark in Durban. The point is the bright object in the centre. It is covered firstly by a circular metal cover, then a small square cover. It is accessed via a manhole.
**GPS Control Points**

These are points we fix on site if there are no control points on or in close proximity to the site to be surveyed. Also, some of the requests from clients are to fix control points on site so that when construction does commence there is a common and known control point from where the setting out of work can begin. The Land Survey Department uses 2 methods of fixing control by GPS namely:

*Post Processing*

*VRS (Virtual Reference Station)*

*These types of surveying methods have been discussed further in detail in a previous published article: Types of GPS Technology*

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**Figure 1**

Figure 1 shows a GPS base receiver on a trig beacon logging data and figure 2 shows the GPS rover set up over a new point to be fixed. This data is combined and processed in a survey GPS survey program eliminating errors and applying all adjustments in order to obtain a co-ordinate value.
Figure 3 shows the VRS Trignet base antenna situated on the City Engineers main building which feeds data continuously to a receiver in an office situated in The Surveying and Land Information Department. This information is then available via internet in real time or saved and accessible on line for up to a month for surveyors to download.

When fixing these new GPS control points they are marked with yellow paint, wooden stakes or red and white chevron tape or combinations thereof depending on the type of point fixed and the area around it (ie. Sidewalks, grass, paving etc). When we commenced fixing GPS points they were given the suffix G (ie. G125, G228 etc.) , we stopped using the suffix G when we reached G999 and have since moved to adding the suffix L (ie. L099, L201 etc). These points are fixed on site in such a way that they are inter visible with other trig or minor control points. These GPS points can later be used when required during the construction phase provided they are not damaged or removed.
The GPS Database

The Survey department uses the GPS post processing survey method to fix new control points for different projects throughout the municipality. These coordinates then form part of our database of control points which are then used to carry out surveys.

The descriptions of the type of points fixed are:

* 16mm steel pegs in the ground
* Steel ‘hilti’ nails
* Brass studs drilled into concrete
* Fence standard knocked into the ground
* Steel studs drilled into concrete

We currently have a Microsoft Access format file which we have compiled and this lists our GPS control points that were fixed since 2003 when we began utilizing GPS instruments and as a new point is fixed it is added to this database. This is then available to the other surveyors in the office as well as private surveyors who find our points on site and require their values over the phone.

This database shows the point name, YXZ values, description, date it was fixed, street name, our survey reference number, etc. There are currently over 2600 GPS points in our database however they are not
maintained such that if they are destroyed on site or damaged in the field we do not update this on the database nor do we re-survey them unless under certain circumstances.

We have a map book which shows all our survey control and a large index sheet which helps identify the relevant sheet in the map book. This is available to be viewed by any member of the public at the Land Surveying counter within the Surveying & Land Information Department.

**Conclusion**

The Survey and Land Information Department will continue to provide accurate surveys as long as there is well maintained and sufficient survey control available. We will continue to fix accurate additional GPS control points and maintain our TSM and Benchmark records so that this information will then be available for use by all surveyors.