INSTRUCTION FOR MEASURING DETAILS WITH THE FINITOR SYSTEM

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Introduction

The Finitor system is designed to make a map (ground plan) of a terrain. The map represents roads, buildings, manholes, trees, railings. The system follows the surveyor's method. It guarantees a high accuracy and is very reliable. A tachymeter or GPS receiver is used as measuring instrument. No drawing- or notepaper is needed. The measuring is a combination of taking observations and data input. The input of data depends heavily on the information that you want to see on the map. In one case you want to represent a tree as a round (symbol); in another case you also want to see how thick the tree is. The more information has to be given, the more important becomes easy manipulation and efficiency. In combination with the processing system Finitor the survey measurements meet this requirement.
Measuring with this system gives the following results:

- Measuring data can with simple processing on the computer be generated into a drawing.
- Lines in the drawing are joined, so areas and lengths can be calculated.
- Levels and dimensions are reliable.
- The drawing has many details without becoming disorderly.

In this instruction the method of mapmaking is worked out. For the sake of convenience, explanation is given for one type of registration format (gsi). Used terminology is not standardized and can be different for each type.
Mentioned subjects are: traverse points, height track, detail measuring and profiles (cross section). In the detail measurement we use: blocks, lines (as polyline, rectangle, arc or circle) with constructions in changing combinations. Lines and blocks that are measured also in height level can be represented in 3D.

Chapter 1 General

Basic knowledge of surveying and levelling is assumed as well as the skill to operate a tachymeter.

Definitions:

- ALL: measuring and registrating (often with the key ALL) the angles and the distance, or coordinates, of a point while at the same time adding extra information (5 code fields). Registration takes place internally in the data file. Before striking ALL, the operator aims accurately the tachymeter reticule (with the cross hairs) on the target prism.

- Centring: positioning the instrument perpendicularly on top of a marked ground point.

- Construction: additional measuring of a point using the measuring tape. An example of a construction is the following task: turn left at the end of a line, 80 cm perpendicular on that line. The constructed point receives its own number and codes.

- Coordinates: the position of a point in relation to chosen axes. Coordinates fix a point on a map. At a local autonomous project you can choose your own system of x- and y-axis without any connection to a geographical system. The distance unit is the meter. The decimal mark is a dot (.).

- Drawing scale: represents the plotting scale. The CAD scale remains 1 : 1.

- Layer code (LC): the 2-character code that determines at which layer an object should be drawn. For instance layer 01 for buildings, layer 02 for infra-structure, layer 3 for hedges, layer 04 for road-metal etc. Each layer has its own colour and line type; layer 09 gets a dashed line in the colour white.

- Map: measured points, lines and objects that are displayed in real proportions on paper or screen. Other names are: graphic presentation, drawing or plan.

- Measure: the length (0 – 99.999) in input field 4 (Meas) for the calculation according to the prescription of field 3 (PO).

- Object code (OC): the code that determines which feature is drawn: a line or a symbol.

- Observation: Aiming at the target and registrating the readings. The readings consist of the horizontal angle (Hz), the vertical angle (V) and the slope distance (SD). The observations are used for the calculation of coordinates. Finitor can also use available coordinates from the tachymeter. A tachymeter file in coordinates is seen as a GPS file by Finitor and treated as such.

- Orientation: setting the horizontal tachymeter direction (reading of the angle) to a known point as reference. All readings of the horizontal angles are related to this orientation.

- Positioning code (PC): determines the position of a detail point. For instance: code 55 means that the point position is directly determined by the prism position. Other “fifties” indicate an eccentric point position from the prism.

- Project map: the map where all files concerning the same project are stored.

- Rec: with a registration key (a key REC) you store the given Codes in the tachymeter or GPS files. For sake of the record format there is added an observation. So you can bring in constructions using the keyboard input, regardless of the tachymeter readings.

- RECMASK: the manner and order in which you store the Codes and instrument readings or coordinates.

- Tachymeter (TPS) or GPS file: the file in which the readings, or coordinates, and the encoding data are stored. Take a simple recognizable name for the project and the following jobs; simple as job1.gsi and job2.gsi.

- Track: a chain of height control points as a basis for the levelling of all detail points. Each new track is appended on a known height at its begin and its end. The name of the height control points file is *.chp

- Traverse points: the (goniometrically checked) control points as a basis for each tachymeter measurement. The name of the traverse points file is *.cfp (control fixed points).

The observations can be saved in different kinds of format. The format is specific for each tachymeter. We take the GSI-format as example. The extension of the filename is GSI. The name consists of alphanumeric characters ending with a serial number, e.g. job01.gsi. The observations that belong to a certain part of the job (day or area) have their own job file. The tachymeter or GPS file is imported in the project map. Imported files are named job# with extension mes. Files without a serial number serve as common files. Job.cfp, for example, contains the coordinates of the collection of known control points for the station setup. Each tachymeter or GPS file is regarded as a unity on its own. That is to say that the x, y, z of each detail point can be calculated without data from an external file.
The position of the station setup must be known for the calculation. Unknown stations have to been first calculated. The standard calculations are: circle (closed chain) measuring and traverse measuring. Both of them may be linked up with two known points. The closing errors are adjusted.
Levelling, to determine the z, can only be done in a linked levelling track. The closing height error is equally divided over each station setup.
To every observation extra information can be fixed, in the so called codes. Example of an code is a tree or a lamppost. It is only sensible to give in information that can be processed. In the appendix you see a few codes. We will give examples in a few of figures.
The program processes the data (registrations) of the tachymeter or GPS file on the PC into a DXF file. A DXF file is a digital drawing that can be read by CAD programs.
Each registration must consist of a point indication (number) followed by 5 codes and of course the observations (Hz, V, SD) or x, y, z coordinates. Codes and observations can't be stored separate. So your REC MASK must be adapted to one complete record at the time.

The 5 codes in the according input fields have the following meaning:

- Code 1 is an object code (OC) for a point (symbol or line). It is a 2-digit numeric code (up to a fourfold of two digits).
- Code 2 is a layer code (LC). It is a 2-digit alphanumeric code and can be fourfold corresponding with the object code.
- Code 3 is a positioning code (PC). It is a 2-digit numeric code that determines the calculation of coordinates.
- Code 4 is a measure code (Measure) for input the measure of the eccentric or levelling measure (meters in 3 decimals).
- Code 5 is the reference code (Reference) needed for some positioning codes. Reference has also a special input possibility in combination with object code 60 and 90. Object code 60 (tree) has as attibute trunk and top projection diameter. This attribute information is determined by Reference. The input is in cm, seperated by . (dot). Reference is also used for the alphanumeric text in the attribute of block 90 (object code 90). Blocks 90 and 60 are drawn on the chosen layer in Code 2.

The mes file has the adjusted format for the Finitor handling.

The following step is the conversion to the calculate file, #.cal. The content of the mes file is checked on illegal input and format. In order to make constructions possible, some dummy rows are added. So it is important that the mes file is correct. Corrections have to be done as early as possible, perhaps already in the tachymeter file. A following cal file can be inserted in a current one. An X,Y,Z file can not be inserted in an Hz,V,ZD file, neither inversely. Take a different point numbering to avoid mistakes in the references.

Chapter 2 Traverse

The traverse is the basis for the goniometric point positioning. The quality of the traverse restricts the quality of the succeeding measurements. Be sure that the traverse is reliable and has sufficient accuracy. In an extensive project you should make a difference between primary and secondary traverse points.
Once the primary traverse is calculated it will serve as an invariable point of departure for all secondary traverses. Therefore the primary traverse points must remain intact. So these points have to be marked reliably.
The GPS measuring does not use the traverse so the following text concerns only the tachymeter.

There are two types of traverse.

- circle (closed chain): the best and simplest choice for a local measurement.
  The local traverse can then be transformed to a known system
- polygonal: an open goniometric figure, connected to known points

The measurements of a circle are checked by the goniometric preconditions. The check is absent for the free polygon. That polygon tied at one end can not be checked. So faults will remain undetected. That problem is solved if you can connect a polygon at both sides with known points.
A general view of the terrain is necessary to determine the best position of the traverse of the polygon. The best form is a symmetric figure with equilateral sides that encloses the terrain to be measured. If necessary, we condense the traverse with new points inwardly. Except for this goniometric condition, a station should comply with the following requirements:

- Free accessible and safe

- Mutual visibility with other stations
- All details and profiles visible
- Height control points must be visible directly
- Little disturbance by surrounding influence
- Easy to recover and to reuse

Station setup

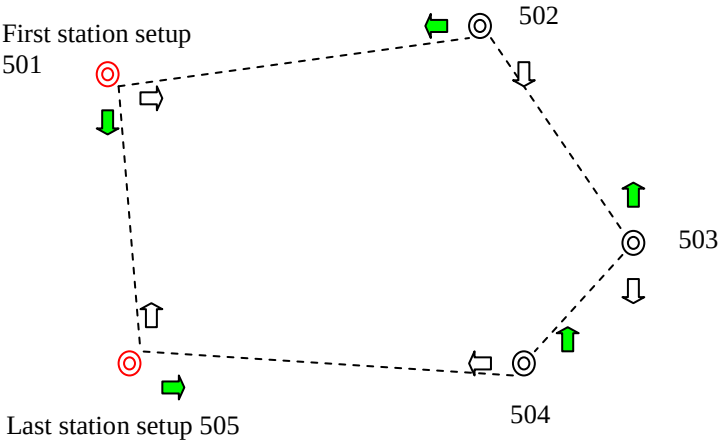
Once placed in position we give in the station setup code, with the station number.
It might be useful to keep track of the numbers in a sketch. It advances the convenient arrangement. You can append remarks at the sketch. Write the number also at the point in the terrain, on a picket.
We begin with the input of the code for a station setup; that is 35 in field 3 (PC):

OC 0 [enter] LC 0 [enter] PC 35 [enter] MEAS 0 [enter] REF 501 [enter] [REC]

Input in MEAS is often not relevant. You can put in the measure of the height of the tachymeter above the control point.
The number of the station, e.g. 501, belongs in REF. The number may consist of 12 digits. Only numeric characters are allowed.
REC or ALL stores the Codes together with the observation in the right format (REC MASK). In the case of the registration of the station setup the observation is of no importance. The readings of the observation are only useful to complete the registration format.
When the positioning of a point needs a distance and a direction we have to measure with ALL. The sequence of the registrations must be consistent. For example: the station setup has to be done before measuring the detail points and not afterwards.

In figure 1 and 2 you see the example for Code input.

Circle polygon measuring, top view



Starting direction (backwards)

Second direction (forwards)

Known point, as connection point with earlier measuring

Encoding is as follows:

OC	LC	PC	MEAS	REF	Hz	V	SD
0	0	35	0	501	-	-	-
0	0	45	-	505	reading	reading	reading
0	0	45	-	502	reading	reading	reading
0	0	35	0	502	-	-	-
0	0	45	-	501	reading	reading	reading
0	0	45	-	503	reading	reading	reading

Figure 1: Polygon measuring

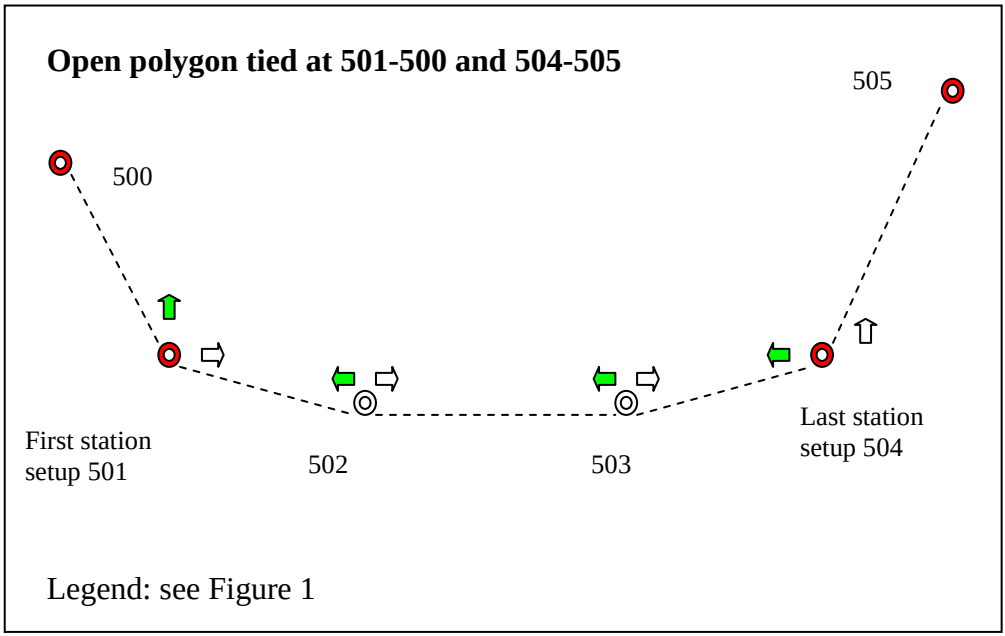


Figure 2: Polygon tied at 501-500 and 504-505

The orientation

After the station setup we have to set the orientation. We must fix the graduated arc of the tachymeter. We aim at the reference point, in this case the known point 500. The positioning code 45 indicates that it concerns a direction from the present station setup.

OC 0 [enter] LC 0 [enter] PC 45 [enter] MEAS 0 [enter] REF 500 [enter]

With ALL the orientation is set. You can call it initial bearing in another terminology. The corresponding station number (500) mentioning belongs in REF. The input in MEAS is often meaningless. Take a "0". With a measure in MEAS you can determine afterwards the height of the ground (marked point). That height is mentioned in the log file of the topography export. For successive stations setup the preceding station is measured first (the backwards direction). The forward direction is the next destination as station setup. This order is a necessary condition for automatic processing. Every station setup, in a polygon or not, needs two directions. This rule has to be applied too at the end of an open polygon, so without a second forward (closing) direction point. We have to measure to the backwards direction twice as if it were to a point forwards. In this case both directions have the same number and there is no check. The registration is then again:

OC 0 [enter] LC 0 [enter] PC 45 [enter] MEAS 0 [enter] REF 500 [enter] ALL

With the two registrations of the readings of the observation the station setup is completed.
In relation to the station setup the detail points can be fixed by three readings (Hz, V and SD).
The second direction can be measured immediately afterwards (by

preference) but can also be taken later. Don't forget the right number in REF. Position code 45 is used while measuring in Face I.
If required you can, after measuring in Face I, also measure in Face II. However, you always have to begin with Face I. Measuring in Face II is only sensible for the calculation when it is carried out on all points of the polygon. The position code for Face II is 46. The backwards direction has to be taken first (as in Face I). You can check the reading (done with 45 or 46) by using the code 47. The difference with the orientation reading is mentioned in the log file without further consequence. It can be used to registrate the collimation and index deviation. You can use code 49 for a check on another known point. That check has no influence on the calculation. You can determine an auxiliary control point by using code 48. The auxiliary control points have to be calculated after the calculation of the primary control points. They will be added to the existing points in the cfp file.
Apart from a station setup in the traverse, you have the possibility of a free station setup.
Two known traverse points must be visible. In addition to the two directions, the distance to the nearest point should be measured. It's preferable to measure both distances. The accuracy and the reliability are better. If the extrapolation is more than twice the deviation of the readings, positioning is refused.
The positioning code (PC) for the free station is 39. The corresponding code for the directions remains 45 (46).
When the two directions are registrated, the station is determined in x and y.
You can possibly measure a thirth traverse point. With position code 49 it can take part in the calculation. Only the first 49 is available.

If necessary for levelling we next determine the tachymeter height (= station height or IH).

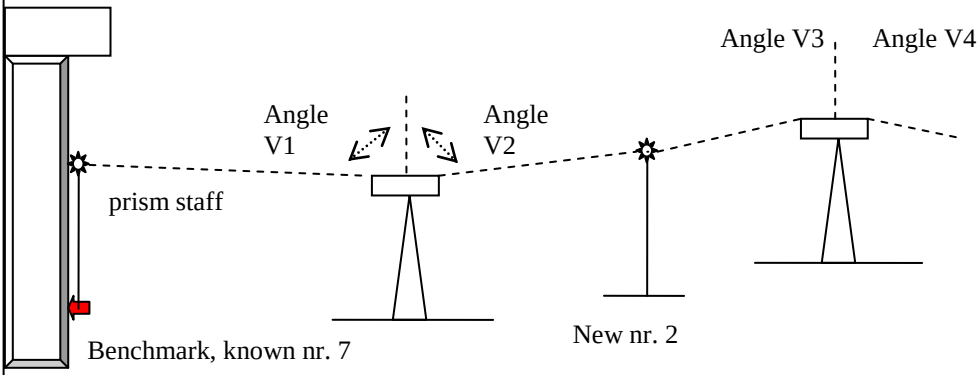
Chapter 3 The levelling track

The GPS measuring does not use the levelling track so the following concerns only the tachymeter.
In general the height is wanted for detail points; z in addition to the x- y position. The word height is often substituted by the word level in case of a plane. A level presumes a reference.
The reference for the levelling is an official bench mark or a relative height control point. The height control points are measured in a closed track, in vertical sense to compare with the previously mentioned traverse. If the station height is known, the x, y, z position of the target (reflector prism) can be calculated by the program. The wanted height is the calculated height of the prism minus the length of the perpendicular from the prism. Two height control points are used at each station setup. The first measuring is called back staff (rod) and the second forward measuring is called fore staff. It seems like levelling with a traditional horizontal telescope and a level rod. The translation of the levels has to be done "leap-frog" forward, preferably in a connected track. A height control point must fulfil the following conditions:

- Stable, over a long time (not a loose stone but the edge of a parapet)
- Easy to recognize (e.g. a manhole cover)
- Visible for stations setup

The measuring is as follows (see figure 3 and 4):

Side view of the height track

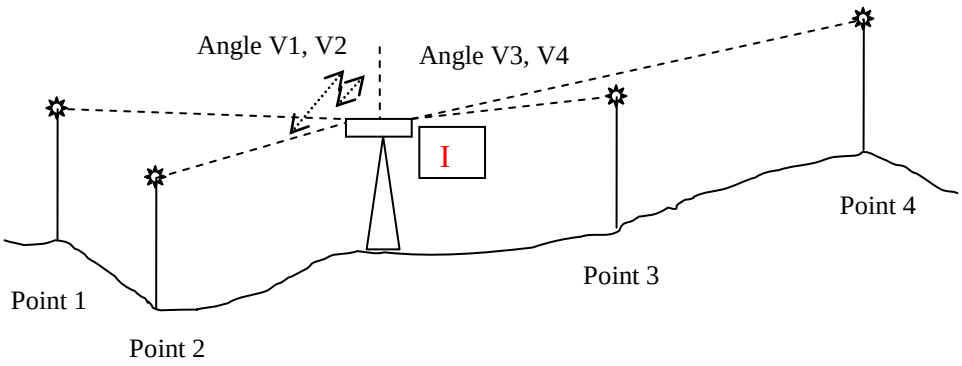


The encoding for the levelling traverse:

station	OC	LC	PC	MEAS	REF
501	-	-	-	-	-
back staff	0	0	81	1.790	7
fore staff	0	0	84	1.790	2
	-	-	-	-	
502	-	-	-	-	
back staff	0	0	88	1.790	2
fore staff	0	0	84	1.790	3
	-	-	-	-	-

Figure 3: Levelling side view

Side view of levelling detail points



The level of the detail points can be calculated in relation to the instrument level after measuring the vertical angle and the distance. In the drawing a circlet appears with as text the level. The circlet is block 99. The code in field PC is 85.

Figure 4: Side view of levelling detail points

At the first station setup we aim first (back staff) at the known benchmark, in this case nr 7. The instrument height (IH) can be calculated. Back staff is the tachymetric equivalent for the traditionally back sight on a levelling rod. Fore staff is the complement.
Related to the IH the next levels can be calculated. The obliged fore staff can be measured immediately or later at the end of measuring the detail points. At the next station setup the former fore staff becomes back staff and so on.

There are 4 positioning codes (PC) for levelling.

- 81 means back staff as begin of a track,
- 88 means back staff in the through levelling,
- 84 means fore staff in the through levelling,
- 89 means fore staff as closing of the track.

The perpendicular of the prism (length of the staff) is given in MEAS in meters, e.g. 1.790.

OC 0 [enter] LC 0 [enter] PC 81 [enter] MEAS 1.790 [enter] REF 7 [enter] and measure with ALL.

Measuring in Face II is possible (after Face I) provided that the numbering and sequence for the whole track in face II are the same as in face I.
The length of the staff has to be mentioned in every registration. It is safe to keep always the same length. When you have used a deviate length, return to the standard again. Deviating lengths are made visible in the measuring file on the PC, so you have a review. It is possible to use the combination 88-84 twice or more to make extra height control points with intermediate sights from the same station setup. The IH is calculated after each back staff, between that back staff and the first fore staff. In case the instrument (tribrach, tripod) is disturbed during the operation time, you can close the track with a fictitious irrelevant fore staff. Consider the current height track as ended and start a new track.

It may occur that you are levelling a long through track without being interested in the x-y positioning of the height control points. You can use the method “Level run” . You have to do the station setup just once. The setup and the orientation, at the beginning of the level run, is merely formal. Further on you have to registrate only the observations for back staff and fore staff, regardless the number of levelling steps.

NB. Sometimes we end the measuring (fore staff) at a provisional height control point with an unknown height. In the calculation on the computer, we fill in a question mark. And conversely we can also start with a question mark for an unknown height. The calculation of a provisional height has to be checked and adjusted later.

The heights of the detail points appear in the drawing as text with a circlet around the decimal point. The decimal point represents the position of the measured point; the circlet is only meant for recognition. The height control points are displayed on an own layer.

Chapter 4 The detail measuring

Once at least one traverse point and one height control point are measured detail measuring (tachymetric) can start.
Each measured point receives its own number. The running numbering can start on any random number. The tachymeter can automatically number consecutively. For the recognition of a special point you can use a conspicuous deviating number.
For example we measure a terrain height first. The 5 codes are: object code 99, layer code 0, positioning code 85, measure code 1.79m, reference code 0. In compact form:

OC 99 [enter] LC 0 [enter] PC 85 [enter] MEAS 1.79 [enter] REF 0 [enter] ALL

The next point can be a lamppost, to be measured without level. The input is then:

OC 50 [enter] LC 0 [enter] PC 55 [enter] MEAS - [enter] REF - [enter] ALL

The positioning code (PC) 55 calculates the x-y coordinates of the target point. Positioning code 85 calculates a 3D point. In addition to the 2D drawing the level of the point is displayed as text. The perpendicular measure of the target to the foot point of the rod is represented by field MEAS. The centre of the prism represents the point level when MEAS is “0”.
A 3D point, if directly without construction or offset, should always be measured with position code 85.

The same detail measuring can possibly also be done by GPS. The observation presents directly x, y, z coordinates. The station setup, as used by the tachymeter, can be omitted. GPS measuring doesn’t use existing control points or height points. The encoding that concerns

the control points or height points can’t be used. The position codes 51, 52, 54, 56, 58, 59 have no sense either and are thus neither allowed. However, constructions (position codes 71, 72, 74, 76, 78, 79) are allowed. These codes are used in the same way as in the tachymeter measurements.
GPS points can be added as auxiliary control points in the CFP file. The position code is 48 as in the tachymeter encoding. GPS points cannot be added as height control points in the CHP file (unless by an external editor).
Tachymeter observations can be directly recorded in coordinates. The encoding is then in the GPS manner as above. See the appendix for the positioning codes.

Chapter 5 Lines, rectangles, arcs and circles

Lines

A line is drawn by connecting two measured points that have a line code (in field object code). A polyline is a chain of joined line pieces. The points are connected in the order of measuring. So when we start a line 1 (object code .1) the start point has to be the very beginning of the line 1. The object code of the next point of that line is 1 or 01. The preceding 0 can be omitted. The layer code has only to be given in at the first point of the (poly)line. That is an advantage when you are measuring several lines simultaneously. For the rest of the points of that line the layer code is neglected, even when you have begun a new station setup. You don't have to indicate the end of a line. But the closing you have to indicate. The object code for closing line 1 is -1. You can add the closing -1 to the code 01 for the last line point. By this double code the end point is joined with the starting point. When you start a new line 1, you have to give in the layer anew. The line identifier can be a letter or a digit. The layer name consists of 2 digits or 2 letters. Starting up 2 lines simultaniously needs the twofold layer input. The maximum is the fourfold object code and the associated fourfold layer code.
Some layers (table 1) have already specified properties. Layer 1 has the colour red, used for buildings. In case of a tree the layer number corresponds with a tree name (see Options-Settings).
You can interrupt a line measuring through measuring other points. The line stays open for resuming until an other line with the same number (or letter) is started.

Rectangle

When you have to measure a rectangle or parallellogram, it is enough to take 3 successive vertices. The fourth vertex can be derived if you are sure about the form of the quadrangle. An open rectangle (U form) is constructed by adding a line segment to the beginning of the line. The measuring of the three line points doesn't need to be consecutive but can be interrupted, as is possible with all line points. In case of a real rectangle, you have an option to adjust the measure inaccuracy in respect of the ideal rectangle. The differences are equally distributed over the three points. The line number in the object code for the third point is preceded by a 4. The encoding in OC for a rectangle on layer 2 is as follows:

At the first point: .2,
At the second point: 02,
At the third point: 42 (U form)

The U can be closed by appending -2 at OC of the third point (42-2).

Arc

An arc is measured through 3 points: begin, middle and end. An arc can be a stand alone figure but can also be a part of a polyline. In the first case the object code is, for line 2, as follows:

At the first point: .2,
At the second point: 12,
At the third point: 22

Two joining arcs should have the double code 22.2 in their joining point.

An arc as part of a polyline 2 has code 02 at the beginning point. The second point has the code 12 and the third has the code 22.

As part of a polyline the arc can be corrected through its connection. A clearly tangential (fluent or continuous) connection obliges to a shift of the tangent point when the pointing by the surveyor was inaccurate. Is the connection not tangential then the arc should be measured in keeping. The arc should have a double code in its joining point (end line and begin line, such as 02.2).

Circle

A circle has also been measured through 3 points: begin, middle and end. A circle can't be a part of a polyline. It is a stand alone object. The code is as follows:

At the first point: .2,
At the second point: 12,
At the third point: 32

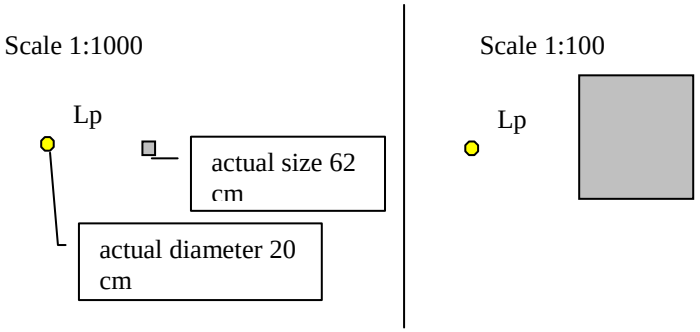
For the correct reproduction of an arc or circle the points have to be measured symmetrically; i.e. the points have to divide the curve in similar pieces. If it is difficult to estimate the right division, you should divide the curve in two or more parts. The allowed difference (Cord proportion in %) in the lengths of the arc sections you can put in under "margins".

A 3D circle and an arc can be drawn as a really 3D unit or as an approaching string of small straights.

Chapter 6 Blocks

Topographic objects such as lamp post, traffic sign, street drain, meter house etc. are measured as blocks. The centre of the object is measured and as block appointed in OC. Object code in this case represents the whole object as a symbol, regardless of the proportion of the object. Each block has its own layer in CAD, except the blocks 60 and 90. You can change the layer in the block list under "Settings". In figure 5 you will find an example of the use of blocks versus lines, depending on the drawing scale.

Effects of the applied scale on objects



Left: scale 1: 1000; a lamppost drawn as block and a manhole cover drawn as a polyline.
Right: the same drawing but with a scale 1: 100.
The symbols (blocks) keep the same size at both scales.
The code for measuring lamp post (1) and the cover (2-4) is as follows:

Pointnr	OC	LC	PC	MEAS	REF
1	50	-	55	-	-
2	.2	2	55	-	-
3	02	-	55	-	-
4	42-2	-	55	-	-

Figure 5: Effects of the applied scale on objects

When the drawing scale is small, small objects as manhole covers should be measured as a block. When the scale is large, these small objects can be better measured in actual size.

When measuring a tree, the program allows for the adding of a trunk diameter, top projection and name. The diameter of trunk and top projection is given in cm in REF. The measures are divided by a dot; e.g. 50.800. The name is defined by the layer code in LC. For example a beech can be defined by layer 41. The result in the drawing is a block “tree” at layer “beech”, a circle with actual size for the top projection at layer “top projection”, and finally the annotation “50/800/beech”. The block number for a tree is always 60, or 61 for a fruit tree.

Block 90 can be used when there is no appropriate block for the topography. Afterwards you can allot a suitable block. You can consider block 90 as a free block. It allows an alphanumeric input (in REF) of 16 characters as text in field Reference. You can choose the layer (in LC). By a zero in REF the value in field Reference becomes the tachymeter point number. That can be applied conveniently at automatic running numbering.

Chapter 7 Eccentricity and Constructions

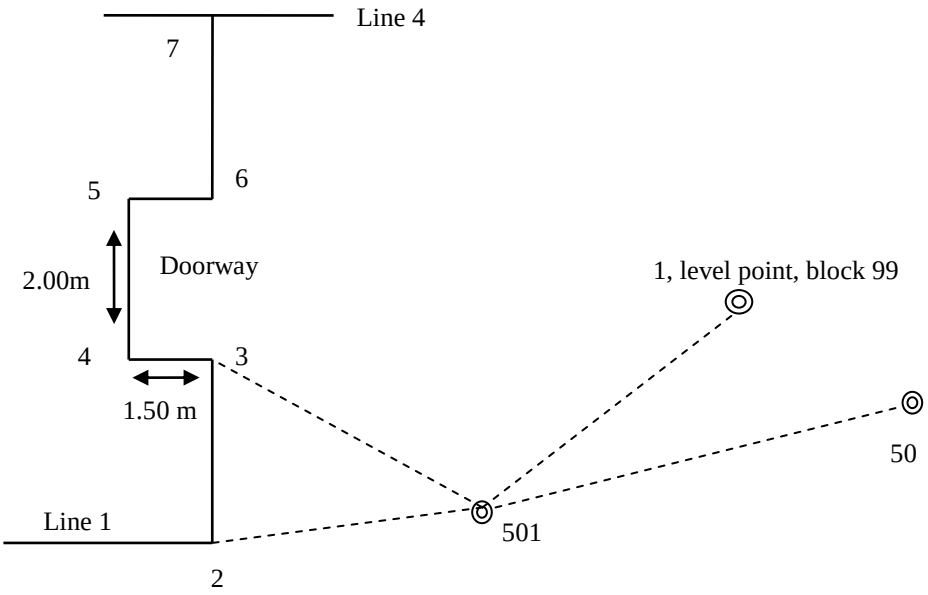
A construction or an eccentricity (=offset) is used when the prism can't be held on the wanted point. A construction is a lengthening or shortening of a line, followed by a perpendicular offset. The method is called "chain and offset". We are using the word offset also for a measure along the "chain".
The chain and offset is applied on two kinds of base lines.

The first kind of baseline is the one from the tachymeter to the prism. The offset is applied directly to the wanted point, without registrating the prism point in the drawing. The wanted point is calculated mostly by the horizontal offset from the target. The direction of the offset can be along the line to the instrument or perpendicular (shift) on that line. The positioning code is 52 for an offset **to** the instrument, 58 for an offset **from** the instrument, 54 for an offset to the **left** and 56 for an offset to the **right** (seen from the instrument). The operator behind the instrument can see the positioning code according to the arrows around the central 5 on the keyboard. If you want to lengthen or shorten an SD with a slope offset, you can use 59 and 51. So 59 and 51 are the 3D equivalent of 58 and 52. Code 54 and code 56 have no 3D equivalent.

The second kind of baseline is the one through the last two measured points. The encoding has the same system as in the first case. The "fifties" are substituted by "seventies".
So 78 means lengthen the base line; 74 means left turn, etc. Two lengthenings after each other are mentioned in the log file as exceptional. It could be a mistake and not seen in the drawing.
Lengthening or shortening a 3D line (with a slope offset) is possible with 79 and 71.
So 79 and 71 are the 3D equivalent of 78 and 72. The points that form the basis for a 3D construction have to be measured in 3D.

See how to measure the situation in figure 6.

Construction: example of measuring a doorway



From station setup 501 point 3 is the last point of line 1 that can be seen. To measure point 4 a construction is needed. With code 74 we go left turn, from 2-3. The measure (1.50m) is given in MEAS.
Point 5 can be seen and could be measured directly. In this case it is faster to go on with constructing, provided that the doorway is rectangular (checked with a pentagon prism). In the table you see the whole doorway encoded with constructions.

Pointnr	OC	LC	PC	MEAS	REF
1	99	-	85	1.79	-
2	.1	1	55	-	-
3	01	-	55	-	-
4	01	-	74	1.5	-
5	01	-	76	2	-
6	01	-	76	1.5	-
7	01.4	4	55	-	-

NB. It is safer to measure point 5 or 6 with the tachymeter. You get a check on the construction. A mistake in the offset will be remarked.

Figure 6: Example how to construct a doorway

We are measuring from station setup 501 the first point of the building. The beginning of a line is indicated by a dot. The layer for building is “1”. The encoding for the registration is:

OC .1 [enter] LC 1 [enter] PC 55 [enter] MEAS 0 [enter] REF 0 [enter]ALL

When we are going to the second point (3) of the building, we only have to remove the dot in OC or to substitute by a zero. This point has also to be measured by ALL. Point nr 4 is not visible for the tachymeter and has to be constructed. You can apply a construction from the tachymeter line, or from the line through the two previous measured points. If it is sure that the doorway is rectangular and if the measure is small, you can choose for the latter:

OC 1 [enter] LC 1 [enter] PC 74 [enter] MEAS 1.50 [enter] REC

NB. Because this is a construction on already measured points, the additional readings of the tachymeter are not relevant. Instead of aiming (ALL) it suffices to press on REC.

If the doorway is obviously rectangular, you can continue the construction. For point 5 the code is:

OC 1 [enter] LC 1 [enter] PC 76 [enter] MEAS 2.00 [enter] REC

A block can be measured with a construction equally well as a line point. It can also be a double; lines, blocks or a combination. To create a baseline for a construction, you can measure an auxiliary point. On layer 77 that point will be regarded as a dummy in the drawing.

Positioning code 75 is the command to repeat the assignment of coordinates. The belonging point number has to be put in REF. When it concerns the repeating of the previous point, REF can be 0

(zero). The double point 7 (corner of the building as well as starting point of line 4) in the figure could also be measured as a single with a repeat (nr 8). The registration for the additional number 8 is:

OC .4 [enter] LC 4 [enter] PC 75 [enter] MEAS 2.00 [enter] REF 0 [enter] REC

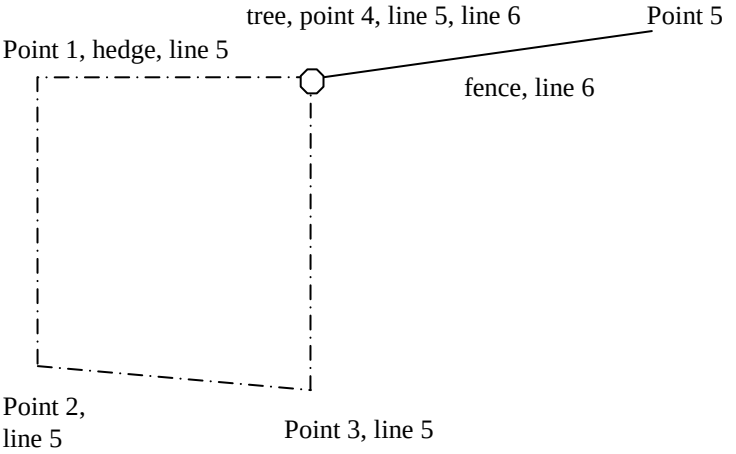
You have the choice to enter 0 in REF or to enter the real assignment number 7. You can only refer to a previous point in the current file. As the measuring for point 7 has to be done with ALL, the registrating of point 8 can be done with REC. REC is for the "seventies" in PC.
It remains unobserved when you have pressed REC twice by accident. The possibility of that occurrence is mentioned in the calculation file, under info, to give you a warning.
Positioning codes 51, 52, 54, 55, 56, 58, 59, 81, 82, 83, 84, 85, 88, 89 must be followed by ALL. A real tachymeter observation with Hz, V, SD is needed. Positioning codes 71, 72, 74, 75, 76, 78, 79 may be followed by ALL or REC. In this case is the registration of the tachymeter readings or the GPS coordinates only useful to complete the record format.

Chapter 8 Efficiency in measuring

Efficiency can be reached by combining information as much as possible to one registration.
Superfluous typing and aiming at the target prism has to be avoided. You should use the possibility to start several (up to 4) lines on different layers, adding one levelling height. With a repeating order you can add again lines to the one measuring on hand. The program executes the codes in OC in pairs of two digits from left to right. The input in OC and in LC is analogue in pairs of two characters. Each pair in OC corresponds with the pair in the same place in LC. The begin zero of a (composed) code can be left out.
For example: at the last measured closing point of line 5 (a hedge) starts line 6 (a fence at layer 6). At the same point there happens to stand a tree. The tree (object code 60) is a beech with a trunk diameter of 50 cm and a top projection of 900 cm. Finally also the ground level is interesting.
This data can be entered in only one registration as follows:

OC 05-5.660 [enter] LC 0641 [enter] PC 85 [enter] MEAS 1.79 [enter] REF 50.900 [enter]

The use of a double code



The corresponding encoding is:

Pointnr	OC	LC	PC	MEAS	REF
1	.5	(0)3	55	-	-
2	(0)5	-	55	-	-
3	(0)5	-	55	-	-
4	(0)5-5.660	(03030)641	85	1.79	50.900
5	(0)6	-	55	-	-

Figure 7: The use of a double code to work efficiently

NB. The doubling concerns only one coordinate point. The calculation is executed in one way. The input in PC always consists of two digits.

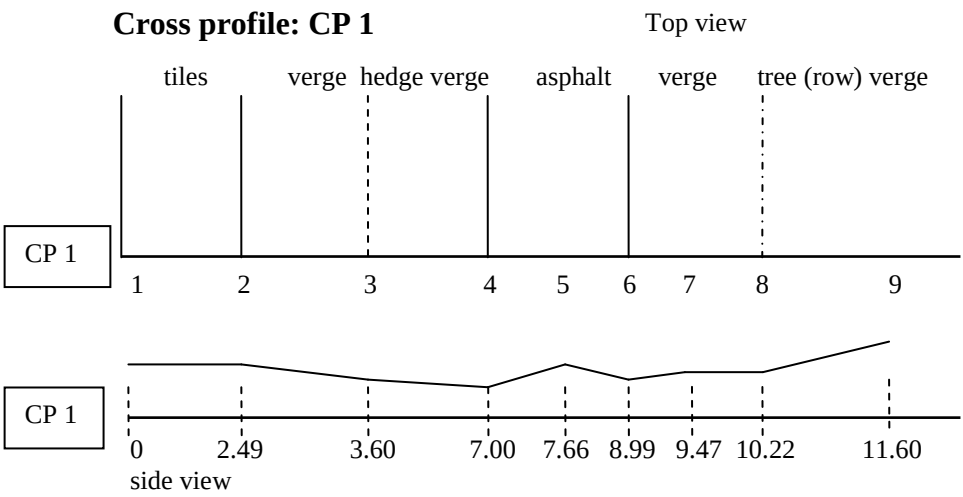
If you can't measure a point directly with the tachymeter, there are three possibilities to measure indirectly:

- Offset of the tachymeter measuring; the positioning code in PC is (in 2D) 52, 54, 56, 58 and (in 3D) 51, 59.
- A construction at the 2 previous points with measuring tape and offset. The positioning code in PC is (in 2D) 72, 74, 76, 78 and (in 3D) 71, 79. If necessary you can construct a suitable base line through dummies. The construction is also useful for GPS measurement.
- Encircle; when the prism can't be placed on the wanted position, at a tree for instance. You measure first the distance to the prism that represents the real distance from tachymeter to the tree. Then you aim, holding the fixed distance, at the tree. With REC you can registrate the correct corresponding horizontal angle together with the other information. In this way it is like measuring with ALL.

NB. The adjustable offset as instrument setting is a fixed addition to the slope distance, often only mentioned as prism constant. This offset is mentioned together with the ppm in the measuring file, only for information. The offset meant in Finitor is used for calculation regardless to the instrument settings. Whether the offset in Finitor is a (positive) horizontal or slope measure depends on the code.

Chapter 9 Profiles

There are two sorts of profiles in Finitor: transversal (cross) section and longitudinal (length) section.
In the case of a transversal section, a fictive plane is thought right across a road, a ditch, etc. The drawing of the section line of that plane and the surface of the road is called diagram or profile. The plane is determined through the beginning and endpoint of the section. The points measured in between are projected on that plane. The code in PC is 83.
The longitudinal section however follows the direction of the road. The fictive vertical plane bends at the measured points of the surface of the road. The total length in the diagram is a sum of the line pieces between the points. For the precision of that length the prism must be placed accurately on the axis of the road. The position code in field PC is 82.
The position of the profiles is drawn in the topography. The profiles as diagram are displayed in a separate drawing.



The points 2- 8 are projected on the straight between point 1 and 9. The use of double codes concerns the pavement and the addition of symbols.
Encoding CP number 1 is as follows:

Pointnr	OC	LC	PC	MEAS	REF
1	93	0	83	1.79	1
2	99	0	83	1.79	1
3	9962	0	83	1.79	1
4	91	0	83	1.79	1
5	91	0	83	1.79	1
6	99	0	83	1.79	1
7	99	0	83	1.79	1
8	9960	0	83	1.79	1
9	99	0	83	1.79	1

Figure 8: Cross profile: CP 1

Measuring a profile is indicated by code 83 or 82 in PC. 83 is used for transversal section, 82 is used for the longitudinal section. For the

rest the encoding is similar for both types. Profile numbers must be different for the two types.
All profile points have to be directly measured, without constructions. So all points have to be seen by the tachymeter or reached by the GPS receiver.
The number of the profile is given in REF. Only whole numbers are allowed. The first point of a profile does not have a special code, nor has the last point. The length measure of the profile starts from the first point, unless another point is marked as starting point. That point has to be marked with object code 00, in addition to the pavement code. The order of measuring determines automatically the order of processing. It is not necessary to complete the current profile before you start a new profile. You can treat a profile point as a detail point, interrupted through other points or a new station setup. For each point you have to indicate (in OC) the pavement (the surfacing), looking forwards. The features of the blocks in the profiles are different from the blocks with the same number in the topography. However, the meaning is the same. A tree in the topography represents the top view; the tree is seen in profile in side view. See appendix.
A second line can be drawn in a profile, also a third or more. The first line has layer code 00 in LC, the second code 01 and so on. The first point of the second line, joined with the continuing first line, can be started by layer code 0100. It could also be 0001, but the program doesn't know whether the zeros are filling zeros or are actually given in.

The encoding of a profile number 3, beginning at the hedge along the tiled path is:

OC 6293 [enter] LC 0 [enter] PC 83 [enter] MEAS 1.79 [enter] REF 3[enter] ALL

When the profile reaches the water of a ditch, you might start a

second line. It's up to you what you are keeping as first (main) line (the waterline or the bottom line). It will be determined by the fact that the dimensioning in the drawing is only applied to the main line. The encoding, with the choice for the bottom of the ditch as first line, is as follows:

OC 9899 [enter] LC 0100 [enter] PC 83 [enter] MEAS 1.79 [enter] REF 3[enter] ALL

Objects can be represented by block 90 on a given layer.
The layer ID is a number greater than 10. You can put the blocks 90 on different layers to a selection in the drawing.

Chapter 10 Notes on possibilities of Tools.

Tools in Finitor are extra operations or calculations on behalf of the surveyor or setting out engineer.

Intersection of two straight lines.

The intersection of two straight lines is often meant as an x-y intersection. The z value is in that case neglected. The z value of the x-y intersection is then the mean of the two values on the lines at the intersection. In a 3D situation (x y z with the same weight) where the straight lines are crossing, we are searching the nearest point to both lines. That point is the middle of the shortest distance.

Regression.

Regression is the name for calculating the best fit function (for example a straight line) through measured points. "Best fit" means that the sum of the squares of the distances from the measured points to the line a minimum is. The distances are supposed to be small inevitable deviations characterized by the normal distribution. The surveyor should be aware of obvious faults in the observations. These faults must be omitted in the calculations. It is not always easy to determine a deviation as a fault.
The calculation can be applied to four cases; straight line, plane, circle, sphere. The straight line can be calculated as a 3D line or as the projection on the x-y plane.

Transformation.

Transformation is in Finitor the name for homogeneous coordinate transformation. A set of coordinates is converted (as a whole, without scaling or deforming) to another coordinate system trough rotation and translation. The best fit solution is found with the least square method (regression). The sum of the squared deviations between all corresponding points has to be a minimum. The corresponding points must have the same numbers. The minimized

deviations, also named residues, are mentioned in a report file.
Topographic measuring will mostly deal with x-y transformation (2D with a z). The z-value can be regarded as an “independent” addition. The transformation can be done separately for the x-y coordinates and the z-coordinate. In case of a really 3D object (x y z with the same weight) the transformation is calculated in one pass.
A 3D object can be fixed on a zero plane trough 3 points.

Clothoid.

The clothoid is the mostly used transition curve between a straight line and an arc (circle part). The complete standard clothoid has a fixed length. If the clothoid does not fit between the tangent points, the clothoid will be lengthen or shorten at the start point. The lengthening or shortening must be small. It results in a bend at the connection.

Appendices

Appendix I: Tables of Layer codes and Object codes

(just as an example)

Table 1

Layer codes (LC):	**Meaning:**
Standard Layers:	
00	General
01	Buildings
02	Infrastructure, Artefacts
03	Hedge
04	Road pavement
05	Water
06	Fence
07	Green
08	Level, talus line
09	Dashed line
83	Profile
99	Used in block composition
Layer codes for profile lines	
00	Main line (dimensioned)
01	One additional line
02	Another additional line
03	etc.

Table 2

Object codes for lines (OC):	**Meaning:**
.#	Starting a line (# = number 1-9 or letter)
0#	Following an existing line #
-#	Closing a line #
1#	Middle of arc or second circle point
2#	End of arc
3#	Third (last) point of a circle
4#	Third point of an open rectangle, U form (optional adjusted)
4#-#	Third point of a closed rectangle

Appendix II: Table of positioning codes

Table 3

Positioning codes (PC):	**Meaning:**
Control Point:	
35 (tachy)	Station setup (39 at free station)
45 (tachy)	Orientation (46 at Face II, 47 checking, 49 additional)
48	Auxiliary control point
Direct 2D:	
55	Direct positioning (measuring without offset)
Offset2D:	Offset on tachymeter line (offset is horizontal measure)
52 (tachy)	Shortening (horizontal distance)
54 (tachy)	Turn left (seen from the tachymeter)
56 (tachy)	Turn right
58 (tachy)	Lengthening
Offset 3D:	Offset on tachymeter line (offset is slope measure)
51 (tachy)	Shortening the SD
59 (tachy)	Lengthening the SD
Construction 2D:	Offset on previous points (offset is horizontal measure)
75	Repeat the coordinates of a known point
72	Backgoing (horizontal, seen in the direction of the base line)
74	Turn left
76	Turn right
78	Furthergoing
Construction 3D:	Offset on previous points (offset is slope measure)
71	Backgoing (3D slope distance)
79	Furthergoing

Height :	
85	Direct positioning (as 55) with leveling
82	Length profile (Longitudinal section)
83	Cross profile (Transversal section)
Height Control Point:	
81 (tachy)	Back staff on first control point of a track
84 (tachy)	Fore staff
88 (tachy)	Back staff
89 (tachy)	Fore staff on last control point of a track

Appendix III: Table of Block codes

Table 4

Block codes (OC):	Meaning:	Abbreviation:	Layer:
50	Lamp post (also in profile)	lp	4
51	Pole (pile work in profile)	pl	2
52	Tube	tu	2
53			
54	Threshold	td	
55	Electra	elec	2
56			
57			
58	Flagstaff	fs	2
59			
60	Tree (also in profile)	tr	7
61	Tree (fruit)	tr	7
62	(hedge in profile)		
63	Switch-cupboard	s	2
64	Pump	p	2
65	Water tap	w	2
66	Fire cock	f	2
67	Oil	ol	2
68	Gas	g	2
69			
70	Sign	si	4
71			
72			
73			
74			
75	Indicator	in	2
76			
77	Dummy	dum	Dum

78			
79			
80	Manhole cover	mh	2
81	Drain	d	4
82			
83			
84			
85			
86			
87			
88			
89			
90	Undetermined (also in profile)	REF	0
91	Asphalt (also in profile)	*symbol*	4
92	Bricks (also in profile)	*symbol*	4
93	Tiles (also in profile)	*symbol*	4
94	Concrete (also in profile)	*symbol*	4
95	Gravel (also in profile)	*symbol*	4
96	Stones (also in profile)	*symbol*	4
97	Vegetation	*symbol* veg	7
98	Water (also in profile)	*symbol*	5
99	Undefined (Blanco in profile)	circlet	99

Appendix IV: Overview of file extensions

Table 5

Extension	Meaning	Remark
avglog	Log of averaging coordinates	
bli	Block settings	Program file
blo	Used blocks in dxf files, for block list	Program file
bmn	Tree names	Program file
cal	Calculation	
callog	Log of Measurement to Calculation	
caplog	Log of calculation auxiliary control points	
cfp	Control points	
cfplog	Log of calculation control points	
chp	Height control points	
chplog	Log of calculation height control points	
coo	Coordinates	
coolog	Log of import to Coordinates	
cpt	Coordinates from Calculation	
div	Coordinates differences	
dxf	Digital drawing	
dxflog	Log of Calculation to dxf	
mes	Measurement	
meslog	Log of import to Measurement	
obs	Traverse Observations in Move format	
prj	Project file in MOVE format	
pro	Profile points from Calculation	
prolog	Log of Calculation to profile drawing	
sor	Sorted coordinates in cpt	
tco	Control points in Move format	
translog	Log of transformation	
wfp	Traverse Observations	