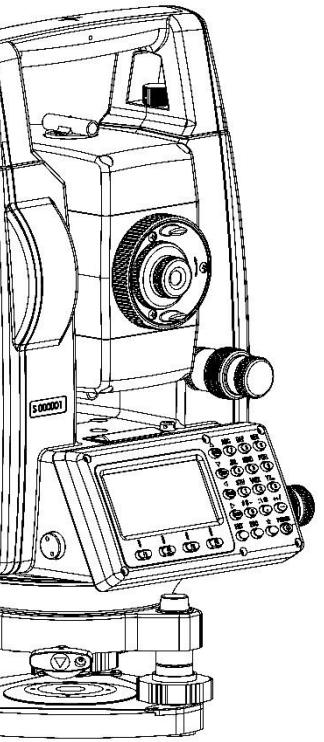
Operation Manual



N6+ Series

Mechanical Total Station

SOUTH

Target your success

INDEX

1. SPECIFICATIONS

1.1 EDM

Carrier Wave	0.65~0.69μm
Effective Range of Bluetooth	10m
Reflectorless Range	1000m/1500m optional
Oscillation Frequency	150MHz
EDM Type	Coaxial
Minimum Reading for Distance	0.1mm
Laser Dot without Reflector (Red laser beam)	Around 7mm×14mm/20m
	Around 10mm×20mm/50m
Atmosphere Correction	Manual Input, Auto correction
Earth Curvature Correction	Manual Input, Auto correction
Prism Constant	Manual Input, Auto correction
Dist.Unit	Meter/US.Feet/International Feet/ Feet-inch optional
Average Measure Time	3 Times

Distance Measurement		
Accuracy With Reflector		
Measure Mode	Accuracy	Time
Fine Mode	$\pm(2+2\times10^{-6}\cdot D^{*1})$mm	<0.3s
Tracking Mode	$\pm(5+2\times10^{-6}\cdot D)$mm	<0.1s
IR Sheet Mode	$\pm(2+2\times10^{-6}\cdot D)$mm	<0.3s
Accuracy w/o Reflector ***with Kodak Gray Card White Side (90% reflective)**		
Fine Mode <500m	$\pm(3+2\times10^{-6}\cdot D)$mm	0.3~3s in normal, less than 10s
Fine Mode >500m	$\pm(5+2\times10^{-6}\cdot D)$mm	

Tracking Mode	$\pm(10+2\times10^{-6}\cdot D)$mm	
Max. Range		
With Reflector	Single Prism	5000m
*2 Good Conditions	IR Sheet	1000m
Without Reflector	White*3	1000m
*2 Good Conditions	Gray Degree 0.18	450m
*1 D= distance in mm *2 Good Conditions: slight haze, visibility about 20km *3 Kodak Gray Standard (90% reflective)		

1.2 Others

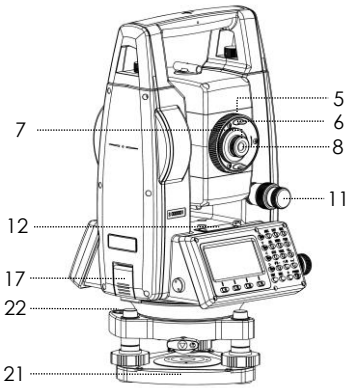
Angle Measurement	
Measuring Method	Absolute Encoding
Diameter of Encoding Disk	79mm
Minimum Reading for Angle	0.1"/1"/5"/10"optional
Accuracy	2.0"/5.0"
Telescope	
Image	Erect
Tube Length	154mm
Effective Aperture	45mm (EDM:50MM)
Magnification	30x
Field of View	1°30'
Minimum Focus Distance	1.2m
Resolving Power	3"
Compensator	
System	Dual axis liquid-electric
Working Range	±4'
Accuracy	1"

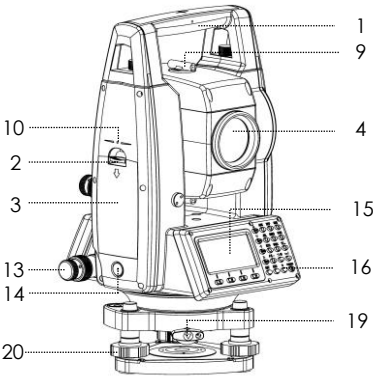
Vial	
Plate Vial	30"/2mm
Circular Vial	8'/2mm
Laser Plummet	
Accuracy	±1.5mm(at 1.5m)
Optical Plummet (OPTIONAL)	
Image	Erect
Magnification	3 x
Focusing Range	0,5m~∞
Field of View	5°
Display Unit	
Type	6 Lines LCD screen
Data Communication	
Port	USB Stick up to 256G, Bluetooth
Battery	
Type	Rechargeable Lithium battery
Voltage	7.4V DC, 3100mAH
Continuous Operation Time	10 hrs
Working Environment	
Temperature	-20℃~+50℃
Dimension	
Size	190mm×195mm×335mm
Weight	5.5kg

* The manufacturer reserves the right to make technical changes without prior notice *

2. BRIEF INTRODUCTION

2.1 Appearance

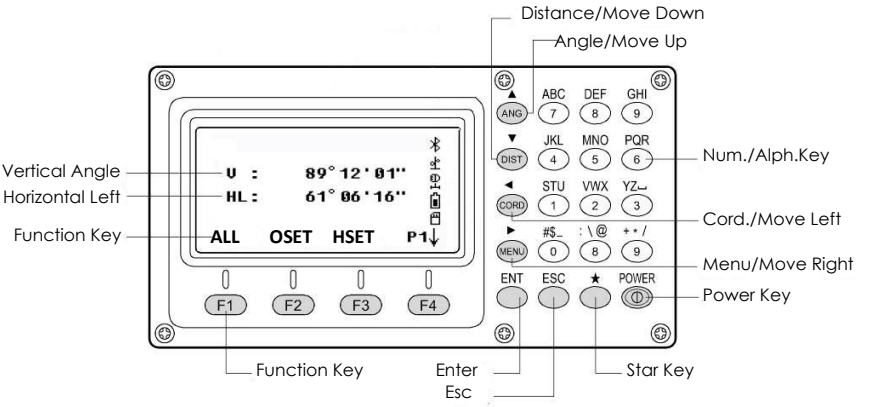




1	Handle
2	Battery Lock
3	Battery
4	Optical Unit
5	Optical Focusing Ring
6	Eyepiece Handle
7	Eyepiece Focusing Ring
8	Eyepiece
9	Collimator
10	Central Mark
11	Vertical Clamp and Tangent Unit

12	Vial Bubble
13	Horizontal Clamp and Tangent Unit
14	Trigger Key
15	Display Unit
16	Power Key
17	USB Comm Port
18	Circle Bubble
19	Tribrach Lock
20	Leveling Screw
21	Base

2.2 Keyboard



Key	Name	Function
★	Star key	Enter the star mode
ANG	Angle	Enter the angle measurement mode
DIST	Distance	Enter the distance measurement mode
CORD	Coordinate	Enter coordinate measurement mode
MENU	Menu	Enter menu
ESC	Esc	Cancel operation, or return to the last page
⏻	Power key	Power ON/OFF
F1 ~ F4	Function key	Functions correspond to information displayed
0 ~ 9	Number keys	numbers/characters, or select items/hot keys
◄ ► ▲	Move keys	Move the cursor to the left, right, up and down
ENT	Enter	Confirm the data, or go down to next item

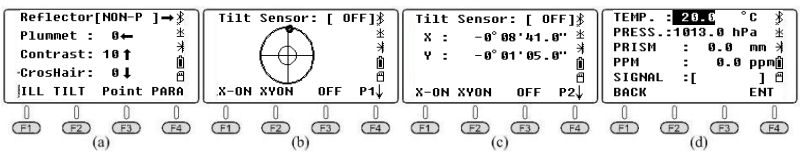
The icon shown as below:

Icon	Meaning	Operation
	Dual sensor	★ F2 F2
	Single sensor	★ F2 F1

	Sensor closed	★ F2 F3
	Bluetooth	Bluetooth on.
	Reflectorless mode	★ ►
	Reflector mode	★ ► ►
	Reflector sheet	★ ► ► ►
	Battery voltage	Display the battery voltage in real time

2.3 Star Key

Press **[★]** to activate the Star Key menu, press direction key **[▲] [▼] [▶] [◀]** to move the cursor, press function keys to operate. Press **[ESC]** to exit the menu.



(1) Direction keys

Reflector: the default setting is NON-P. Press **[▶]** to switch among Prism, Sheet and Non-prism mode.

Plummet: the intensity for laser plummet. Press **[◀]** to switch the value among 2→1→0→4→3→2, 0 means off.

Contrast: the default value is 10. Press **[▲]** to switch the contrast for LCD screen among 10→11→……→16→00→01→02……→09→10.

CrosHair: Illumination for crosshair (reticle unit). The default value is 0. Press **[▼]** to switch the value among 0→1→2→3→4→0, 0 means off.

(2) Function keys

F1 **ILL:** Illumination for LCD screen and keyboard. The default

setting is on. Press **[F1]** to open or close the illumination.

F2 **TILT:** On/Off the tilt sensor. The default setting is dual-axis sensor. Press **[F2]** to enter 1/2 page. Then press **[F1]** X-ON for single X-axis compensation, press **[F2]** XYON for dual-axis compensation. Press **[F3]** OFF to close the compensator. Press **[F4]** to enter 2/2 page. It will display the compensate value on current position.

F3 **Point:** On/off laser pointer. The default setting is off. Press **[F3]** to switch the laser pointer between on and off.

F4 **PARA:** Parameter setting menu.

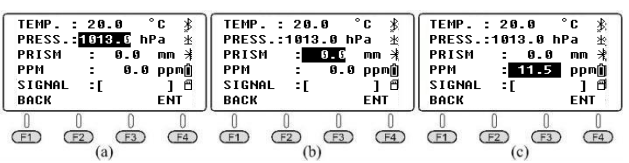
Input the value of temperature and atmosphere pressure. It will calculate the PPM automatically based on the atmosphere correction.

Reference value: Temperature 20℃, pressure P=1013hPa

Calculation formula: $$PPM = 278.44 - \frac{0.294922P}{1+0.003661t}$$

Users can also calculate the PPM value based on the formula by themselves and input the value by manual.

Note: a) Input range for temperature :-30℃~+60℃, increased by 0.1 ℃ ; Input range for atmosphere pressure560~1066hPa, min.0.1hPa increase. B) Input range for PPM is -999.9~999.9ppm.



2.4 Hot Keys

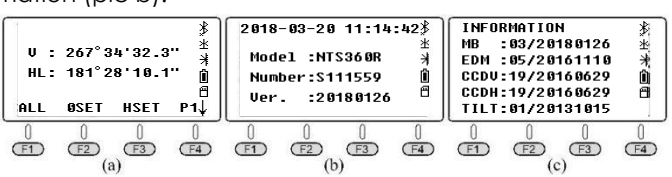
When the total station is under the basic measurement surface, click the numeric keyboard to quickly access to the other pages.

Key	Quick Access To
0	Stake Out
.	Tilt Sensor
-	Data Confirm
1	Memory MGR.
2	View Meas File
3	View Coord File
4	Resection
5	Created Meas & Coord File
6	Read Coordinate File
7	STN Setup
8	BS setup by coordinate
9	BS setup by angle

2.5 System Information

Hold the power key in 1s to power on. The initial page is the angle measurement mode (pic a), press **[ESC]** to enter the system information page (pic b).

Press **[Menu]** - **[F4]** P2 - **[3]** Information to check the hardware information (pic b).



3. PREPARATION

3.1 Preparation

Unpacking

Lay down the case lightly with the cover upward. Unlock the case and take out the instrument.

Storage of Instrument

Cover the cap, put the instrument into the case with the vertical clamp screw tightened and circular vial upwards (lens towards tribrach).

3.2 Instrument Setup

1) Setting up the tripod

A. Loosen the screws on the tripod legs, pull out to the required length and tighten the screws.

B. Make the center of tripod and the occupied point approximately on the same plumb line.

C. Step on the tripod to make sure if it is well stationed on the ground.

2) Instrument setup (Laser plummet)

A. Place and fix the instrument carefully on the tripod

B. Press **[★]** and turn on the laser plummet. Hold the two legs which are not fixed on the ground and decide the position to fix according to the laser dot. When the laser dot is roughly on the station point, fix those 2 legs.

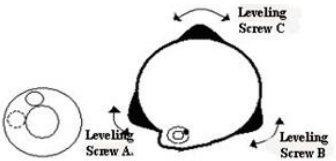
Instrument setup (Optical plummet)

Adjust the eyepiece of the optical plummet telescope to your eyesight. Slide the instrument by loosening the tripod screw; place

the point on the center mark of the optical plummet. Sliding the instrument carefully as to not rotate the axis will allow you to get the least dislocation of the bubble.

3) Roughly leveling by the circular vial

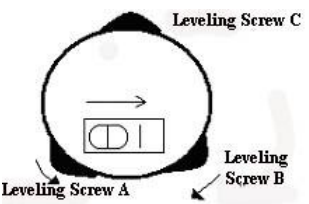
A. Rotate the foot-screw A and B to move the bubble in the circular vial, in which case the bubble is located on a line perpendicular to a line running through the centers of the two leveling screw being adjusted.



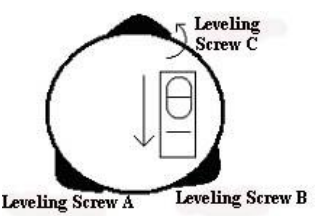
B. Rotate the foot-screw C to move the bubble to the center of the circular vial.

4) Leveling by the plate vial

A. Rotate the instrument horizontally by loosening the horizontal clamp unit and place the plate vial parallel to the line connecting rotating the foot-screw A and B, and then bring the bubble to the center of the plate vial by rotating the foot-screw A and B.



B. Rotate the instrument in 90° (100gon) around its vertical axis and turn the remaining leveling screw or leveling C to center the bubble once more.



C. Repeat the steps and check whether the bubble is correctly centered in all directions.

If the laser or optical plummet doesn't stay at the center position after levelling, please slightly loosen the screw under the tripod head and move the instrument (don't rotate the instrument) until the equipment is on the station point. Tighten the screw and level the instrument again. Repeat these steps until the instrument is precisely centered and leveled.

Note: You can also level the instrument precisely by the E-bubble. When the tilt is over ±4', the system will enter the adjusting page of tilt sensor automatically.

3.3 Battery

Inserting

Put the battery into the instrument. Check and insert it correctly to side into the housing.

Replacing

Press the battery lock on the top of batter case, then remove the battery. When the remaining voltage is less than one grid, please stop your operation and charge it as soon as possible.

Before remove the battery from the instrument, make sure that the power is turned off. Otherwise, the instrument may be damaged.

Charging

The battery must be charged prior to using before the first time

operation.

The battery LB-01 should be charged only by the official charger NC-10, which packed together with the instrument. Please connect the power supply in 110V - 220V, among 0°~±45°C.

When the indicator on the charger is red, the charging process has begun. When indicator turns green, the charging has finished. For safety, please pull out the battery and charger in time.

In order to get the maximum service life, please charge the battery at least once in a month.

Note:

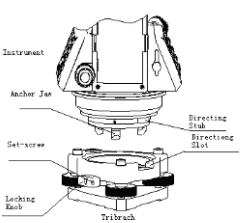
a) *The operating time depends on the outside conditions, such as ambient temperature, charging time, the cycles of charging, etc. It is recommended for safety to charge the battery beforehand or to prepare spare full-charged batteries.*

b) *The remaining voltage of battery shows the power regarding to the current measure mode. The consumption of distance measurement is higher than angle measurement in normal. When switching the measurement mode from angle to distance in a low battery voltage, the equipment might be interrupted.*

3.4 Tribrach

Dismounting

If necessary, the instrument can be dismounted from tribrach. Turn the locking knob in 180° counter-clockwise to disengage anchor jaws, and take off the instrument.



Mounting

Insert three anchor jaws into holes of tribrach and line up the directing stub. Turn the locking knob about 180° clockwise to mounting the instrument.

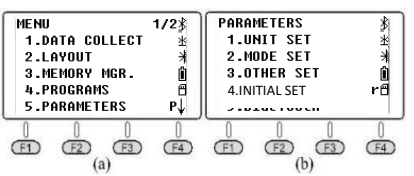
3.5 Eyepiece Focusing

Sight the Telescope to bright place and rotate the eyepiece tube to make the reticle clear. Roughly collimate the target by the top of the triangle mark on EDM cover.

Rotate the focusing screw on eyepiece to make the image clear.

3.6 Parameters

Press **[Menu]**-5.Parameters to set the total station.



3.6.1 Unit Set

3.6.1.1 Feet

Select the unit of N6+ total station between international feet and USA fee. 1 international feet = 0.999 845 6 USA feet.

3.6.1.2 Angle

Select the angle unit among DEG(degree), GON and MIL. The default select is DEG. 360 DEG = 400 GON = 6400MIL.

3.6.1.3 Distance

Select the distance unit among Meter, Feet and Feet.Inch. 1 Meter = 3.280839895 Feet, 1 Feet = 12 Inch.

3.6.1.4 Temp.&Press

Select the unit of temperature and pressure.

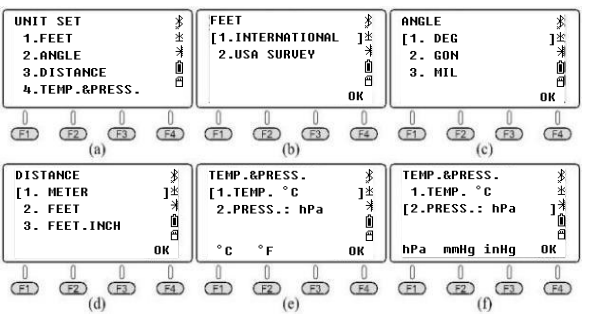
① Temperature Unit

When the cursor remain at the 1st line, press **[F1]℃** or **[F2]℉** to select the unit of temperature. Press **[F4]OK** to confirm.

The default select is ℃.

② Pressure Unit

When the cursor remain at the 2nd line, press **[F1]hPA**, **[F2]mmHg**, or **[F3]inHg**, and press **[F4]OK** to confirm. The default select is hPa.



3.6.2 Mode Set

3.6.2.1 Power On Mode

Select the initial page when power on the equipment.

The default page is "Angle Measure".

3.6.2.2 Dist Mode

Select the measure mode among Fine[S] (single), Fine[3] (3 times), Fine[R] (Repeat) and Tracking mode. Press **[F4]OK** to confirm. The default set is Fine[S].

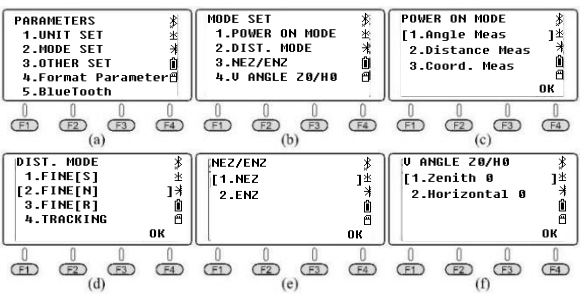
3.6.2.3 NEZ/ENZ

Select the display order of the coordinates by NEZ or ENZ. Press **[F4]OK** to confirm. The default set is NEZ.

N stands for the X coordinate, E stands for the Y coordinate, and Z stands for Height H.

3.6.2.4 V Angle Z0/H0

Set the vertical angle as zenith 0 or horizontal 0. Press **[F4]OK** to confirm. The default set is zenith 0.



3.6.3 Other Set

3.6.3.1 Min Angle Read

Press 1/2/3/4 to select the minimum angle reading among 1s, 5s, 10s and 0.1s. The default set is 1s.

3.6.3.2 Min Dist Read

Press 1/2 to select the minimum distance reading between 1mm and 0.1mm. The default set is 1mm.

3.6.3.3 Face in L or R

Press 1.Differ to keep the unequal coordinate between HL/HR direction. Press 2.Equation to keep the equal coordinate, no matter in HL/HR direction. The default set is Equation.

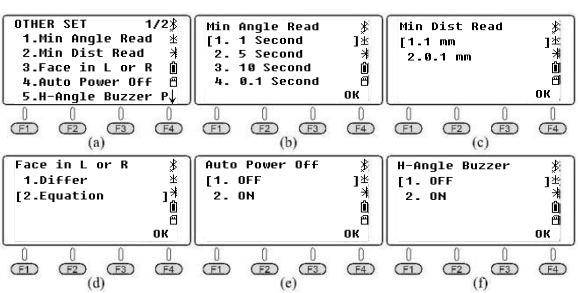
If the equipment has been set as "Equation". In HR measurement, the system will use HR±180°as the azimuth angle to calculate the coordinate. If the equipment has been set as "Differ", in HR measurement, the system will use the actual direction as the azimuth angle. In other words, the difference between the two mode is 180°, the azimuth angle from occupied point to the target.

3.6.3.4 Auto Power Off

Press 1/2 to OFF/ON the function of auto power off. If you select "ON" to open the function, the equipment will power off automatically in 30mins without any operation. The default set is OFF.

3.6.3.5 H-Angle Buzzer

Press 1/2 to OFF/ON the function of horizontal-angle buzzer. When the h-angle is in the range of 0°±4°30', 90°±4°30', 180°±4°30', 270°±4°30', the equipment will activate the buzzer. The default set is OFF.



3.6.3.6 Meas Buzzer

Press 1/2 to OFF/ON the function of measurement buzzer. The equipment will activate the buzzer when the measurement has finished in each time. The default set is ON.

3.6.3.7 W-Correction

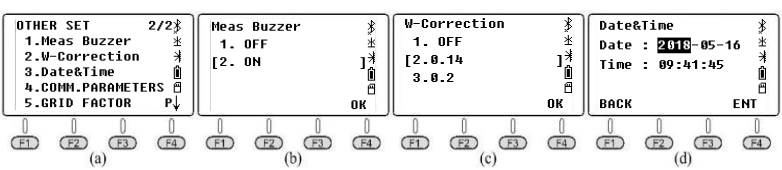
Press 1.OFF to off the w-correction. It will set the w-correction, k=0; Press 2.0.14 to set the w-correction, k=0.14; Press 3.0.2 to set the w-correction, k=0.2. The default value is 0.14

*k is the earth curvature and atmospheric vertical refraction coefficient, also known as w-correction.

3.6.3.8 Date & Time

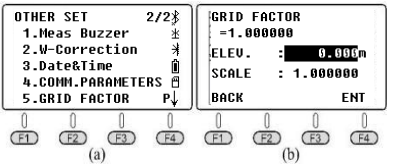
Input the current date and time by numeric keys. Press F4 OK to confirm.

The inside clock of total station is supported by the battery on mainboard. The date and time you inputted will not disappear even power off the equipment. Only if the equipment has been reserve without operation in a long-term, the battery on mainboard will exhaust and lose the data. The battery LB-01 will charge the mainboard automatically so long as power on the equipment in 3-4hrs.



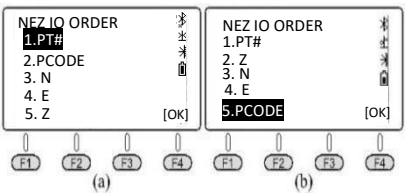
3.6.3.9 Grid Factor

The default value of grid factor is μ=1.



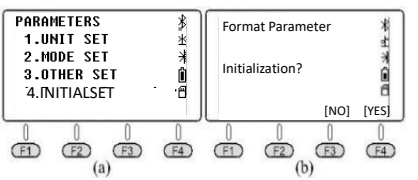
3.6.3.10 IMP/EXP Order

Set the import and export order of coordinate. Press the left or right navigation to switch the settings.



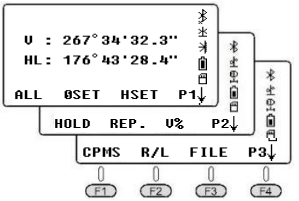
3.6.4 Initial Set

Press 4.Initial Set to recovery to initial settings.



4. ANGLE MEASUREMENT

When power on the equipment, N6+ will enter the angle measurement mode automatically.



Press **[ANG]** to enter the angle measurement mode.

4.1 [F1] ALL

Measuring and saving the data of angle.

Q.: Setup a station at Point A, how to measure the horizontal angle for Target B/C by multiple round observation?

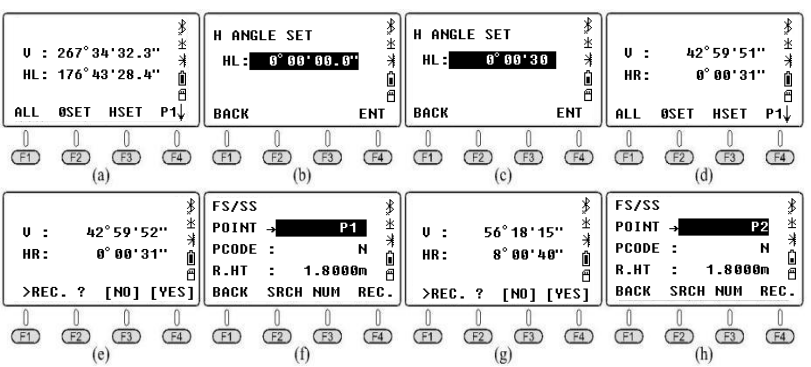
a) Aim at target B in Horizontal Left (HL), press **[F3] HSET** , input value as 0°00' 30".

Press **[F1] ALL**, and **[F4] YES** to record the result of HL. Input point name for target B. Press **[F4] REC** to save the data under the current file.

b) Rotate the equipment in clockwise direction to aim at target C.

Press **[F1] ALL**, and **[F4] YES** to record the result and name the point.

Press **[F4] REC** to save the data.



c) Rotate the EDM in vertical direction in Horizontal Right. Aim at target C. Press **[F1] ALL**, and **[F4] YES** to record the result of HR and name the point. Press **[F4] REC** to save the data.

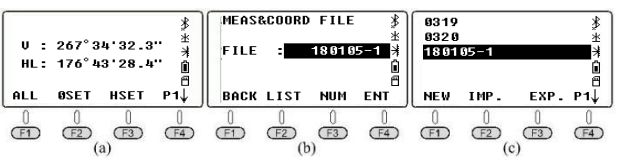
d) Rotate the equipment in anti-clockwise direction to aim at target B. Press **[F1] ALL**, and **[F4] YES** to record the result and name the point. Press **[F4] REC** to save the data.

In the second round, input HSET value as 90°00' 30". Measure and record the data as the above steps. ∠BAC can be calculated as below:

Station	Target	HA	Reading	Half-round	Whole-round	Average
1st Round	B	HL	0° 00' 28"	138° 14' 22"	138° 14' 19"	138° 14' 19.5"
	C		138°14' 50"			
	B	HR	180° 00' 31"	138° 14' 16"		
	C		318° 14' 47"			
2nd Round	B	HL	90° 00' 26"	138° 14' 25"	138° 14' 20"	
	C		228° 14' 50"			
	B	HR	270° 00' 31"	138° 14' 15"		
	C		48° 14' 46"			

e) Export the file by USB stick:

Press **[F4] P1/P2** turn to page 3, then click **[F4] FILE** - **[F2] LIST** – **[F3] EXP** to export the data of the current file "180105_1" :



180105_1_600.txt Format 600 file

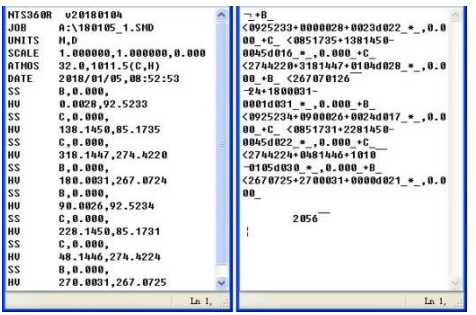
180105_1_300.txt Format 300 file

180105_1.dat Coordinate file for SOUTH CASS

180105_1.csv Coordinate file for SOUTH CASS

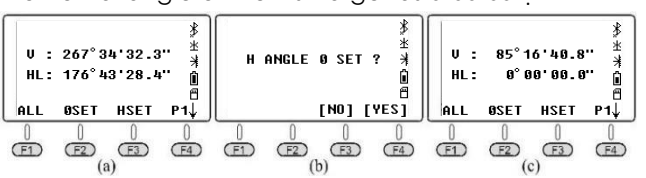
There are some differences between format 600 and format 300.

Check the picture shown as below. 600.txt included the data in two lines for each measured point. SS line is Point Name, Target Height, Code; while HV line is Horizontal Reading and Vertical Reading.



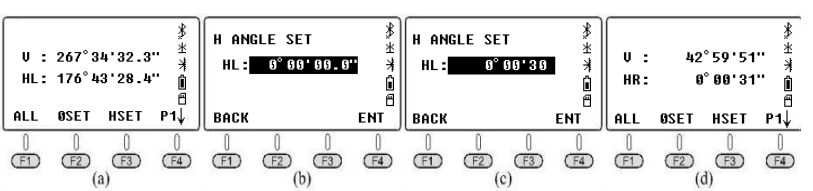
4.2 [F2] 0 Set

Set the horizontal angle of the first target as 0°00'00".



4.3 [F3] H Set

Input the horizontal angle by manual. The value will apply to the target. The input format is 123.4567. 123 means degree. Range is from 0-359. 45 is minute from 0-59. 67 means second from 0-59.



4.4 [F1] HOLD

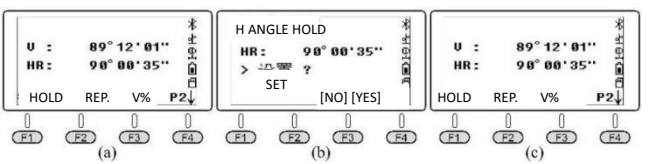
Define and hold the horizontal angle of target as previous value.

Q.: How to "hold" the angle reading in 90°00'00"?

a) Rotate the equipment and make the horizontal angle near to 90° 00'00" , then adjust the tangent screw until it's fully reached the value.

b) Press **[F1] HOLD**, enter the Horizontal Angle setting page. Then loosen the horizontal tangent screw to aim at the target. In this moment, the horizontal angle will not change.

c) Press **[F4] YES** to confirm the setting.



4.5 [F2] REP.

[REP.] is the abbreviation of repeat measurement. It requests the measurement under horizontal right, under the clockwise direction.

Suppose that the total station has been setup at point A, the guidance of repeat measurement as below:

a) Aim at target B (pic a), press **[F2] REP.** The HR is 0°00' 00" (pic b).

b) Rotate the equipment in clockwise direction, aim at target C (pic c) and press **[F4] HOLD** (pic d).

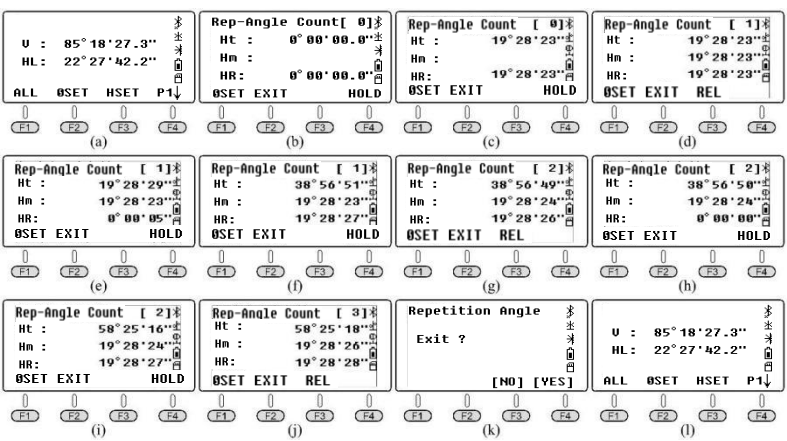
c) Rotate the equipment in clockwise direction, aim at target B in the second time, press **[F3] REL.** to release (pic e).

d) Rotate the equipment in clockwise direction, aim at target C in the second time (pic f), press **[F4] HOLD**, it will show us the horizontal value of ∠BAC during this two times, the average value is 19°28' 24"(pic g).

e) Rotate the equipment in clockwise direction, aim at target B in the third time, press **[F3] REL.** (pic i)

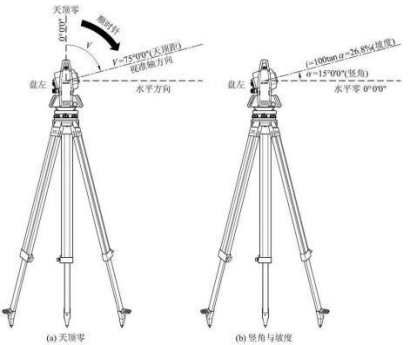
f) Rotate the equipment in clockwise direction, aim at target C in the third time, press **[F4] HOLD**. It will show the horizontal value of ∠ BAC during this three times, the average value is 19°28' 26" (pic j)

g) Press **[F2] EXIT** and **[F4] YES** to exit the menu.



4.6 [F3] V%

Switch the reading of vertical angle from vertical degree to percent.



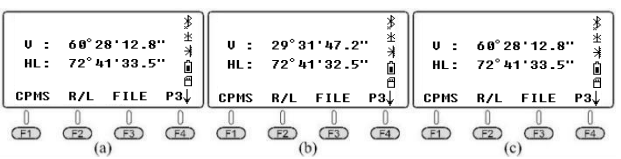
As picture shown, if the vertical reading has been set as Zenith 0, HL= 75°00' 00".

aL=90°−L=90°−75°00'00"=15°00' 00"

The slope angle i=100×tan 15°00'00"=26.7949 %≈26.79%.

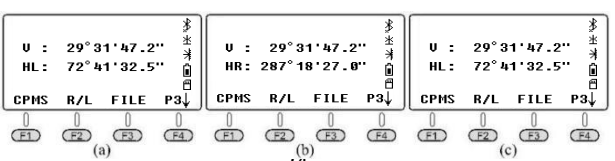
4.7 [F1] CPMS

Switch the display format of vertical angle. The angle of depression is negative number while the elevation angle is positive number.



4.8 [F2] R/L

Switch the horizontal angle between Horizontal Right and Left. In same direction, HR + HL = 360°

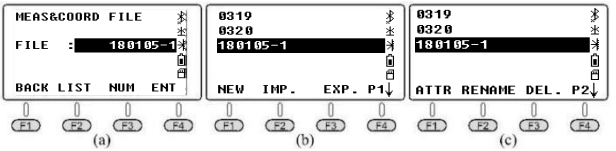


4.9 [F3] FILE

In this page, we can change the current job, create a new job, rename or delete the existed job, export or import data.

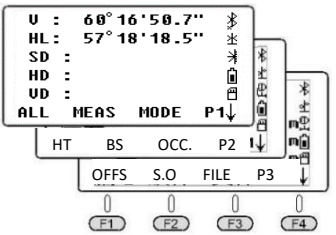
Press **[F3] FILE** , **[F2] LIST** to enter the profile list, or press **[F3] NUM/ALPH** to create a new job.

[F1] NEW: Create a new job.
[F2] IMP.: Import the data from USB flash disk to total station.
[F3] EXP.: Export the data from total station to USB flash disk.
[F1] ATTR: Check the file name, create time and date.
[F2] RENAME: Rename the selected file.
[F3] DEL.: Delete the selected file.



5. DISTANCE MEASUREMENT

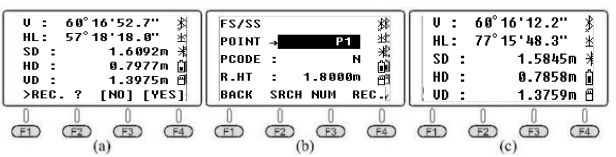
Press **[DIST]** to enter the distance measurement mode.



5.1 [F1] ALL

Measure and record the distance.

N6+ will calculate the coordinate of target based on the current station, instrument height and target height, then it will be recorded in coordinate file and measurement file.

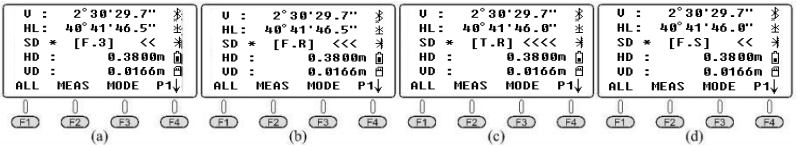


5.2 [F2] MEAS

Measure the current target without recording.

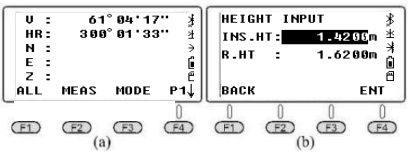
5.3 [F3] MODE

The default measure mode is single. Press [F3] MODE to switch the measure mode among [F.S], [F.3], [F.R], [T.R].



5.4 [F1] HT

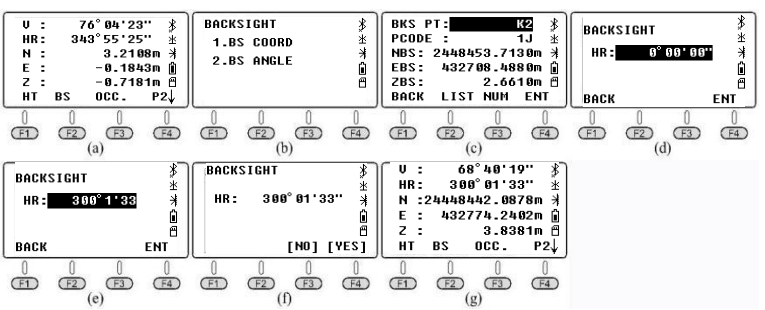
Set the instrument height or target height (pic b).



5.5 [F2] BS

Orient the backsight by point or angle. Select the existed point or enter the angle 300.1.33 to define the backsight.

Rotate the equipment to aim at the target K2. Press **[F4] YES** to set the orientation of backsight.

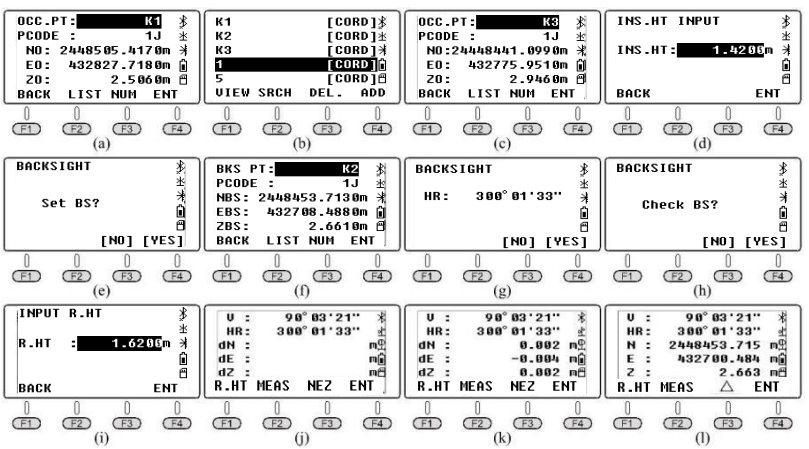


5.6 [F3] OCC.

Press **[F3] OCC** to enter the setting page for occupied point (pic a), it will show the coordinates of the last occupied point.
Press **[F2] LIST** to enter the list of points. (pic b)

Move the cursor to K3 and press **[ENT]** to select it. it will show the details of this point, including the code and coordinate. Press **[ENT]** and input the instrument height and the backsight. (pic e).

The horizontal angle - HR should be the angle from K3 to K2 (pic g). Rotate the equipment, aim at the target of backsight K2, press **[F4] YES** to set the orientation.



Check BS

After the orientation of backsight, press **[F1]R.HT** to input the prism height. Press **[F2]MEAS** to measure the backsight again. The

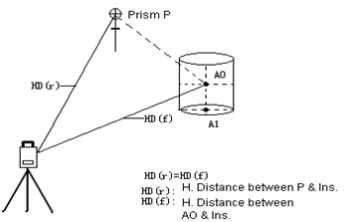
equipment will check and calculate the difference between the known point K3 and the measured point.

[F3]NEZ.: Check the coordinate of measured point.
[F3]Δ: Check the difference.

5.7 [F1] OFSET

5.7.1 Angle Offset

If the target is invisible, it is difficult to set up a prism on the target directly, for example the center of a tree. Angle offset helps you calculate the coordinate of invisible target by an offset point.

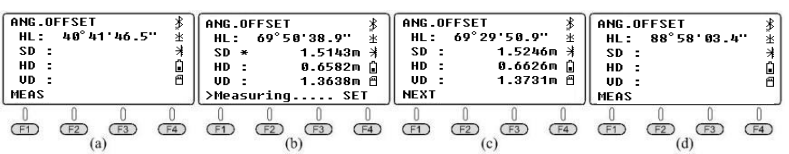


Steps:

A) When target A0 is invisible and difficult to set the target, please set an offset point at Point P which is near to A0.

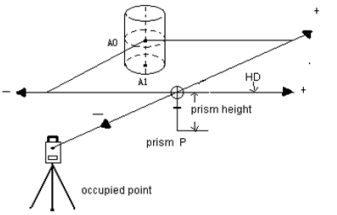
B) Aim at prism P(pic c), press **[F1] MEAS**, rotate the equipment, then aim at the invisible target A0. (pic d)

C) Press **[CORD]** to check the coordinate of Point A0. Press **[DIST]** to check the distance.



5.7.2 Distance Offset

This function calculates the coordinate of point based on lateral and longitudinal offset or height difference of the target.

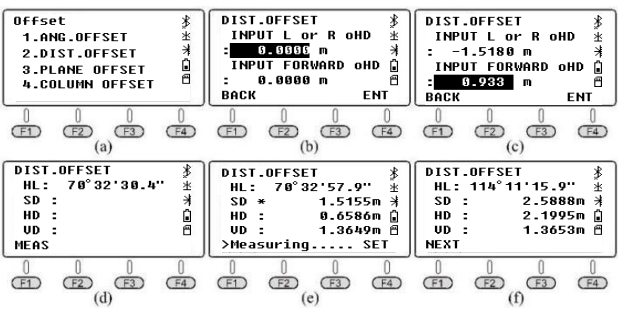


Steps:

A) Input the offset value, press **[F4]ENT** to confirm (Pic d)

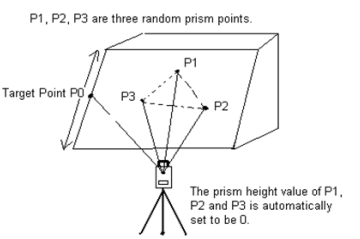
B) Aim at the offset point P, press **[F1]MEAS** (pic e)

C) Press **[CORD]** to check the coordinate of Point A0. Press **[DIST]** to check the distance.



5.7.3 Plane Offset

This function calculates the point which cannot be measured directly from the other three points in same plane.



Those three points (P1/P2/P3) can be measured, inputted or selected from the data list to define a plane.

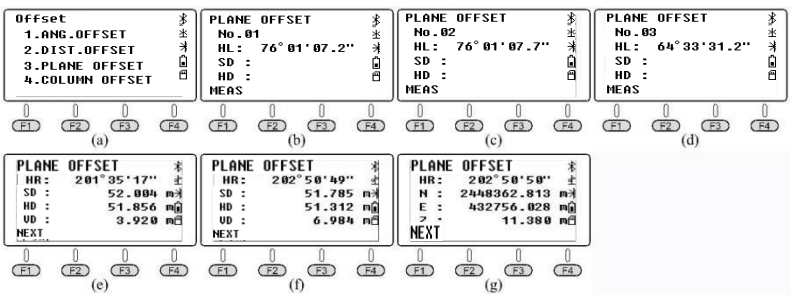
Then aim at the target (P0) to calculate the coordinate and SD/HD/VD from station.

Steps:

A) Press **[F1]MEAS** to aim at P1/P2/P3 to define a plane(pic e)

B) Rotate the equipment, aim at point P. It will show the distance between station to Point P(pic f)

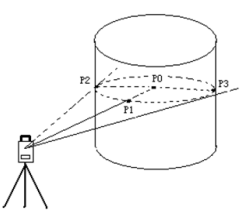
C) Press **[CORD]** to check the coordinate of Point A0. Press **[DIST]** to check the distance.



**Note: in this case, the equipment should switch into "non-prism mode" in advance. Set the equipment height as 0.*

5.7.4 Column Offset

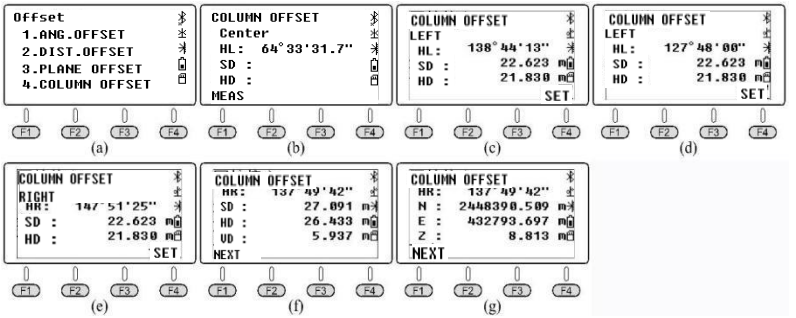
It calculates the coordinate of a hidden point (P0) that is not directly visible inside from the center (P1) and edge (P2/P3) of column.



Steps:

A) Press **[F1] MEAS** to measure P1 at first. Then aim at the edge of column P2 and P3, press **[F4]SET** (pic f)

B) Press **[CORD]** to check the coordinate of Point A0. Press **[DIST]** to check the distance.



5.8 [F2] S.O

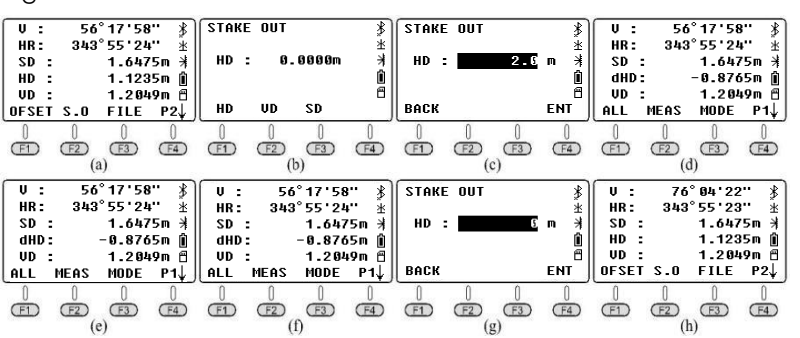
This function calculates the distance elements (SD/HD/VD) to stakeout points

Steps: Use **[F1]HD** as an example.

A) Input the horizontal distance: 2.0m, press **[F4]ENT** to confirm.

B) Rotate the equipment and then ask the prism move to the correct sight of view. Press **[F2]MEAS** in the first page, the difference will show as pic e.

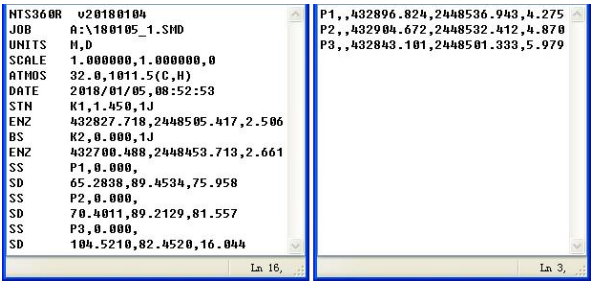
C) dHD= actual HD - stake out HD = -6.8265m. It means that the prism should move away from the equipment in 6.8265m. Press **[F2]MEAS** again to confirm.



5.9 [F3] FILE

The users can change the current file, create a new file, rename, delete, import or export freely by Bluetooth or USB flash disk.

There are some differences between 600.txt and .dat.



STN K1,1.450,1J — Station Point K1, Station Height 1.45m, Code: 1J

ENZ 32827.718,2448505.417,2.506 —Coordinate of station

BS K2,0.000,1J —Backsight point K2, Target Height: 0, Code: 1J

ENZ 432700.488,2448453.713,2.661 —Coordinate of backsight point

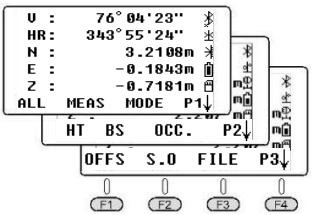
SS P1,000 — Measured point P1, Target Height 0

SD 65.2838,89.4534,75.958 —Horizontal / Vertical value, HD

In .dat profile, which is widely used in South CASS software, the format is "Point Name; Code; E,N,Z".

6. COORDINATE MEASUREMENT

Press **[CORD]** to enter the coordinate measurement mode.

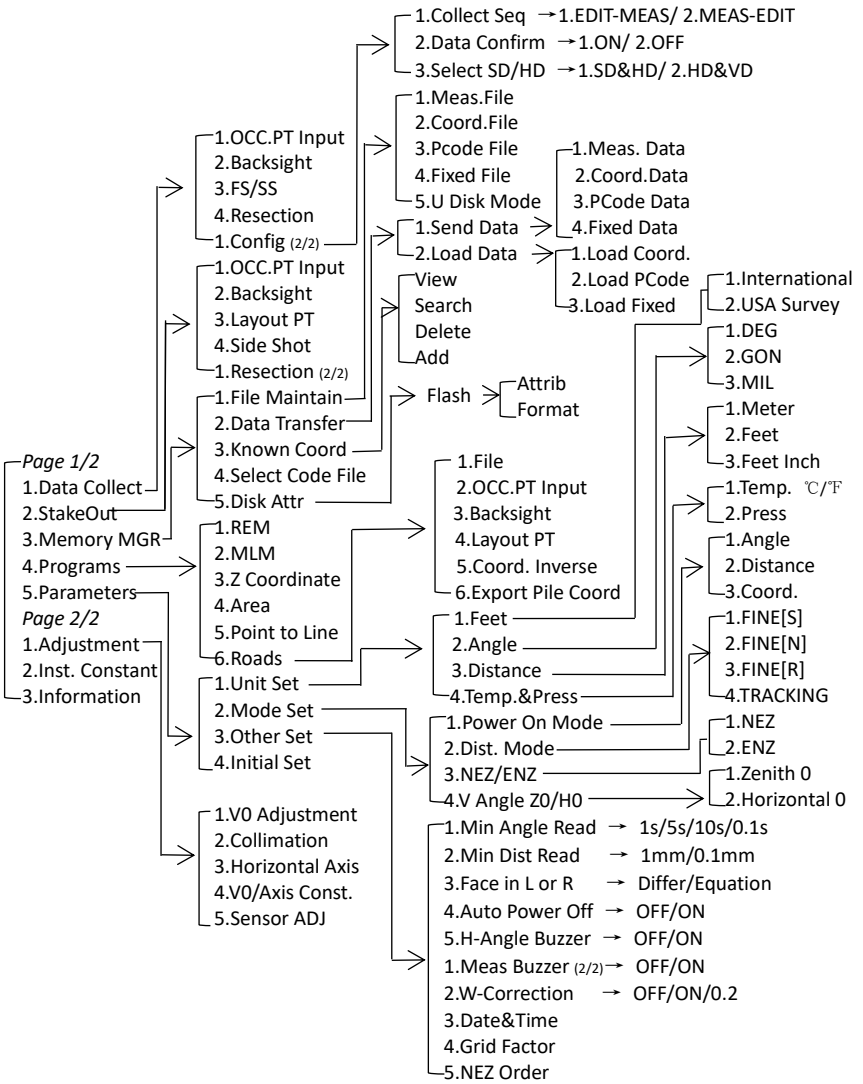


Users can input the coordinates of occupied point by a standard CASS format "Point Name; Code; E, N, Z", maximum 200 points and save as ".csv" format by Bluetooth or USB Flash Disk.

Insert USB flash disk into total station, import the .csv profile into the existed FIX.LIB menu. It can be listed when the user need to settle the occupied point and backsight point in coordinate mode, data collection and stakeout program.

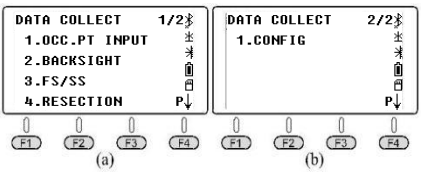
7. MENU

The structure underlying the Menu system as below:



7.1 Data Collect

Data Collect, is used for measure and save the coordinates under the current coordinate file, and it will also save the measured data under the current measure file.



7.1.1 New Job

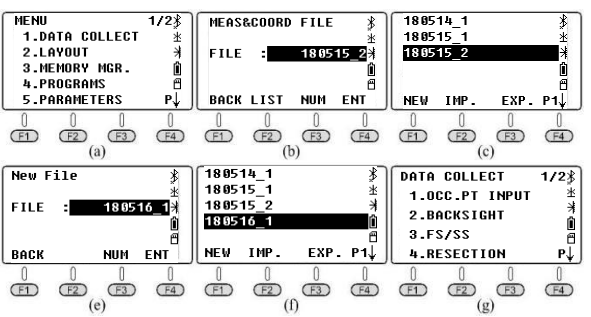
Press **1.Data Collect** in the first page of menu, enter the file selecting page, the equipment will show the latest file on the screen. Press **[F4] ENT** to confirm, or press **[F2] LIST** to select the other job.

[F1] NEW: Start to create a new job. The system will name the new job as "Date_Num". Press **[F3] NUM/ALPH** to switch the characters between number and alphabet.

The equipment will create a *.SMD and a *.SCD file automatically. SMD records the data of horizontal disk, vertical disk and slope distance. SCD records the coordinate of measured points.

[F2] IMP.: Import the job from USB flash disk to your total station

[F3] EXP.: Export the job from total station to USB flash disk.



7.1.2 OCC Point Input

A. Press **[F2] LIST** to enter the point list, move the cursor to the known point K3, press **[ENT]** to view the coordinate of K3(pic d).

B. Input the instrument height (pic e) and press **[ENT]** to confirm.

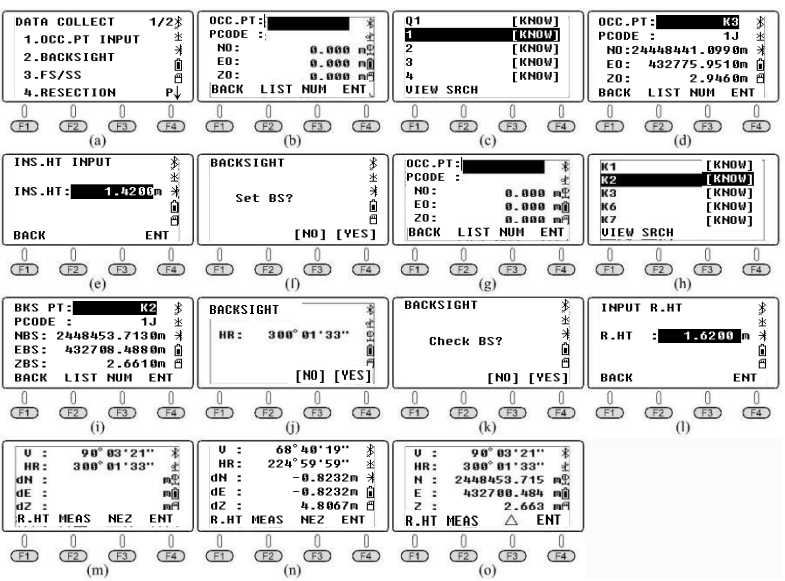
C. The equipment will enter the backsight setting page (pic f). Press **[F2]LIST** to select the backsight point from memory (pic h), or input the coordinate directly. The equipment will calculate the backsight angle(pic i).

D. Aim the backsight, press **[F4]YES** for orientation(pic j).

Check BS

a. Press the EDM trigger key or **[F2]MEAS** to measure the backsight (pic m), the equipment will show the difference(pic n).

b. Press **[F3]NEZ/△** to check the coordinate of backsight.



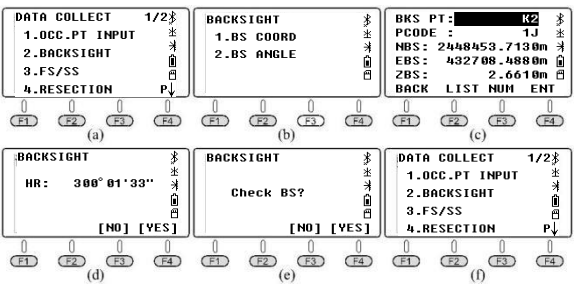
7.1.3 Backsight

The backsight is able to be oriented by coordinate or by angle.

BS COORD

[F2] LIST: Select the coordinate from the list.

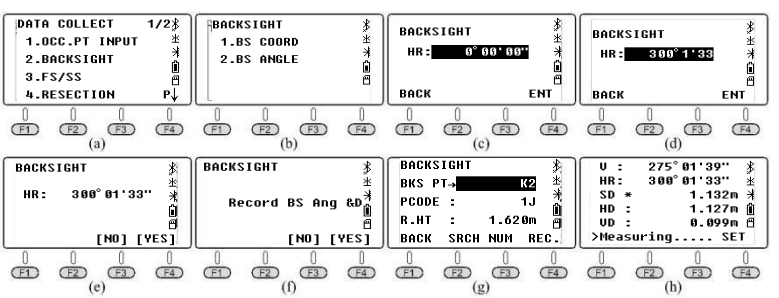
[F3] NUM/ALPH: Enter the coordinate directly as the backsight.



BS ANGLE

Input the angle as backsight: 300°01'33"(pic c).

Aim at the target center of backsight, press **[F4]YES** to set the horizontal angle as the backsight(pic e). Press **[F4]YES** to confirm the angle(pic f) and then press **[F4]REC** to measure the distance (pic g).



7.1.4 FS/SS

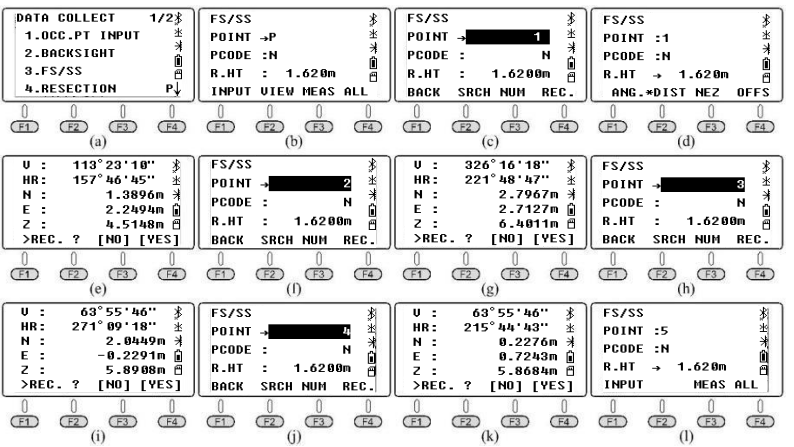
Measure and save the coordinate of points.

[F1] INPUT: Input the point name, code and target height (R.HT)

[F2] VIEW: Enter the point list.

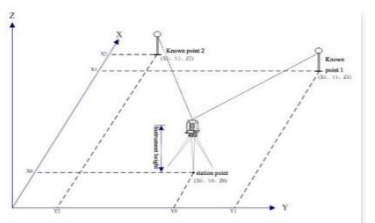
[F3] MEAS: Measure angle, distance, or coordinate

[F4] ALL: Measure and save



7.1.5 Resection

A resection sets up the station by using the angle and distance measurements in maximum 5 points.



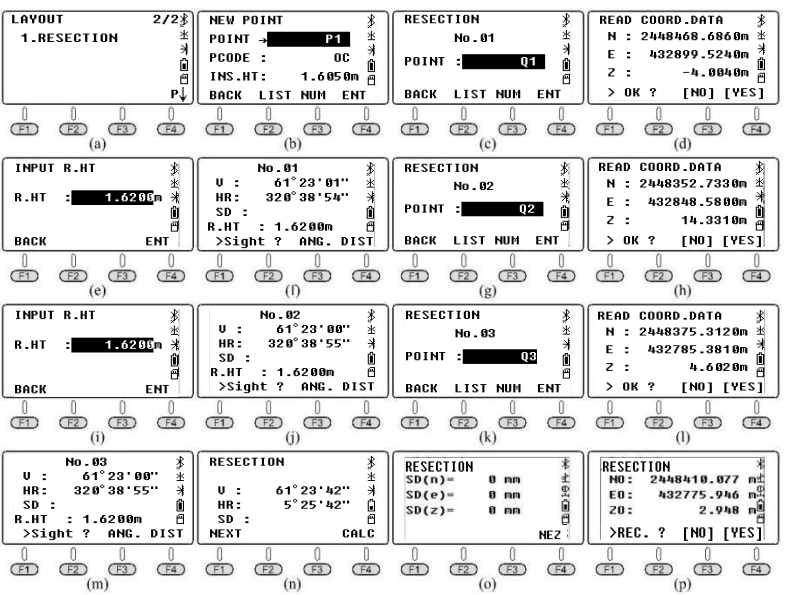
1) Resection by Angle

The station can be calculated after the measurement of at least 3 points.

Steps:

1) Input P1 as the unknown station, and the equipment height (pic b). Press **[F4]ENT** to the measure page.
2) Input the known point Q1. The system will select Q1's coordinate from list. Aim at the prism center of Point Q1 (pic f). Press **[F3]ANG** to measure the angle. Then it will continue the measurement for the 2nd point.
3) Repeat the steps to select and measure the 2nd known point: as picture g-j shown.
4) Repeat the steps to select and measure the 3rd known point, as picture k-m shown.
5) After the measurement for point Q1/Q2/Q3, press **[F1]NEXT** to the 4th point.

   Or press **[F4]CALC** to calculate the coordinate (pic o).



2) Resection by Distance

The distance resection method should include at least 2 known points to calculate the coordinate. The steps are similar to angle resection methods. The only thing you should notice is press **[F4] DIST** after aiming at the target.

7.1.6 Config

7.1.6.1 Collect Sequence

Set the sequence. The default setting is "EDIT→MEAS"

① EDIT→MEAS: Set the point name, code and target height before measure the points.

② MEAS→EDIT: Measure the points before edit the point name, code and target height.

7.1.6.2 Data Confirm

Turn on or off the function of data confirm. The default set is ON.

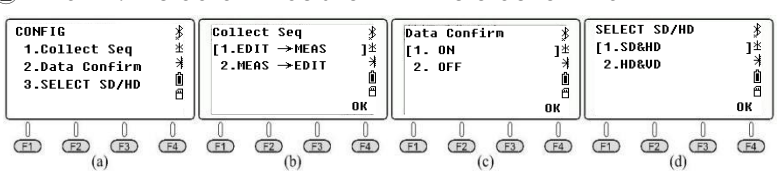
① ON: After measure the points, it will reminder the user to confirm the data storage.

②OFF: After measure the points, the equipment will save the data automatically without user's confirm.

7.1.6.3 Select SD/HD

① SD&HD: The data will be shown in the order of SD&HD

② HD&VD: The data will be shown in the order of HD&VD



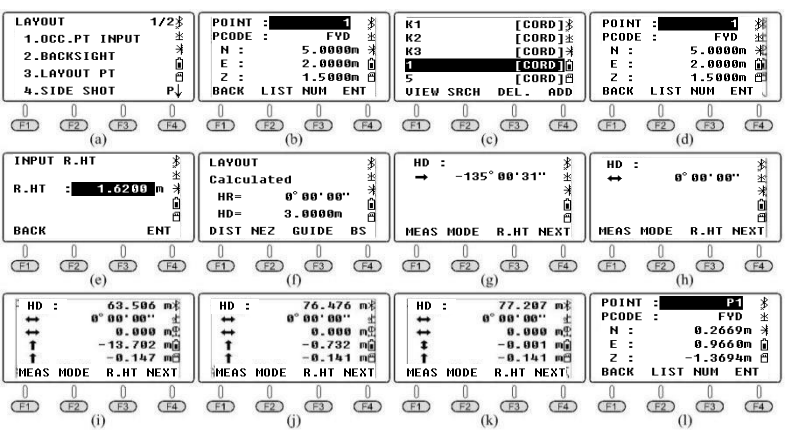
7.2 Stake Out

Press **[F2]LIST** to view the file list (pic), move the cursor to select the file where you saved the data.

7.2.1 Layout Pt

Press **[F2]LIST** to select a point from the list (pic d), Press **[F1]VIEW** to check the detail information for the selected point.

1) **[F3] GUIDE:** Check the guidance of direction. ➡ -53°50'36" means the prism should turn right in 53°50'36" to find the stake-out point (pic h). Guide and set the prism on the azimuth of EDM until the value of HD become 0°00'00".
2) Rotate the equipment vertically to aim at the target center (please notice that the horizontal angle should not be moved), press **[F1]MEAS** to measure the distance (pic i);
3) Guide the prism and move -13.702m, the minus distance means the prism should move backward. Aim at the target center and press **[F1]MEAS** again after the movement (pic j)



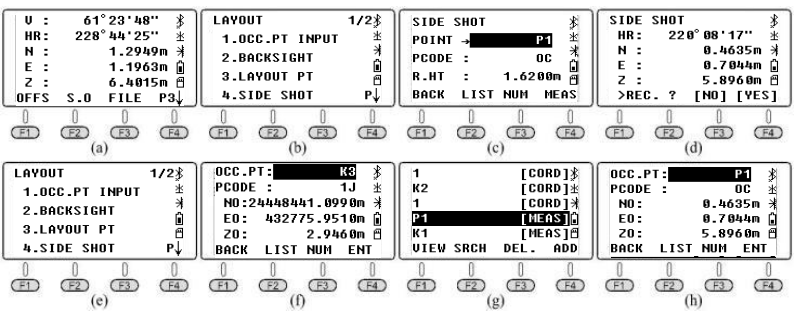
7.2.2 Side Shot

If the stake out point is invisible, we can use Side Shot to add another point as station to find the target.

Input P1 as the point name, aim at the target center.

Press **[F4] MEAS** to measure the coordinate of point P1. Then press **[F4] YES** to record it.

Move the total station to P1 and well-settled the position. Press 1.OCC. PT INPUT under stake-out menu. Select Point P1 from data list and set the backsight and station on this point.

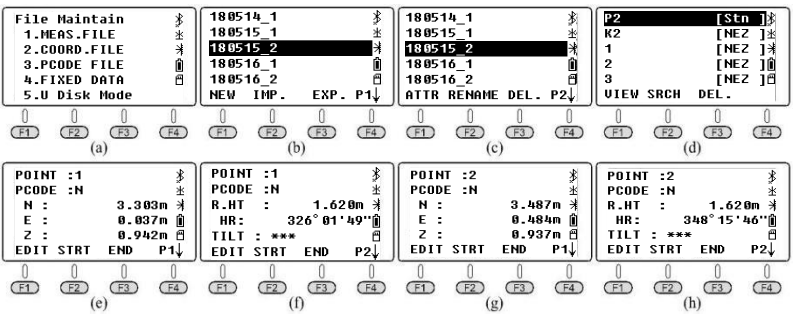


7.3 Memory MGR.

7.3.1 File Maintain

Create, import, export, check, rename or delete the files.

7.3.1.1 Meas File



[F1]NEW: Add a new file, the system will create two files, "SMD" and "SCD". "SMD" for measurement data, while "SCD" for coordinate data.

[F2]IMP: Import the coordinate file "SCD" from USB flash disk to equipment.

[F3]EXP: Export the "TXT", "DAT", "CSV" and "DXF" to USB flash disk.

[F1]ATTR: Check the attribute for the current file. Including the name, size, quantity of data, create time and date.

[F2]RENAME: Rename the file which has been selected.

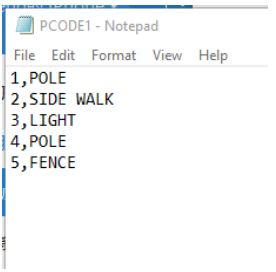
[F3]DEL: Delete the file which has been selected. Please notice that "SMD" and "SCD" file will be deleted in the same time.

7.3.1.2 Coord. File

Press 2.COORD.FILE to enter the file list of coordinate.

7.3.1.3 Pcode File

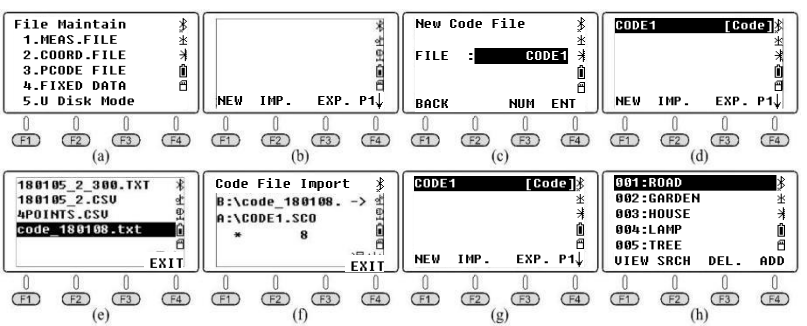
Before the measurement, you can create a TXT file on PC to edit codes, each code appears on its own line within 10 characters. Copy the TXT file from, as below picture shown:



[F1]NEW: Input the code name "CODE1" (pic c)

[F2]IMP: View the file list under the root directory of USB stick, move the cursor to the file you need (pic e) and press **[ENT]** to import the code file to CODE1, the equipment will back to the file list automatically (pic g);

In the code list, press **[F1]VIEW** and **[F1]EDIT** to edit the selected code; Press **[F3]DEL** and **[F4]OK** to delete the selected code; Press **[F4]ADD** to add the new created code at the end of file list.



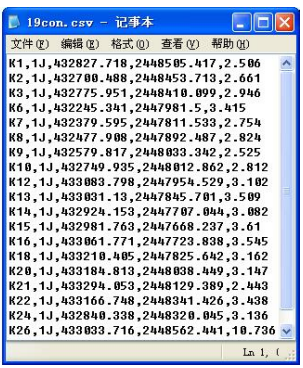
7.3.1.4 Known Coord.

Press 4.Known Coord. under the "File Maintain" menu (pic b) to enter the list of coordinate files. The file name is FIX.LIB which is not able to edit; the number refers the quantity of coordinates.

Import the Coordinates of Occupied Point into Total Station:

As picture shown, input those coordinates by "Point Name; Code; E, N, Z". The maximum number of characters for code is 10.

	A	B	C	D	E
1	K1	1J	432827.718	2448505.417	2.506
2	K2	1J	432700.488	2448453.713	2.661
3	K3	1J	432775.951	2448410.099	2.946
4	K6	1J	432245.341	2447981.5	3.415
5	K7	1J	432379.595	2447811.533	2.754
6	K8	1J	432477.908	2447892.487	2.824
7	K9	1J	432579.817	2448033.342	2.525
8	K10	1J	432749.935	2448012.862	2.812
9	K12	1J	433083.798	2447954.529	3.102
10	K13	1J	433031.13	2447845.701	3.509
11	K14	1J	432924.153	2447707.044	3.082
12	K15	1J	432981.763	2447668.237	3.61
13	K16	1J	433061.771	2447723.838	3.545
14	K18	1J	433210.405	2447825.642	3.162
15	K20	1J	433184.813	2448038.449	3.147
16	K21	1J	433294.053	2448129.389	2.443
17	K22	1J	433166.748	2448341.426	3.438
18	K24	1J	432840.338	2448320.045	3.136
19	K26	1J	433033.716	2448562.441	10.736



Steps:

A) Save the file as *.csv, it can be opened by excel.

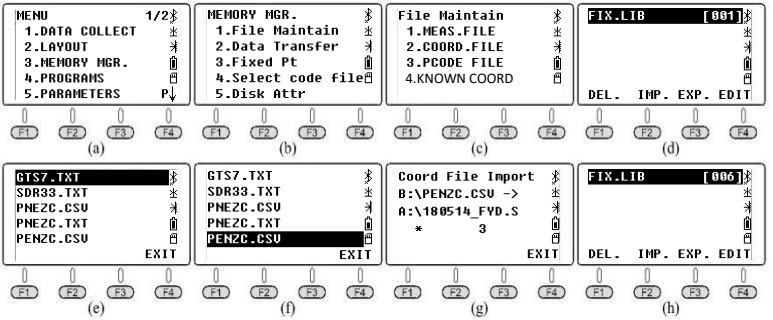
B) Copy the *.csv file under the root menu of USB Flash Disk. Insert it into total station. Press **[MENU]** to enter the menu, press **3. MEMORY MGR.**, **1.File Maintain**, **4.FIXED DATA**. The equipment will record the data under "FIX.LIB" in default, the number [001] refers to the number of known coordinate is 1.

C) Press **[F2]IMP**, there are three kinds of profile, .dat/.txt/.csv. Move the cursor to the *.csv file you need. Press **[ENT]** to confirm.

D) the internal memory is called FLASH.

*Note: the files import from USB stick can be duplicated by same

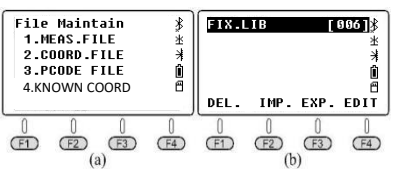
name. If there has duplicated point, the system will add a same point name under the same file without any notice.



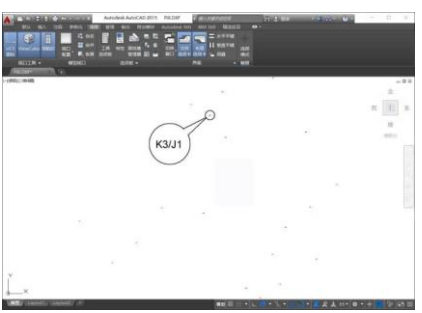
Export the Coordinates of Occupied Point to USB Stick:

Press **[F3]EXP.** To export the file FIX.LIB to USB stick.

FIX.dat is SOUTH CASS format, the data can be recognized as "Point Name; Code; E, N, Z"; the other file FIX.dxf is a graphics interchange format, which can be opened by AutoCAD and save as .dwg file.



The right picture is the interface when open the FIX.dxf file by AutoCAD, the user should execute the "zoom/e" commend to view the whole map.



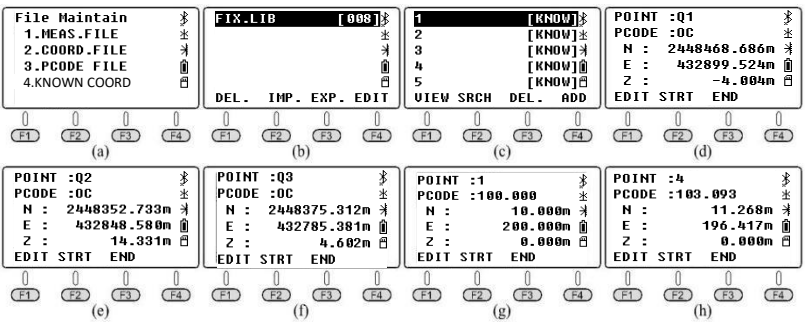
Edit the Coordinates of Occupied Point:

[F1]VIEW: Check the coordinate of the first known point (pic d), press **[△]** or **[F3]END** to check the last point (pic e)

[F2]SRCH: Search known points. (pic h); Press **[F1]EDIT** to edit the selected point.

[F3]DEL: Delete the selected point.

[F4]ADD: Add a new occupied point by manual.

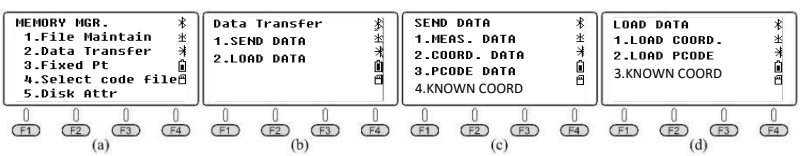


* It is able to save 200 points in maximum.

* the file imported from USB stick to equipment should be under the same format as the equipment setting (CASS or NEZ, check it in Menu - 5.PARAMETERS - 3.OTHER SET - 4.COMM.PARAMETERS in Page 2). The default format is CASS.

7.3.2 Data Transfer

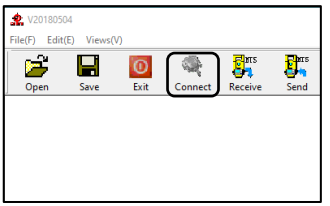
Press 2.Data Transfer under the "MEMORY MGR" menu (pic b), press 1.SEND DATA or 2.LOAD DATA for data sending (pic c) or loading (pic d).

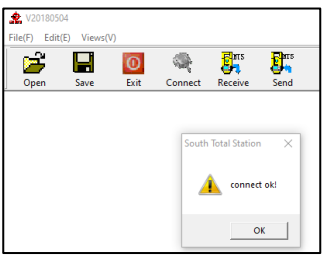


7.3.2.1 Connection between N6+ and PC

N6+ only can connect to PC transfer software by Bluetooth.

Click “Start” icon on a laptop which features Windows 10 system and Bluetooth in the same time. Choose “Setting - Device - Bluetooth” to open the Bluetooth connection and search the equipment. Edit the pairing code as “1234”.





Open the data transfer software. Click “Connect” button activate the connection, it will show “connect ok” when it successful.

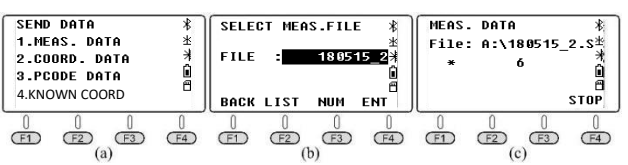
7.3.2.2 Send Data

There are four kinds of data which can be transferred from N6+ to PC: measure data, coordinate data, code data and known coordinate.

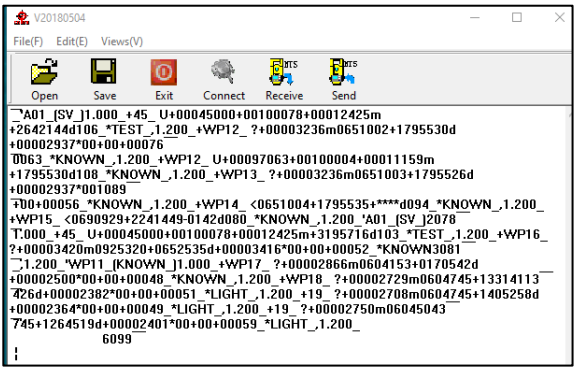
The data is saved in flash memory. Please activate the transfer software before sending data.

Using measure data as an example.

Press 1.MEAS DATA to select the file (pic b), it will show the latest file name on the screen.



Click "Receive" button on PC before press **[ENT]** on N6+ to send the selected file. Click "Save" button on PC to save the file after receiving data from total station.



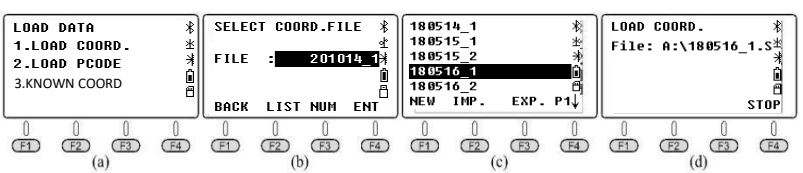
7.3.2.3 Load Data

N6+ can transfer three types of data from PC: coordinate, Code and known point. Please select the file and power on the equipment for data loading before transforming.

Use coordinate data as an example:

① Activate the software, click CONNECT to connect between PC and TS. Then open the coordinate data.

② Press 1.LOAD COORD. Under "LOAD DATA" menu (pic a) and enter the page for file selection (pic b). Press **[F1]LIST**, **[F1]NEW** to create a new file. Move the cursor to the new one (pic e). Press **[ENT]** to confirm the data loading.



③ Click "SEND" button on PC to activate the software, the equipment will show the process for data loading in real-time

7.3.3 Edit the Known Coordinates

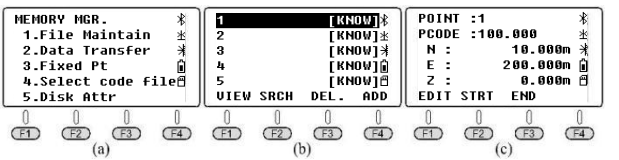
Press 3.EDIT under the "MEMORY MGR" to enter the point list (pic b).

[F1]VIEW: Check the point name, code, N/E/Z

[F2]SRCH: Search the point by point name

[F3]DEL.: Delete the selected point

[F4]ADD: Add a known point



7.3.4 Select the Code File

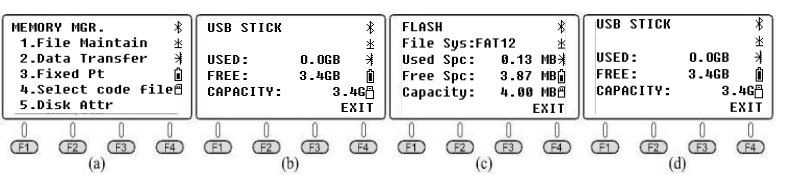
Press 4.Select Code File under the "MEMORY MGR" menu (pic a) to select the code file for current job.

7.3.5 Disk Attribute

Press 5 DIST ATTR under the "MEMORY MGR" menu (pic a) to check the information of disk.

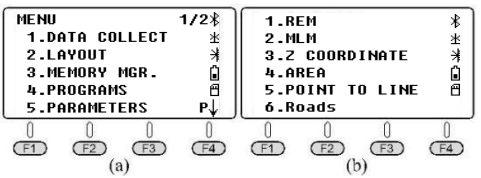
[F1]ATTRIB: Check the used and free capacity.

[F2] FORMAT: Format the disk



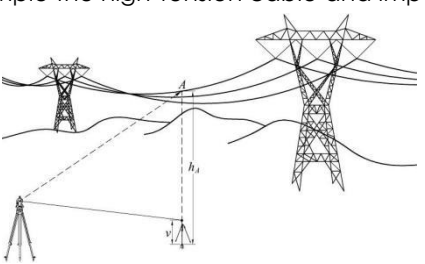
8.PROGRAMS

Press 4.Programs in the first page of Menu to enter the system programs. The programs on N6+ included REM, MLM, Z coordinate, area measurement, point to line and roads. In this chapter, we will talk the all those programs in detail except road. The description of road will be described separately.



8.1 REM

REM function is mainly used for measuring the vertical height for tiny objects, for example the high-tension cable and impending cable.

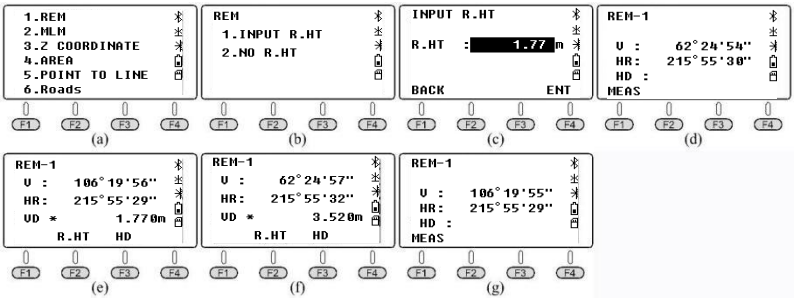


Set a prism on the plumbing line below the target, measure the prism height. The target can be measured with or without prism height.

Press 1.INPUT R.HT to input the prism height (pic c), press **[F4]ENT** to confirm. Aim at the prism center and press **[F1]MEAS** to measure the distance (pic e). VD means the prism height.

Aim at target A, it will show the height difference from target A to the ground (pic f).

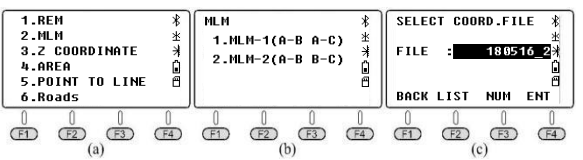
You can press **[F3]HD** to measure the new point.



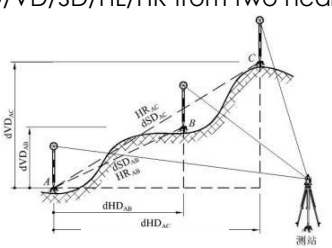
8.2 MLM

MLM function is mainly used for the measurement of HD/VD/SD/HL/HR between two arbitrary points. The coordinate of points can be invoking from the known file or current file, inputting by manual or measurement.

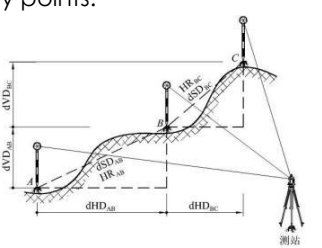
There included two options, MLM-1 (A-B A-C) and MLM-2 (A-B B-C).



MLM-1 (A-B A-C) is used for measure the HD/VD/SD/HL/HR from start point A to arbitrary point B,C...., MLM-2 (A-B B-C) is used for measure the HD/VD/SD/HL/HR from two nearly points.



MLM-1 (A-B A-C)

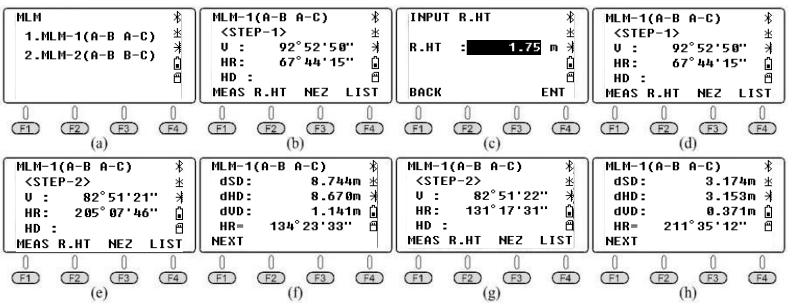


MLM-1 (A-B B-C)

8.2.1 MLM-1 (A-B A-C)

8.2.1.1 Calculate by distance measurement.

Press **[F2]R.HT** to input the prism height (pic c), press **[F4]ENT** to confirm; Aim at target A and press **[F1]MEAS** for step-2. Aim at target B (pic e) and press **[F1]MEAS,** the dSD, dHD, dVD and HR from A to B will be shown on the screen (pic f).

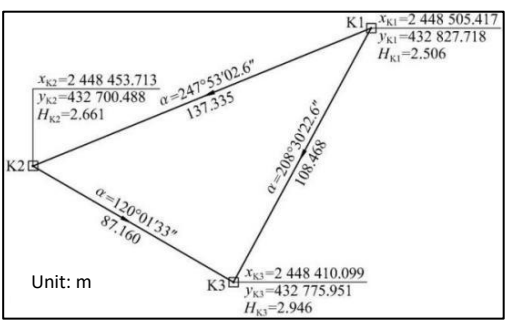


Press **[F1]NEXT** to repeat step-2 and aim at the target center of point C (pic g). Press **[F1]MEAS**, the dSD, dHD, dVD and HR from point A to C will be shown on the screen (pic h).

8.2.1.2 Calculate by coordinate invoking

Assume that the coordinate file with 19 control points "19con.csv" has been imported to FIX.LIB file in N6+ total station.

The picture shows the plot map for K1, K2 and K3. The length of side and the angle can be calculate inversely through the coordinates of those three points.

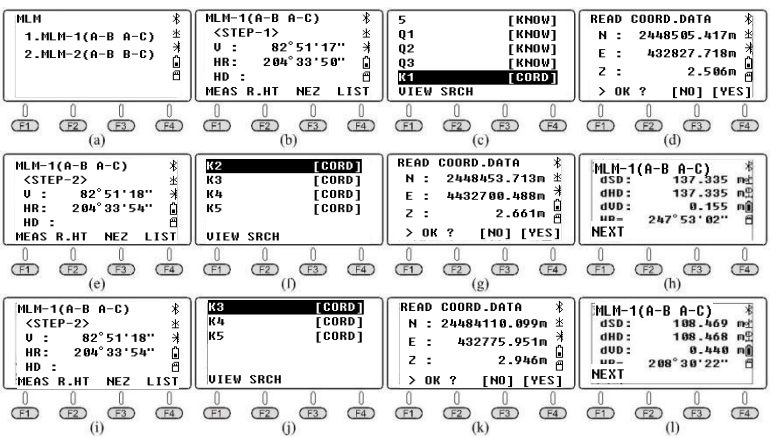


Use the coordinate of K1/K2/K3 as point A/B/C to calculate the edge.

Press 1.MLM-1 (A-B A-C) to enter the step-1 (pic b), press **[F4]LIST** to enter the point list. The cursor will remain in the first line K1 (pic c), press **[F1]VIEW** to check the detail for K1 (pic d).

Press **[F4]YES** to read the coordinate for the next step (pic e); Press **[F4]LIST** and move the cursor to K2 (pic f). Press **[ENT]** to view the coordinate of K2 (pic g).

Press **[F4]YES,** the dSD, dHD, dVD and HR from point A to B will be shown on the screen (pic h). The value of dHD and HR are same to the value on the picture noted.



Press **[F1]NEXT** to repeat step-2 (pic i). Press **[F4]LIST** and move the cursor to Q3 (pic j), and **[ENT]** to view the coordinate of Q3 (pic k).

Press **[F4]YES**, the dSD, dHD, dVD and HR from point A to C will be shown on the screen (pic l). The value of dHD and HR are same to the value noted on the picture.

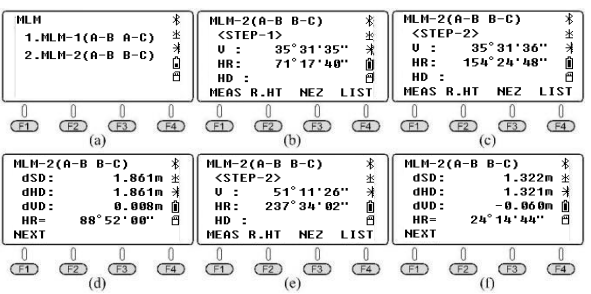
8.2.2 MLM-2 (A-B B-C)

8.2.2.1 Calculate by distance measurement.

Press 2.MLM-1(A-B, B-C) to enter the step-1 (pic b); aim at the prism center of point A (pic b) and press **[F1]MEAS** to measure the distance and enter step-2.

Aim at the prism center of point B (pic c), press **[F1]MEAS** to measure the distance. The value of dSD, dHD, dVD and HR from point A to B will be shown on the screen (pic d).

Press **[F1]NEXT** to repeat step 2. Aim at the target center of point C (pic e), press **[F1]MEAS** to measure the distance, dSD, dHD and HR from point B to C will be shown on the screen (pic f). Press **[F1]NEXT** to repeat the steps.



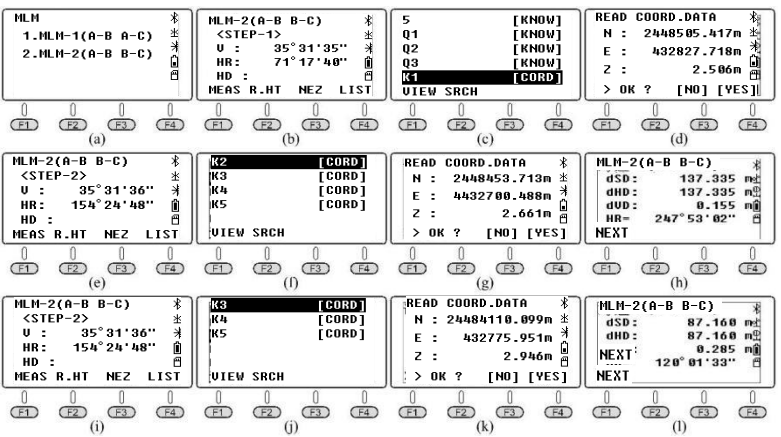
8.2.2.2 Calculate by coordinate invoking

Press 2.MLM-2 (A-B B-C) to enter the step-1 (pic b), press **[F4]LIST** to enter the point list. The cursor will remain in the first line K1 (pic c), press **[F1]VIEW** or **[ENT]** to check the detail for K1 (pic d).

Press **[F4]YES** to step-2 (pic e); Press **[F4]LIST** and move the cursor to K2 (pic f). Press **[ENT]** to view the coordinate of K2 (pic g).

Press **[F4]YES**, the dSD, dHD, dVD and HR from point A to B will be shown on the screen (pic h). The value of dHD and HR are same to the value on the picture noted.

Press **[F1]NEXT** to repeat step-2 (pic i). Press **[F4]LIST** and move the cursor to K3 (pic j), and **[ENT]** to view the coordinate of K3 (pic k). Press **[F4]YES**, the dSD, dHD, dVD and HR from point A to C will be shown on the screen (pic l). The value of dHD and HR are same to the value noted on the picture.



8.3 Z Coordinate

Press 3.Z coordinate to enter the coordinate selecting page (pic b), press **[F4]ENT** to confirm.

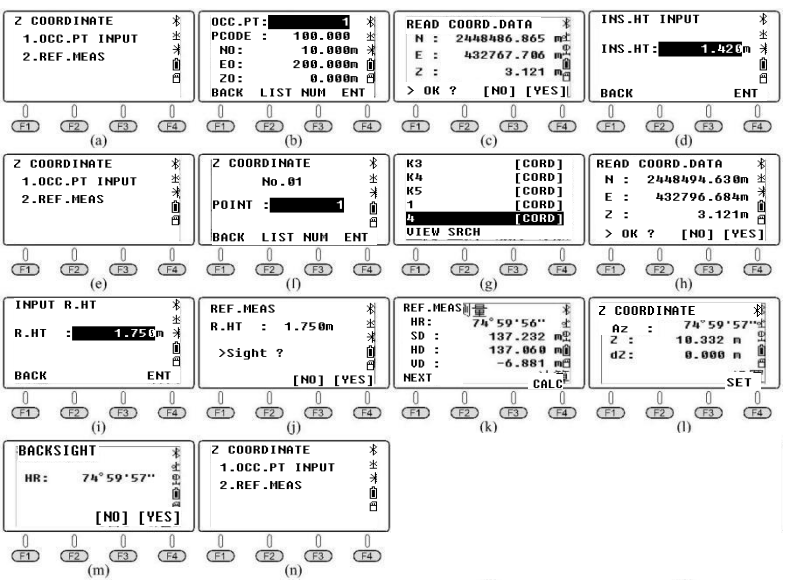
1.OCC PT INPUT: Input or call the occupied point.

2.REF MEAS: Calculate the Z coordinate inversely by distance measurement.

Press 1.OCC PT INPUT under "Z Coordinate" menu (pic b). Press **[F1]INPUT** or **[F2]LIST** to input or call the occupied point.
Press **[F4]ENT** to view the coordinate of point 1, then input the instrument height (pic d) and press **[F4]ENT** to confirm.

Press 2.REF MEAS to enter the measurement page of reference point (pic f). Press **[F2]LIST** to enter the point list, move the cursor to point 4 (pic g)which should be requested. Press **[ENT]** to select the point. Input the reflector height and press **[ENT]/[F4] ENT** to confirm.

Aim at the prism center of point 4, press **[F4]YES** to start measurement, the result shown as picture k. Press **[F4]CALC** (pic l) and **[F4]SET** to calculate the azimuth from point 1 to point 4 (pic m). Press **[F4]YES** to well-set the equipment (pic n).



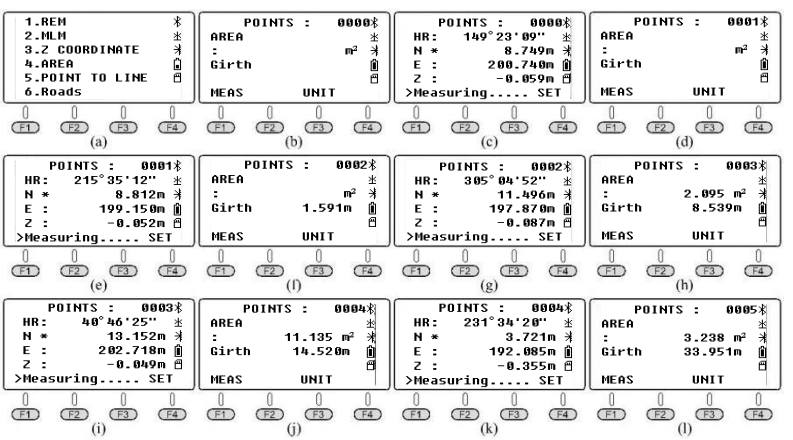
In "Z Coordinate" page, press 1.OCC.PT INPUT to enter the next page as picture o shown. Point 4 will be shown on the screen, press **[F3] NEZ** to view the coordinate for current occupied point. Compare with picture c, we can find that the horizontal coordinate has not been changed , but the Z coordinate has been updated by the new height.

8.4 Area

Through the actual measurement for vertex, Area is used for area and perimeter calculation for polygon. The measurement of vertexes should base on the order of point 1→point 2→point 3...., in clockwised or anti-clockwised direction.

[F1]MEAS: Aim and measure the target

[F3]UNIT: Change the unit for area or perimeter.

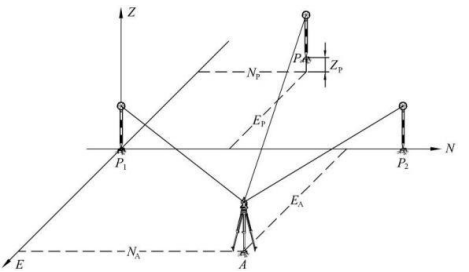


8.5 Point to Line

Measure the distance between two arbitrary point P1 and P2, set P1 as original point, azimuth from P1 to P2 as N axis.

The equipment will calculate the horizontal coordinate NA and EA for the occupied point A.

Then measure another point P, to calculate the coordinate NP, EP and ZP for point P. EA and EP should be the vertical distances from point A/P to Line P1-P2.



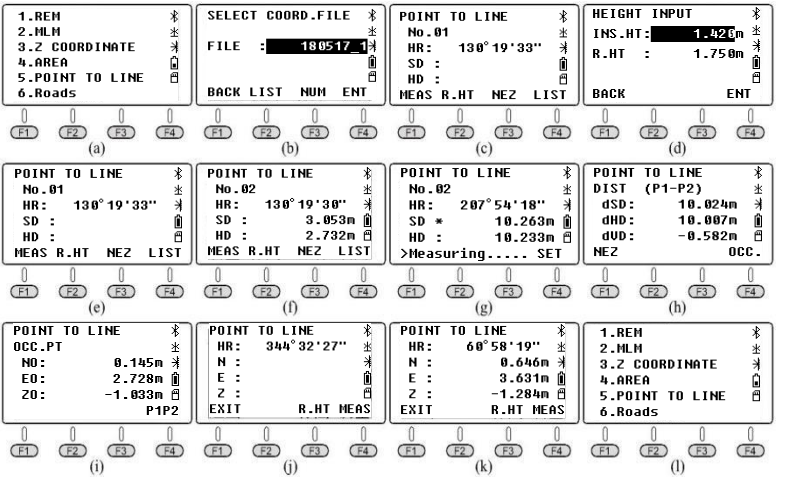
Steps:

Set the equipment on point A. Press 5.Point to Line under "Program" menu (pic a) and enter the coordinate list (pic b). Press **[F2]R.HT** to input the instrument height and reflector height (pic d). Press **[F4]ENT** to confirm.

Aim at the prism center of point P1, press **[F1]MEAS**, the equipment will skip to the page for 2nd point (pic f). Aim at the prism center of point P2 (pic g), press **[F1]MEAS**, the dSD, dHD and dVD from point P1 to P2 will be shown on the screen (pic h).

Press **[F4]OCC** to view the coordinate of point A under the independent coordinate system (pic i); E0=21.439 means point A is located at the right side of line P1-P2 with vertical distance 21.439m

Press **[F4]P1/P2** to back to the page of pic h. Press **[F1]NEZ** to enter the measurement page for coordinate. Aim at point P and press **[F4]MEAS** to calculate the coordinate under this independent system (pic k). E0=-9.844m meas point P is located at the left side of line P1-P2 with vertical distance 9.744m.



9.ROADS

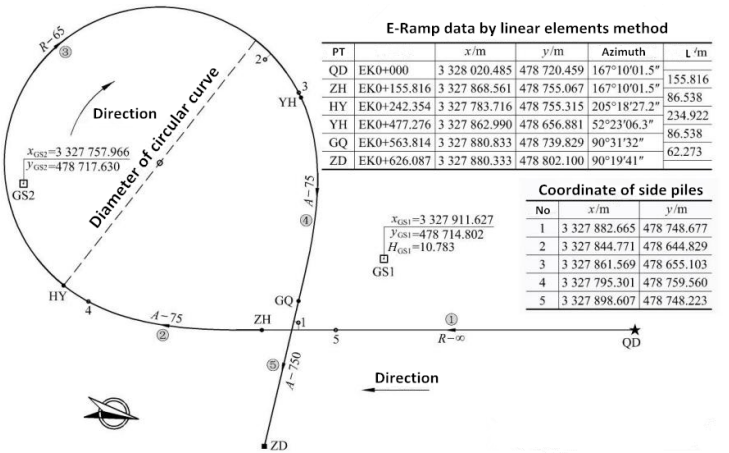
Roads in N6+ is a kind of program wrote by Linear Element Method, which can calculate the coordinate of middle line by positive and negative computation.

In this program, it allows the non-completed transition curve with random deviation angle, the direct-turning line, and the arbitrary Short-Chainage. Also it included the function of coordinate calculation by positive and negative computation, the one by one calculation for piles; It can also handle the processing of horizontal curve in any combination.

9.1 Case Study - Horizontal & Vertical Curve in Ramp

9.1.1 Design Drawing for Horizontal &Vertical Curve

The picture below is a flat curve from an e-ramp road. The data of vertical curve is listed on Form 6-1. In this case, the length of No.3 circular curve is longer than the half-perimeter of this circle.



E-Ramp data by linear elements method

PT		x/m	y/m	Azimuth	L/m
QD	EK0+000	3 328 020.485	478 720.459	167°10′01.5″	
ZH	EK0+155.816	3 327 868.561	478 755.067	167°10′01.5″	155.816
HY	EK0+242.354	3 327 783.716	478 755.315	205°18′27.2″	86.538
YH	EK0+477.276	3 327 862.990	478 656.881	52°23′06.3″	234.922
GQ	EK0+563.814	3 327 880.833	478 739.829	90°31′32″	86.538
ZD	EK0+626.087	3 327 880.333	478 802.100	90°19′41″	62.273

Coordinate of side piles

No	x/m	y/m
1	3 327 882.665	478 748.677
2	3 327 844.771	478 644.829
3	3 327 861.569	478 655.103
4	3 327 795.301	478 759.560
5	3 327 898.607	478 748.223

PIC6-1: Designed Drawing of An E-ramp Road in Zhejiang, China

FORM6-1: Data Sheet for Vertical Curve & Slope

PT Name	Pile No.	Height *H*/m	Slope *i*/%	Radius *R*/m	Tangent Length *T*/m	External Dist. *E*/m
SQD	EK0+145	17.066				-1.2
SJD1	EK0+190	16.526	3 300	44.785	0.304	-3.91
SJD2	EK0+376	9.244	2 500	55.787	0.622	0.55
SZD	EK0+484.973	9.841				

The horizontal curve of this ramp was connected by 5 linear elements.

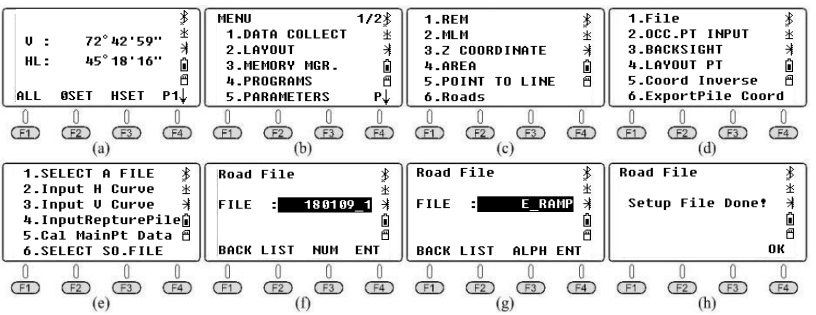
1st linear element is the straight line (R=∞); 3rd linear element is a circular curve; 2nd, 4th and 5th is a transit-curve, this drawing only mentioned linear constant without starting radius RS and ending radius RE. However, RS/RE is necessary for the road program on N6 total station. Please calculate the starting and ending radius for 2nd, 4th and 5th curve before the beginning of job.

9.1.2 How to Use N6+ to Calculate the H&V Curve in Ramp

9.1.2.1 Create a new file as the current job.

Press 4.Programs, 6.Roads, 1.File and 1.Select a File to enter the file selection page (pic f).

Input a new name "E_RAMP" as an example (pic g), press **[F4]ENT** and **[F4]OK** to confirm.

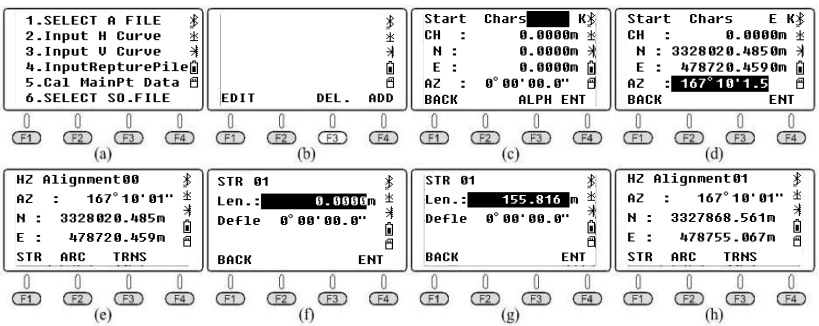


** Press **[F2]LIST** to call an existed file as the current file.*

9.1.2.2 Input the designed value of horizontal curve

(1) Input the starting value

Press 2.Input H Curve in "Roads" (pic a) and enter the elements list (pic b); Press **[F4]ADD** to add a new element (pic c). Input the characters, start number of pile, coordinate of middle pile and azimuth value (pic d). Press **[F4]ENT** to confirm and move the cursor to next line.



(2) Input the designed value of 1st line

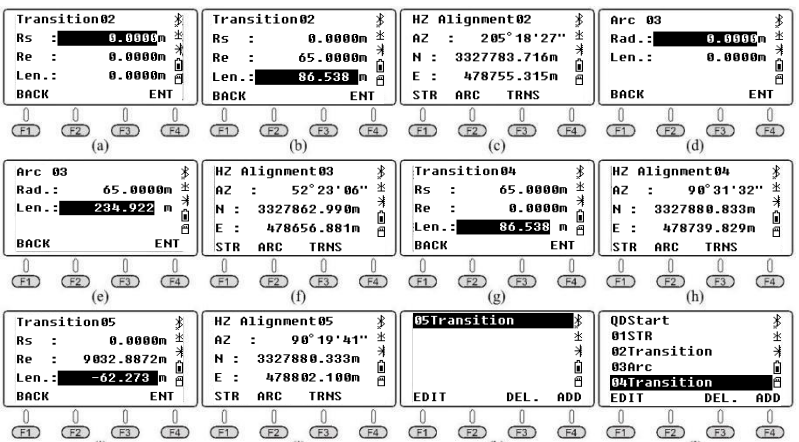
Press **[F1]STR** to input the designed value of straight line (pic f). When the 2nd line share the same axis with the 1st line, you only need to input the length of 2nd line in next step. Otherwise, both length and deflection angle are necessary.

Press **[▼]** to move the cursor to the deflection line. Input minus value for the left deflection angle, input positive value for the right deflection angle. In this case, the 1st line do not have the other linear elements following. So you can keep the deflection angle to 0 and input the length only (pic g). Press **[ENT]** or **[F4]ENT** to check the azimuth angle and coordinate of middle pile (pic h).

(3) Input the designed value of 2nd transit curve

Press **[F3]TRNS** to input the designed value of transit curve (pic a), RS (starting radius), RE (ending radius) and length are necessary. Please keep the lacked value as 0 when R = ∞ . The length should be minus when the transit curve towards the left; on the contrary, the length should be input in positive value when the transit curve towards the right.

Input the designed value of 2nd transit curve (pic b) and press **[F4] ENT** to check the azimuth angle and coordinate of middle pile (pic c)



(4) Input the designed value of 3rd circular curve

Press **[F2]ARC** to input the designed value of circular curve (pic d), the radius and length are necessary. When the curve towards to the left, the length should be minus, in the contrary, it should be positive. Input the data (pic e) and press **[F4]ENT** to check the current azimuth

angle and coordinate of middle pile (pic f).

(5) Input the designed value of 4th transit curve

Press **[F3]TRNS** to input the designed value of transit curve (pic g) and input the value based on the previous description. Press **[F4]ENT** to check the current azimuth angle and coordinate of middle pile (pic h).

(6) Input the designed value of 5th transit curve

Press **[F3]TRNS** to input the designed value of 5th transit curve (pic i). The length should be minus because this transit curve towards the left, press **[F4]ENT** to check the azimuth angle and coordinate of middle pile (pic j). The system will calculate the data of ending point, compare with the designed data as below:

Form 6-3 Comparison between Calculated and Designed Value

	Pile	*x*/m	*y*/m	α
Calculated	EK0+626.087	3327880.336	478802.099	90°19'37"
Designed	EK0+626.087	3327880.333	478802.100	90°19'41"
Deviation	0.000	0.003	-0.001	-0°00'04"

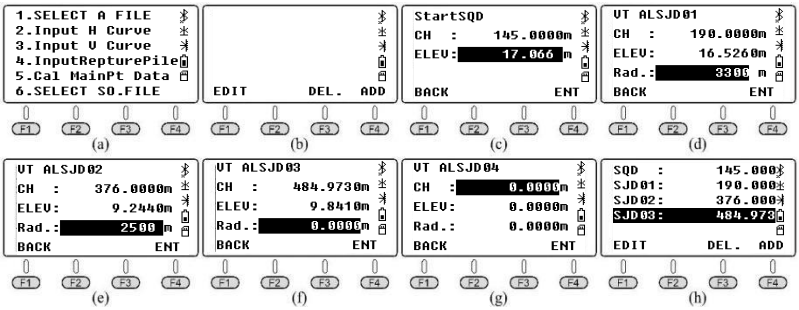
Press **[ESC]** back to the elements list, the cursor will remain at the last element in default. Press **[F1]EDIT**, **[F3]DEL** or **[F4]ADD** to edit, delete or add the elements.

* please notice that **[F3]DEL** is used for deleting the last element, not the selected one.

9.1.2.3 Input the designed value of vertical curve

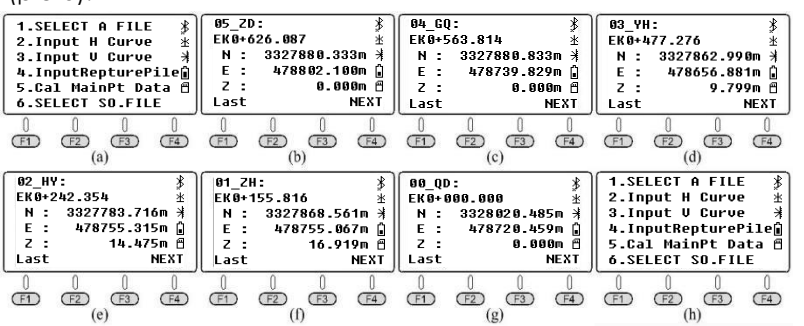
Press 3.Input V Curve in "Roads" (pic a) and enter the elements list (pic b); Press **[F4]ADD** to add the value of starting point, **[F4]ENT** to

confirm. Input the designed data of slope point SJD1 (pic d) and **[ENT]** to confirm. Repeat the steps until the slope points are all included in the system.



9.1.2.4 Calculate the coordinate of main pile

In this case, there is no Short-Chainage included. Press 5.Cal MainPT Data under File menu to calculate the coordinate of main pile directly. The coordinate of ending point will be shown on the screen (pic b).

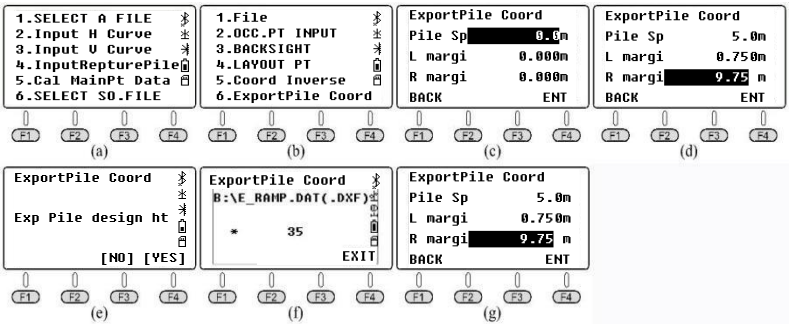


Consider that the ending pile for vertical curve is EK0+484.973, smaller than the ending pile for horizontal curve: EK0+626.087, so the height for the ending Chainage on horizontal curve should be 0, which means this point does not have designed height. Press

[F1]LAST to check the last data one by one (pic c-g).

9.1.2.5 Data Export

Press 6.Export Pile Coord under road menu (pic a). Input the interval between center piles(5m), the interval from left (0.75m) and right (9.75m) to the center. Press **[F4]ENT** to confirm and export the data.



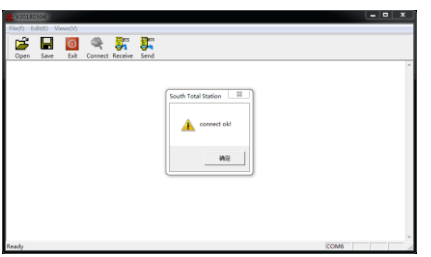
The data can be transferred by USB stick, Bluetooth. Please check Chapter 7.3.2 Data Transfer as a reference.

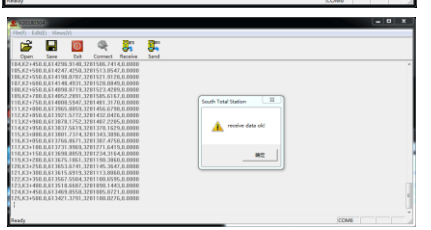
1.Connect PC and N6+ total station by Bluetooth

2.Open the software, then click  to connect the equipment. Click OK to close the dialog.

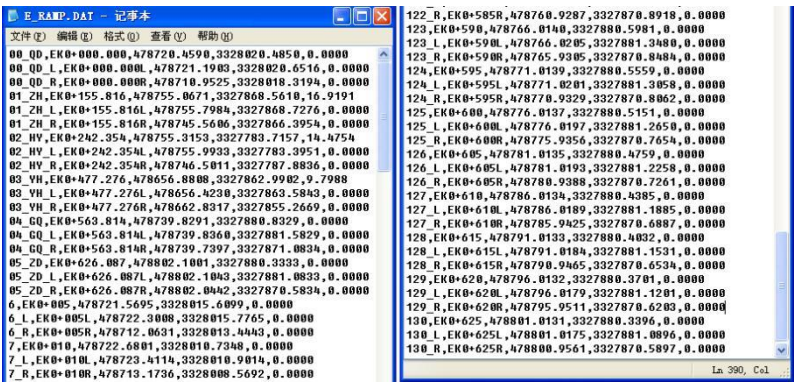
3.Click  [Receive] to activate the data receiving from N6+

4.The coordinate of main points and middle pile will show on the screen.





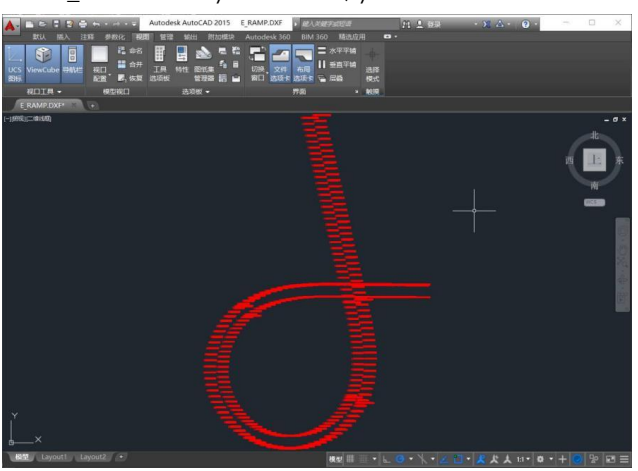
N6+ will export all the coordinate of main points before the piles. Each line on the screen shows the coordinate of point on the curve one by one. The format is South CASS format, in "Point Number, Pile Number, Y, X, H ".



Use Windows TXT to open the file E_RAMP.dat (export via USB stick)

9.1.2.6 Use AutoCAD to open the dxf file

Open the E_RAMP.dxf by AutoCAD, you can save the file as dwg.



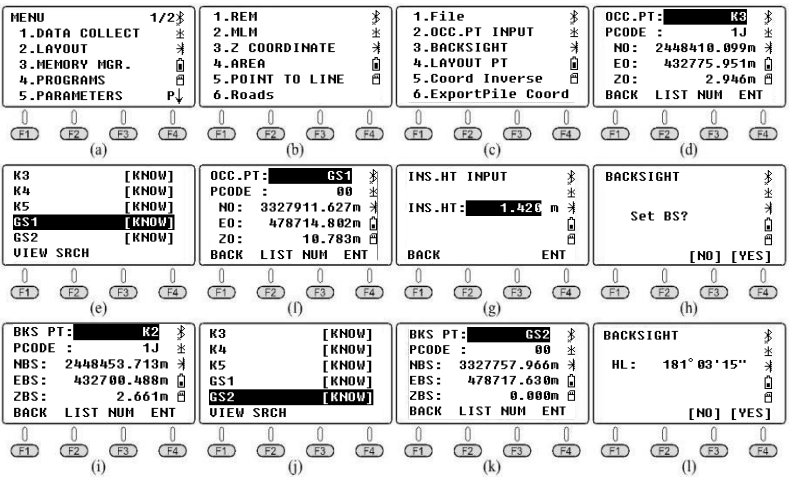
9.1.2.7 Layout points

① Input occupied point under existed file

Before the piles S.O, please input the occupied point GS1 and GS2 as the STN and BS point.

② Set the STN and BS

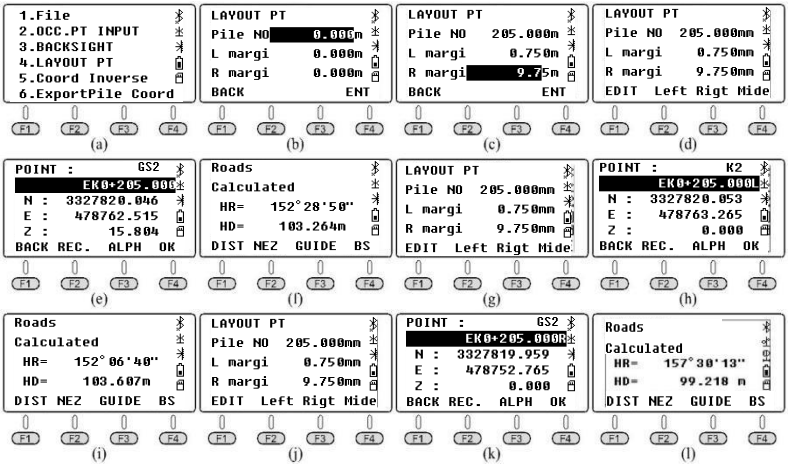
Press 6. Roads, 2.OCC. PT INPUT and **[F2]LIST** to call GS1 from the point list (pic e), move the cursor to GS1 and press **[F4]ENT** to select. Input the instrument height (pic g).



Press **[F4]YES** to set the BS, **[F2]LIST** to call GS2 from the point list (pic j). Press **[ENT]** to select it. The total station will display the azimuth angle from GS1 to GS2 (pic l), aim at GS2 and press **[F4]YES** to set the backsight.

④ Coordinate calculation and S.O

On the main menu of Roads, press 4.LAYOUT PT (pic b). Input the pile number 205, left 0.75m and right 9.75m as an example (pic c), press **[F4]ENT** to next step (pic d).



Press **[F4]MIDE** to check the coordinate of middle pile (pic e). Press **[F4]OK**, it will show the HR/HD difference from STN GS1 to pile EK0+205 (pic f). Please check Chapter 7.2 Stake Out as the reference.

After the layout of middle pile, press **[ESC]** to back to the last page (pic g). Press **[F2]Left** to check the coordinate of left pile EK0+205L (pic h), press **[F4]ENT**, it will show the HR/HD difference from STN GS1 to left pile EK0+205L and finish the S.O. (pic i).

After the layout of left pile, press **[ESC]** to back to the last page (pic j). Press **[F2]Rigt** to check the coordinate of left pile EK0+205L (pic k), press **[F4]ENT**, it will show the HR/HD difference from STN GS1 to right pile EK0+205R and finish the S.O. (pic l).

*Note: consider that pile EK0+205 belongs to the vertical curve EK0+145 - EK0+484.973, the height of EK0+205 will be displayed on

the screen (pic e). But the designed height of left and right pile will keep 0 (as pic h and pic k shown). When the coordinate of left/right/middle pile shown on the screen, input the point name and press **[F2]REC** to record the data under the current file.

9.1.2.8 Inverse calculation

① Inverse calculation from point 1

Press 5. Coord Inverse in Roads menu (pic b), press **[F2]R.HT** to input the target height.

There are three ways to get the coordinate: a) Press **[F3]NEZ** to input the coordinate by manual; b) Aim at the target and press **[F1]MEAS** to measure; c) Press **[F4]LIST** to call the point from list.

EG. Use manual input as an example

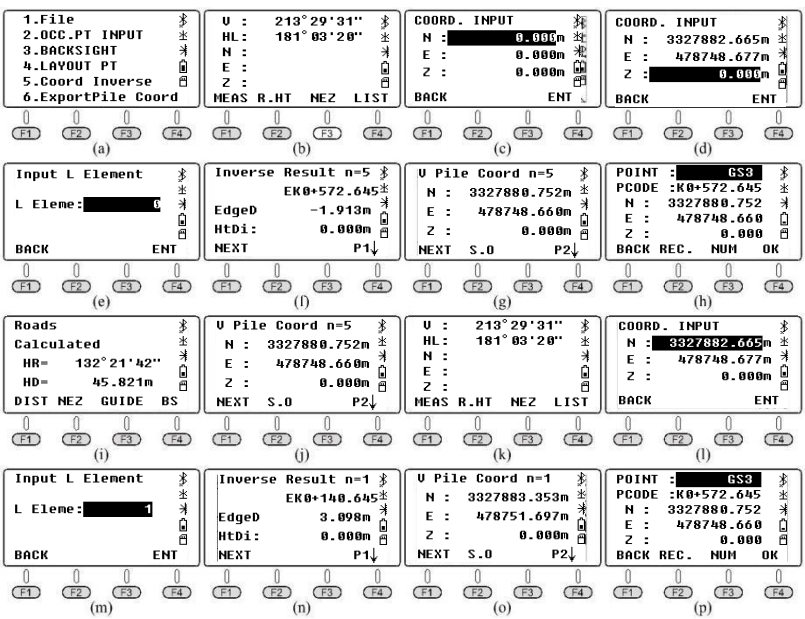
Press **[F3]NEZ** and input the coordinate of P1(point 1 from PIC6-1) , press **[F4]ENT** to the next page (pic d). Input the linear element number for point 1 (pic e), if you don't have this data, keep 0 for this page. Press **[F4]ENT** to find the linear number for point 1. The system will calculate the minimum data for side pile automatically.

As pic f shown, the first line n=5 means the vertical point of P1 is on the 5th linear element; the second line EK0+572.645 is the pile number of this vertical point; The value on the third line is -1.913m, the minus value means the point is on the left of middle line. If the edge difference is > 0, it means the point is on the right side. Press **[F4]P1↓** to the next page, it will display the coordinate of middle-pile on the screen (pic g).

Press **[F2]S.O** (pic h), and **[F4]OK** to confirm, it will show the HR/HD

difference from STN GS1 to the vertical point of P1 (pic i). The steps to stake out this point are same to previous chapter.

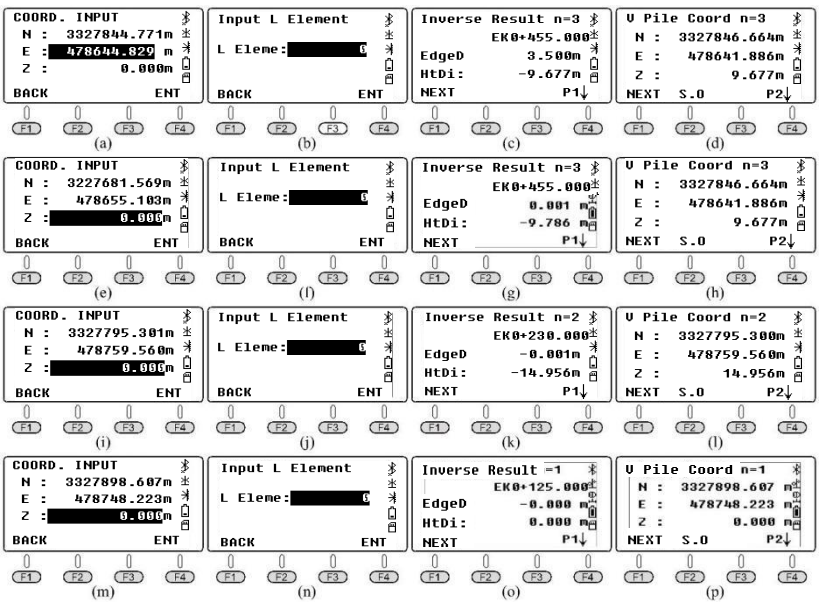
As picture shown, P1 has two vertical point on 1st and 5th linear element; the system calculated in the first time is the vertical point on 5th linear element (pic g). After S.O, press **[ESC]** back to the page of V Pile Coord (pic j). Press **[F4]P2↓**back to the page of coordinate measurement (pic k). Press **[F3]NEZ** again to check the latest coordinate which has been input by manual recently (pic l). Press **[F4]ENT** and input 1 in this time instead of 0 (pic m), press **[F4]ENT** to calculate the coordinate of P1 on 1st linear element (pic n). Press **[F4]P1↓**to check the coordinate of middle pile on 1st linear element, then finish the S.O steps.



② Coordinate inverse calculation from point 2-5

Input the coordinate of P2 by manual and calculate the vertical point on road (pic a-d). The pile number EK0+455 belonging to the range of vertical curve, so the height will be shown on the screen.

Input the coordinate of P3, P4, and P5 based on the similar steps.



**Note: User can draw the coordinate P1-5 on AutoCAD; command LINE to draw the vertical line from P1-5 to middle line of the ramp; command di to measure the distance; command id to check the coordinate of vertical point.*

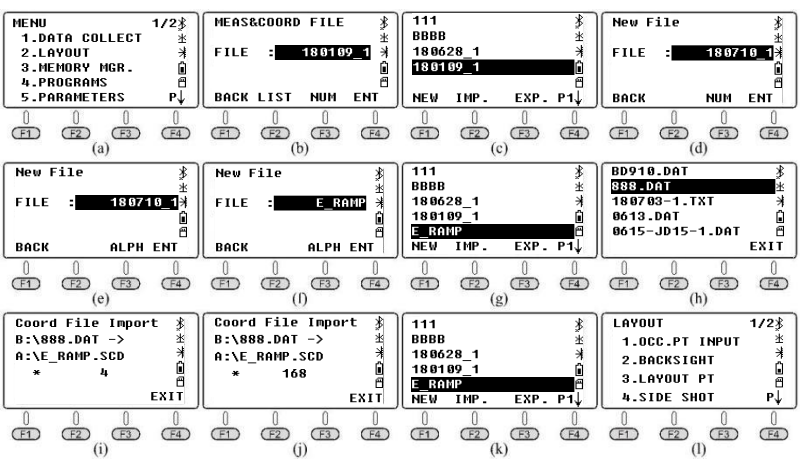
9.1.2.9 Stake out the middle and side piles

Press 6.Export Pile Coord under road menu (pic b). Export the file E_RAMP.dat to USB stick. You can also import those data into current coordinate file, and then stake-out the points.

① Import the coordinate of piles into current file

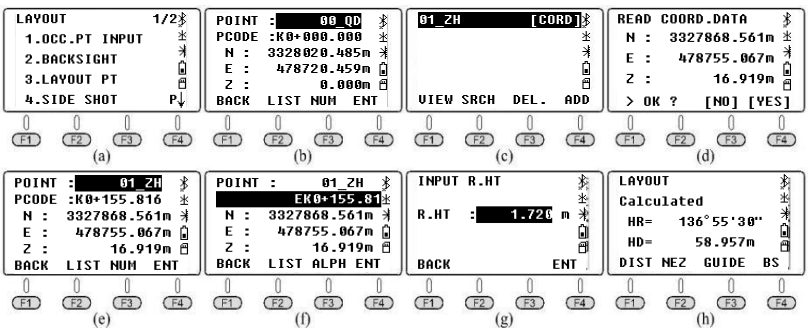
Press 2.Stake Out in menu, press **[F2]LIST, [F1]NEW** (pic f) to create the new file "E_RAMP" (pic f) and press **[F4]ENT** to confirm (pic g). Press [F2]IMP to the root menu of USB stick, move the cursor to the file which you need (pic i) and press **[ENT]** to import the data into internal memory of N6. After the data import, the screen will show as pic l.

**Note: It can save 96000 points in internal memory. If the quantity of points is larger than the limitation, please edit the data by Windows TXT and separate it into several files, or enlarge the interval of piles when export the coordinate in Roads.*



② Call the S.O point from current file

Press 3.LAYOUT PT under Stake Out menu (pic a) to check the layout data (pic b). Press **[F2]LIST** and move the cursor to "01_ZH" (pic c), press **[ENT]** to view the coordinate (pic d), press **[F4]YES** to check the detail information (pic e). Move the cursor to PCODE line to check the full code, 20 digits in maximum (pic f). Press **[F4]ENT** to confirm. Input the target height (pic g) and press **[F4]ENT** to confirm. The system will show the HR/HD difference from STN GS1 to point 01_ZH (pic h)



9.2 Case Study - H Curve in Renovation Project

9.2.1 Design Drawing for the Horizontal Curve JD17

PIC 6-23 on the below is a flat curve shown by intersection method, it is a renovation project located in Guangdong, China.

PT		Pile No & Coordinate	Azimuth	Features /m					
				Radius	Transit Parameter	Transit Length	Tangent Length	Total Length	Straight Line
QD	P	K11+349.420	$\alpha_{QD-JD17}$=307°23'38.35" (Inverse calculation by QD and JD17)						
	N	2 626 870.231							0
	E	50 354.882							
JD17	P	K11+485.969	24°46'36.2"(Z)	621.25	0	0	136.549	269.448	
	N	2 626 953.156			1779.189 5	90.159	137.172		95.746
	E	50 246.397							
ZD	P	K11+714.614	$\alpha_{JD17-ZD}$=282°37'02.03" (Inverse calculation by JD17 and ZD)						
	N	2 627 004.034							
	E	50 019.103							

Note: the 2nd transit curve in JD17 is not complete, azimuth angle for point YH is 234°57'56.09"

In theory, the flat curve designed in intersection method should have 4 flat curve across in an intersection point. They are: 1st transit curve, circular curve, 2nd transit curve, intermediate straight line before two intersection points.

The constant for 1st transit curve A1=0, so JD17 only included circular curve and 2nd transit curve in this situation. The length of intermediate straight line between main point HZ to the last intersection point (ZD in this case) is 95.746m; The line from QD → YH is called the intermediate straight line from start point to JD17, with the length 0. So this road should have 3 elements only: circular curve, 2nd transit curve and straight line HZ-ZD.

The total length of this curve JD17: L=269.448m the length of 2nd transit curve: Lh2=90.159m, but the length of circular curve is unknown. It can be calculated by Ly = L- Lh2 = 269.448-90.159=179.289m.

The 2nd transit curve in JD17 is an incomplete transit curve, the starting radius of transit curve equals to the radius of circular curve Rs=621.25m, the ending radius is not included in the drawing. You can calculate it in South MSMT app or the other related calculator to find out the ending radius Re.

9.2.2 Transfer the Form into Linear Elements

Select the data from PIC 6-23 on the below. Consider that the turning angle on JD17 are all left to the direction, the length of 1st and 2nd linear elements should be minus.

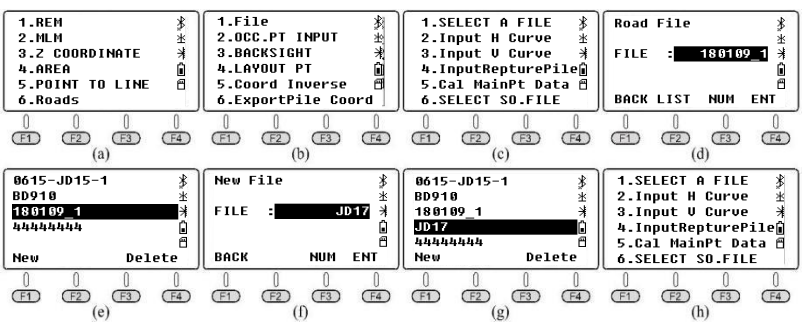
FORM 6-4 Linear Elements Data for Road JD17

PT	Pile No.	x/m	y/m	Azimuth Angle α_{QD}
QD	K11+349.42	2 626 870.231	50 354.882	307°23'38.35"
NO	R_S/m	R_e/m	L/m	Note
1	621.25	621.25	-179.289	Circular Curve
2	621.25	632.440 5	-90.159	Incomplete Trans-Curve
3	0	0	95.746	Straight Line

9.2.3 How to Use N6+ to Calculate the Road in H Curve

9.2.3.1 Create a new file as the current job.

Press 4.Programs, 6.Roads, 1.File and 1.Select a File to enter the file selection page (pic d). The system will select the latest file in default. Press **[F2]LIST** and **[F1]New** to create a new file "JD17". Press **[F4]ENT** and back to the file list (pic g). Move the cursor to JD17 and press **[ENT]** to set the file (pic h).



9.2.3.2 Input the designed value of the horizontal curve

(1) Input the starting value

Press 2.Input H Curve in "Roads" and enter the elements list (pic a); Press **[F4]ADD** to add a new element (pic b) based on the FORM 6-4. Press **[F4]ENT** to confirm and back to the elements list (pic c).

(2) Input the designed value of 1st circular curve

Press **[F4]ADD** and **[F2]ARC** to input the value of 1st circular curve from FORM 6-4 (pic e), the length of circular curve should be minus, press **[F4]ENT** to confirm. The ending azimuth and coordinate of middle pile will show on the screen (pic f).

(3) Input the designed value of 2nd transit curve

Press **[F3]TRNS** to input the value of 2nd transit curve (pic g) from FORM 6-4. The length of 2nd transit curve should be minus, press **[F4]ENT** to confirm. The ending azimuth and coordinate of middle pile will show on the screen (pic h).

(4) Input the designed value of 3rd straight line

Press **[F1]STR** and input the data from FORM 6-4 (pic i). The deviation angle keeps 0 when the 3rd straight line compatible with the direction of 2nd transit curve. Press **[F4]ENT** to check the azimuth angle and the coordinate of middle pile (pic j).

(5) Calculate the main coordinate

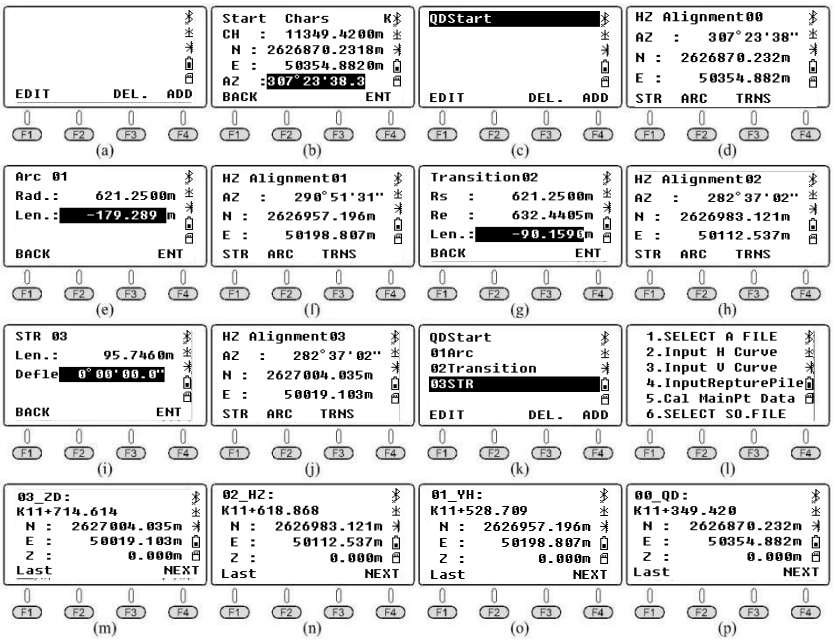
Press 5. Cal. MainPT Data to check the number of ending pile and coordinate of middle piles (pic m). The compare result shown on FORM 6-5.

The ending azimuth will not display completely because of the limitation (pic m). The azimuth angle from FORM 6-5 was collected from pic j.

Press **[F1]LAST** to check the main points one by one (pic n - p)

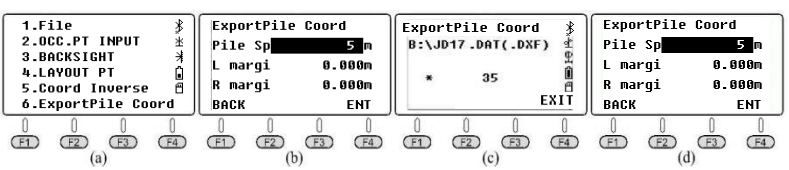
FORM 6-5 Compare between calculated result and designed result in JD17

	Pile Number	*x*/m	*y*/m	α
Calculated	K11+714.614	2 627 004.034	50 019.103	282°37′02.03″
Designed	K11+714.614	2 627 004.034	50 019.103	282°37′02″
Differ	0.000	0.000	0.000	0°00′00.03″

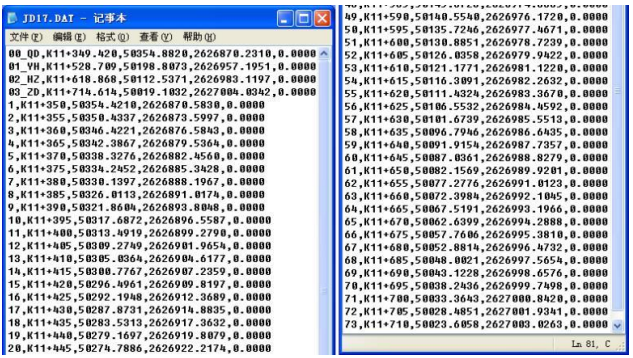


9.2.3.3 Export the data to USB stick

Press 6. Export Pile Coord (pic a), input the interval between center piles(5m). Press **[F4]ENT** to confirm and export the data "JD17.dat".



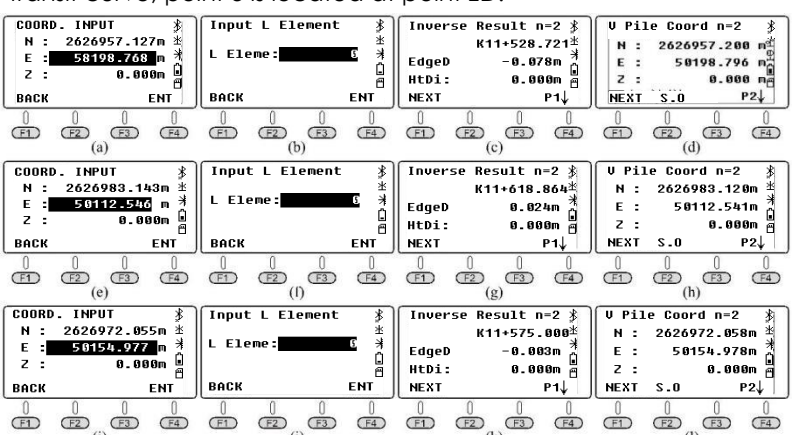
Open the "JD17.dat" by Windows TXT as below picture shown. Consider that this file doesn't including the data of vertical curve, the height of all those points will keep 0.



9.2.3.4 Inverse calculation

In this chapter, we will calculate the coordinate of vertical points from point 1-3 as an example. The vertical points from point 1-3 are all located around 2nd transit curve.

Point 1 is located around point YH, point 2 is located among 2nd transit curve, point 3 is located at point ZD.



9.3 Case Study - Vertical Curve in Road Project

9.3.1 Design Drawing for the Vertical Curve JD39-JD43

As picture shown below, there are 5 intersection points from JD39 to 43. Including single-curve JD39 and JD42, symmetrical curve JD40 and JD43, the 1st and 2nd transit curve are both complete curve intersected by JD40 and JD43; JD41 is a direct-turning point without curve.

PIC 6-30: Designed drawing JD39-JD43 in road project A3 section

No		Pile No. & Coordinate	Tunning Angle	Features /m					Straight Line
				Radius	Transit Parameter	Transit Length	Tangent Length	Total Length	
QD	P	K28+543.561	$\alpha_{QD\text{-}JD39}$=26°32′18.38″						
	N	3 246 012.339							353.741
	E	442 908.051							
JD39	P	K28+959.588	1°29′14.9″(R)	3 872.956	0	0	50.276	100.547	
	N	3 246 373.787							0
	E	443 088.565 2			0	0	50.276		
JD40	P	K29+069.848	15°18′36.1″(L)	260	114.017 5	50	59.992	119.475	
	N	3 246 471.122							291.44
	E	443 140.375 7			114.017 5	50	59.992		
JD41	P	K29+420.771	71°23′04.4″(R)	0	0	0	0	0	
	N	3 246 813.934							551.268
	E	443 217.731 8			0	0	0		
JD42	P	K30+022.507	0°02′53.5″(R)	120 000	0	0	50.468	100.936	
	N	2 627 004.034							1 034.163
	E	50 019.103			0	0	50.468		
JD43	P	K31+291.423	17°38′48″(R)	800	309.838 7	120	184.285	366.394	
	N	3 247 005.146							339.572
	E	445 078.585 2			309.838 7	120	184.285		
ZD	P	K31+813.103	$\alpha_{JD43\text{-}ZD}$=101°47′43.21″						
	N	3 246 898.061	K28+553.99=K28+566						
	E	445 591.380 7	K28+553.99−K28+566=-12.01m						

FORM 6-6 Vertical curve and slope in road project at JiangXi province

Pt	Pile	*H*/m	*i*/%	*R*/m	Tangent *T*/m	External *E*/m
SQD	K28+200	25.2	-1.1			
SJD1	K28+650	20.381	0.6	8 000	68.01	0.289
SJD2	K29+060	22.841	0	15 000	45	0.068

SJD3	K29+670	22.841	-0.7	50 000	174.998	0.306
SJD4	K30+150	19.481	0	22 000	76.999	0.135
SJD5	K31+300	19.481	1.5	20 000	149.992	0.562
SZD	K32+440	36.581				

9.3.2 Transfer the Data into Linear Elements

As picture shown, 4th circular curve is a kind of basic curve named JD40, the length Ly = L - Lh1 - Lh2 = 119.475-50-50=19.475m; The 11th circular curve is a kind of basic curve named JD44, the length Ly = L - Lh1 - Lh2 = 336.394 - 120 - 120 = 126.394m. 4th straight line is a direct-turning line for JD41, so the deviation angle should be the turning angle of JD41.

FORM 6-7 Linear element data for JD39 - 43

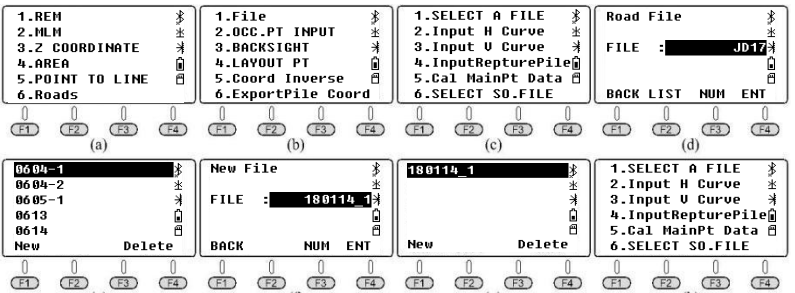
PT	Pile No.	x/m	y/m	Azimuth Angle α_{QD}
QD	K28+543.561	3 246 012.339	442 908.051	26°32'18.38"
NO	R_s/m	R_e/m	L/m	Note
1	0	0	353.741	Straight line
2	3 872.956	3 872.956	100.547	JD39 Circular curve
3	0	260	-50	JD40 1st Trans-curve
4	260	260	-19.475	JD40 Circular curve
5	260	0	-50	JD40 2nd Trans-curve
6	0	0	291.44	Intersected line
7	0	0	551.268	Devi: 71°23'04.4"
8	120 000	120 000	100.936	JD42 Circular curve
9	0	0	1034.163	Intersected line
10	0	800	120	JD43 1st Trans-curve
11	800	800	126.394	JD43 Circular curve
12	800	0	120	JD43 2nd Trans-curve
13	0	0	339.572	Intersected line

9.3.3 How to Use N6+ to Calculate the Road

9.3.3.1 Create a new file as the current job.

Press 4.Programs, 6.Roads, 1.File and 1.Select a File to enter the file selection page (pic d). The system will select the latest file as the

current one in default. Press **[F2]LIST**- **[F1]NEW** to create a new name "180114_1" (pic f). Press **[F4]ENT** to confirm and back to the file list. Move the cursor to line 180114_1 (pic g), press **[ENT]** to set (pic h).



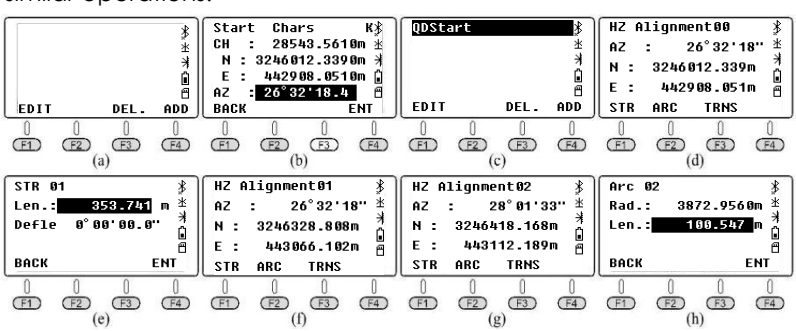
9.3.3.2 Input the designed value of horizontal curve

(1) Input the starting value

Press 2.Input H Curve in "Roads" and enter the elements list (pic a); Press **[F4]ADD** to add a new element (pic b) based on the FORM 6-7. Press **[F4]ENT** to confirm and back to the elements list (pic c). Press **[F4]ADD** to check the latest data of starting point (pic d)

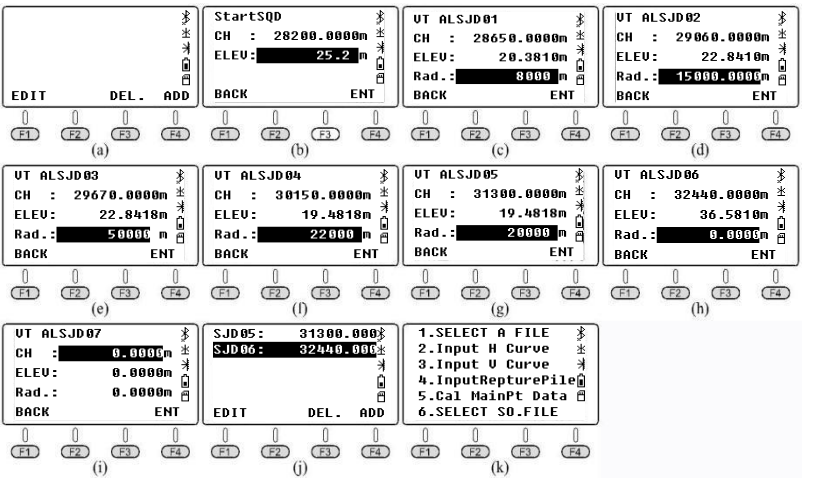
(2) Input the value of linear elements

Pic e-p shows the steps to input the data of 1st and 2nd curve from FORM 6-7, and input the data of 3rd to 13th curve based on the similar operations.



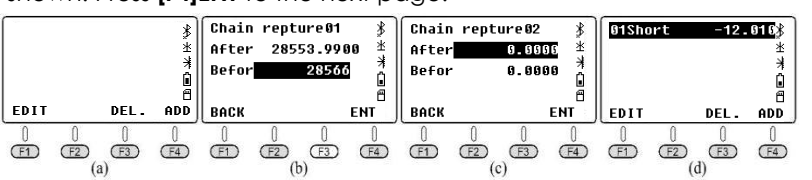
9.3.3.3 Input the value of vertical curve

Press 3.Input V Curve to enter the slope list (pic a). Press **[F4]ADD** to input the data of starting point (pic b); press **[F4]ENT** to check the result as pic c-g. The radius of vertical curve will keep 0 at the ending point. Press **[F4]ENT** to enter the inputting page for SJD7.



9.3.3.4 Input the data of Short-Chainage

Press 4.InputRepturePile to enter the list of short-pile (pic a), press **[F4]ADD** to input a new data for Short-Chainage (pic b) as picture shown. Press **[F4]ENT** to the next page.



9.3.3.5 Calculate the coordinate of main points

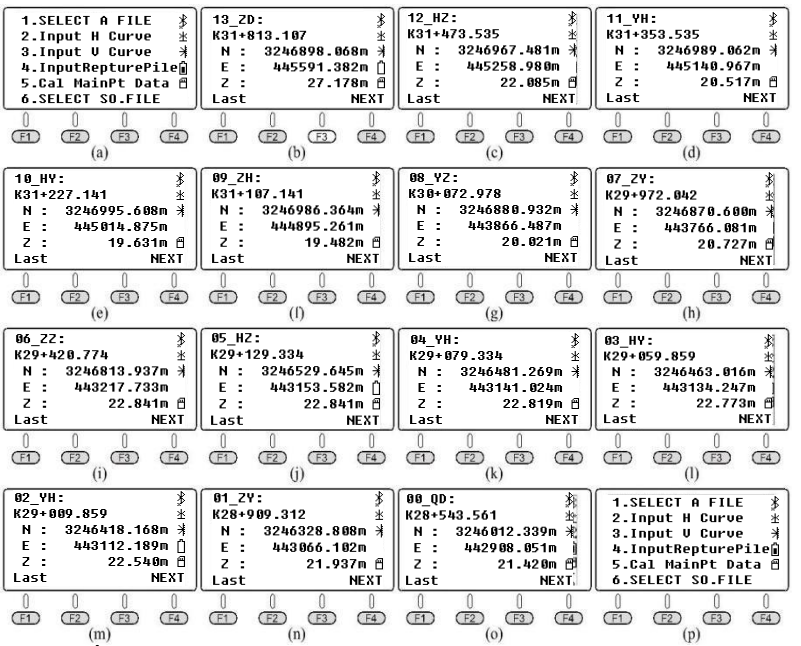
Press 5.Cal MainPt Data to calculate and get the result of pile

number, coordinate and height for ending point (pic b).

FORM 6-8 Compare between calculated result and designed result

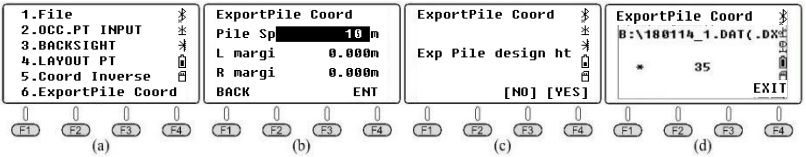
	Pile	*x*/m	*y*/m	α
Calculated	K31+813.107	3 246 898.068	445 591.382 5	101°47′42″
Designed	K31+813.103	3 246 898.061	445 591.382	101°47′43.21″
Differ	0.004	0.007	0.000 5	-0°00′01.21″

Pres **[F1]LAST** to check the data one by one, as pic c - o shown.

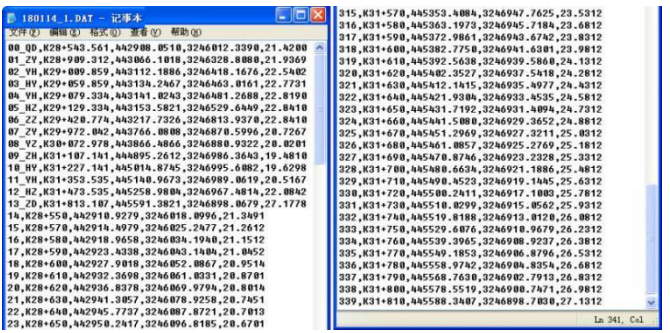


9.3.3.6 Export the data

Press 6.Export Pile Coord under road menu (pic a). Input the interval between center piles(10m), the interval from left and right keep 0. Press **[F4]ENT** to confirm and export the data.

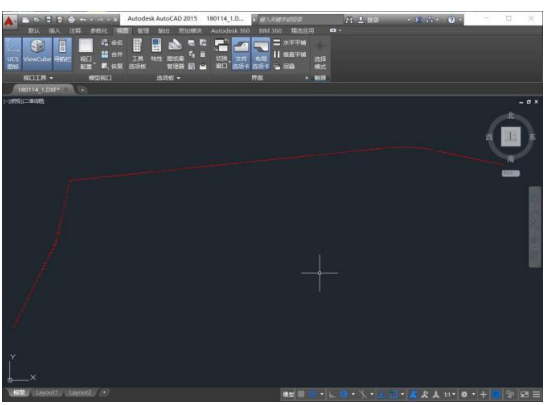


Open the file "180114_1.dat" by Windows TXT as below:



9.3.3.7 Use AutoCAD to open the dxf file.

When export the data, it will generate a DXF file automatically. Open the file "180114_1.dxf" by AutoCAD 2015. You can save the file as dwg format.



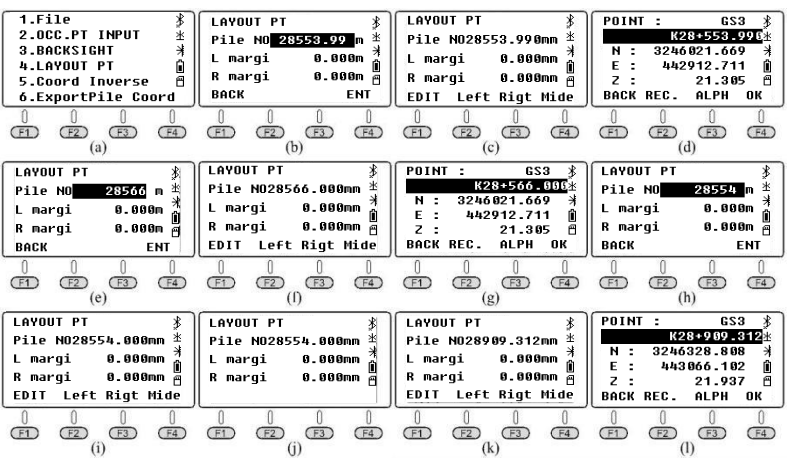
9.3.3.8 Layout points

① Calculate the coordinate of extra pile which located behind the Short-Chainage

Press 4.LAYOUT PT under Roads, press the pile number 28553.99 which located behind the Short-Chainage (pic b). Press **[F4]ENT** and **[F4]Mide** to check the coordinate (pic d).

② Calculate the coordinate of extra pile which located before the Short-Chainage

Press **[ESC]**-**[F1]EDIT** to enter the pile number 28566 (pic e), press **[F4]ENT** and **[F4]Mide** (pic g). As picture shown, K28+553.99=K28+566, so the pile K28+553.99 and K28+566 are the same point in actually (pic d/g).



③ Calculate the coordinate among the Short-Chainage

Press **[ESC]**-**[F1]EDIT** to enter the pile number 28554 (pic i), press **[F4] ENT** and **[F4]Mide** (pic j). As picture shown, K28+553.99=K28+566, so

the pile K28+553.99 and K28+566 are the same point in actually (pic d/g). The equipment will display "Miss Pile In SC" in 1s. It means the pile you added is belonging to the Short-Chainage. The number should be not existed in actual road.

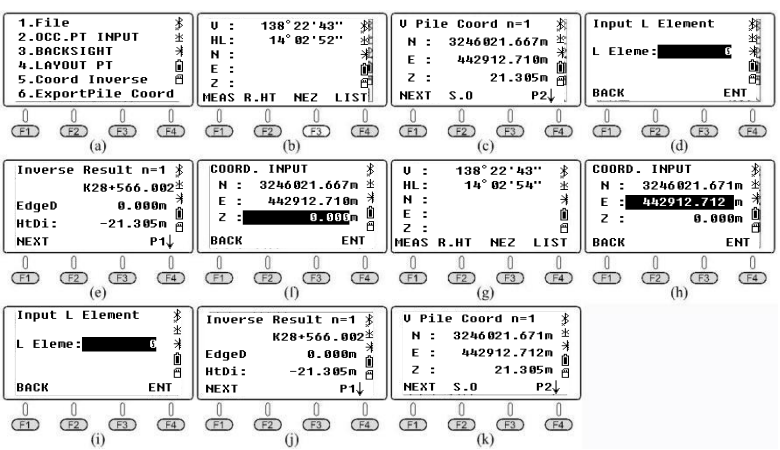
9.3.3.9 Inverse calculation

① Calculate the pile number of vertical point around the Short-Chainage

Press 5.Coord Inverse (pic a) under the road menu. Press **[F3]NEZ** and input the coordinate of measured point which located after the Short-Chainage in 0.002m (pic c). Press **[F4]ENT** in two times to search the number of linear element in automatically (pic d/e/f).

Press **[F1]NEXT** and **[F3]NEZ**, input the coordinate before the Short-Chainage in 0.002m (pic h). Press **[F4]ENT** in two times to search the number of linear element in automatically (pic j/k).

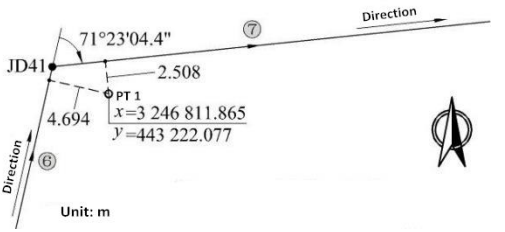
The HD difference is 0.004m, but the pile difference is K58+566.002 - K28+553.988 = -12.014m.



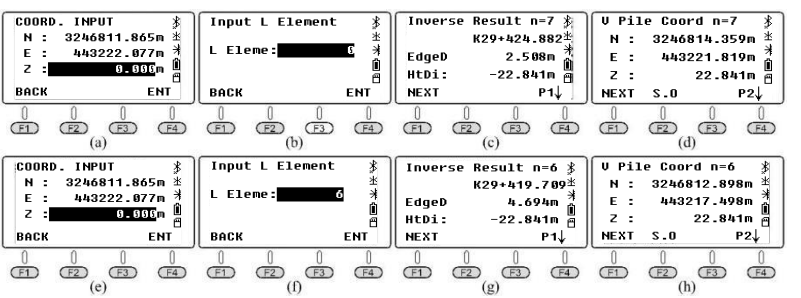
② Calculate the coordinate of vertical point around the turning point

As PIC6-42 shown, point 1 is located around the turning point JD41, the vertical point of P1 are both existed in 6th and 7th straight line.

PIC6-42 Drawing of the turning point JD41



If the linear element is lacked (L Eleme: 0), N6 will calculate the vertical point on 7th straight line in automatically, with edge distance 2.508m; when L Element is 6, N6 will calculate the vertical point on 6nd straight line, with edge distance 4.694m.



9.4 Case Study - H Curve A13 in High-speed Road

9.4.1 Design Drawing for A13

The character of this case is that the road included a Long-Chainage. The data listed below:

PIC6-44: Drawing of high-speed road A13

<table>
<tr><th rowspan="2">NO</th><th colspan="2" rowspan="2">Pile No.
& Coordinate</th><th rowspan="2">Turning Angle</th><th colspan="5">Features /m</th></tr>
<tr><th>Radius</th><th>Transit Parameter</th><th>Transit Length</th><th>Tangent Length</th><th>Total Length</th><th>Straight Line</th></tr>
<tr><td rowspan="3">QD</td><td>P</td><td>YK207+300</td><td colspan="6" rowspan="3">$\alpha_{QD\text{-}JD60}$=216°59′50.71″ (Inverse calculate from QD and JD60)</td><td></td></tr>
<tr><td>N</td><td>2 758 265.864</td><td rowspan="2">225.091</td></tr>
<tr><td>E</td><td>488 148.591</td></tr>
<tr><td rowspan="3">JD60</td><td>P</td><td>YK207+859.026</td><td rowspan="3">27°27′44.6″(Z)</td><td rowspan="3">1 100</td><td>378.153 4</td><td>130</td><td>339.935</td><td rowspan="3">657.240</td></tr>
<tr><td>N</td><td>2 757 819.391</td></tr>
<tr><td>E</td><td>487 812.181</td><td>378.153 4</td><td>130</td><td>339.935</td><td rowspan="2">725.622</td></tr>
<tr><td rowspan="3">ZD</td><td>P</td><td>YK208+906.056</td><td colspan="6">$\alpha_{JD60\text{-}ZD}$=189°32′06.05″ (Inverse calculate from ZD and JD60)</td></tr>
<tr><td>N</td><td>2 756 774.472</td><td colspan="6">Long YK208+300=YK208+298.102</td><td></td></tr>
<tr><td>E</td><td>487 636.665</td><td colspan="6">Chng YK208+300−K208+298.102=1.898m</td></tr>
</table>

FORM 6-9: Vertical curve and slope in high-speed road A13

PT	PILE	*H*/m	*i*/%	*R*/m	*T*/m	*E*/m
SQD	YK207+100	304.144	-1.52			
SJD1	YK207+430	299.128	-2.853	14 000	93.303	0.311
SJD2	YK207+900	285.719	1.3	8 010	166.325	1.727
SJD3	YK208+630	295.185	2.095	48 000	190.871	0.379
SZD	YK209+400	311.319				

9.4.2 Transfer the Form into Linear Elements

JD60 is a symmetrical horizontal curve, 1st and 2nd transit curve is complete with length Lh1 = Lh2 =130m. The full length of curve: L = 657.24m. So the length of circular curve is Ly = L - Lh1 - Lh2 = 657.24 - 130 - 130 = 397.24m.

In this case, there are 5 elements included, QD-JD60 line, 1st transit curve + circular curve + 2nd transit curve in JD60, and JD60-ZD line. List the data from PIC 6-44. The length of 2nd, 3nd and 4th element should be minus because of the direction of those element.

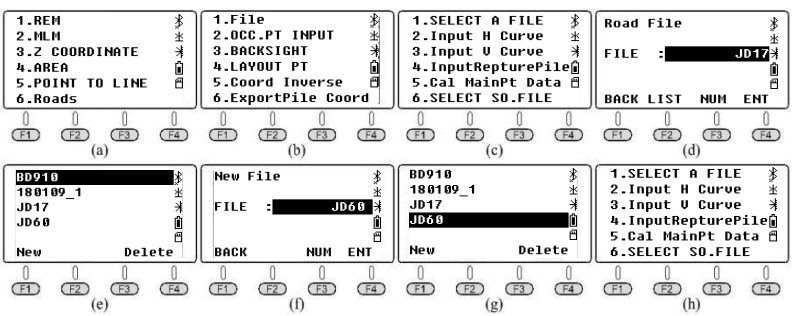
FORM 6-10: Linear element form for JD60

PT	Pile No.	x/m	y/m	Azimuth Angle α_{QD}
QD	YK207+300	2 758 265.864	488 148.591	216°59′50.71″
No	R_s/m	R_e/m	L*/m	Note
1	0	0	225.091	QD→JD60 Straight Line
2	0	1 100	-130	1st Complete transit curve
3	1 100	1 100	-397.24	Circular curve
4	1 100	0	-130	2nd Complete transit curve
5	0	0	725.622	JD60→ZD Straight Line

9.4.3 How to Use N6+ to Calculate the Road

9.4.3.1 Create a new file as the current job.

Press 4.Programs, 6.Roads, 1.File and 1.Select a File to enter the file selection page (pic d). The system will select the latest file as the current one in default. Press **[F2]LIST** and **[F1]NEW** to create a new name "JD60" (pic f), **[F4]ENT** to confirm and back to the file list. Move the cursor to line JD60 (pic g), press **[ENT]** to set (pic h).



9.4.3.2 Input the designed value of horizontal curve

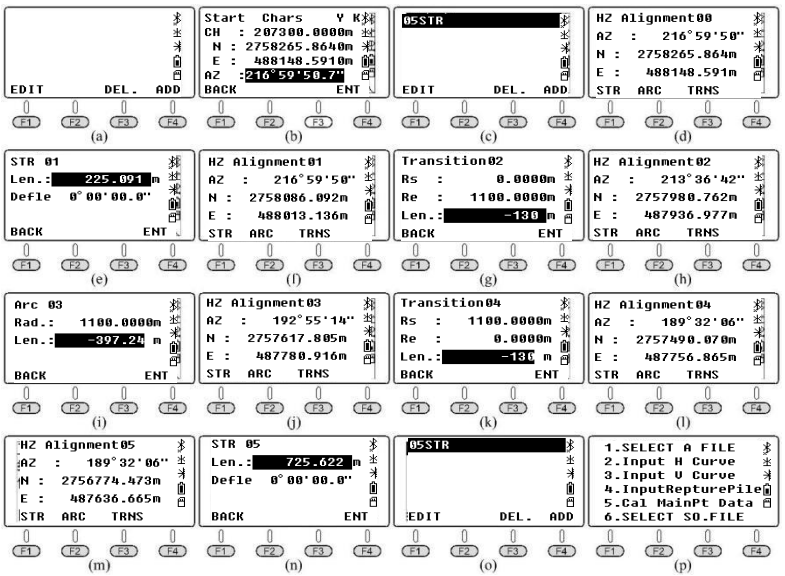
(1) Input the starting value

Press 2.Input H Curve in "Roads" and enter the elements list (pic a); Press **[F4]ADD** to add a new element (pic b) based on the FORM 6-10. Press **[F4]ENT** to confirm and back to the elements list (pic c). Press

[F4]ADD to check the latest data of starting point (pic d)

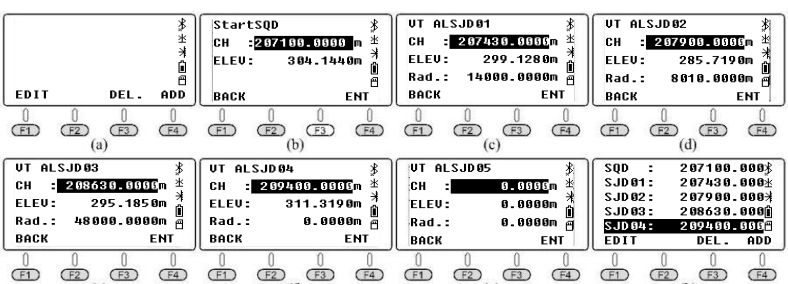
(2)Input the value of linear elements

Pic e-n shows the steps to input the data of 1st - 5nd elements from FORM 6-10. Press **[ESC]** and then back to the element list (pic p).



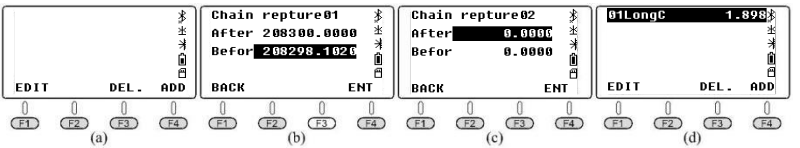
9.4.3.3 Input the value of vertical curve

Press 3.Input V Curve to enter the slope list (pic a). Press **[F4]ADD** to input the data of starting point, slope point and ending point as below picture shown.



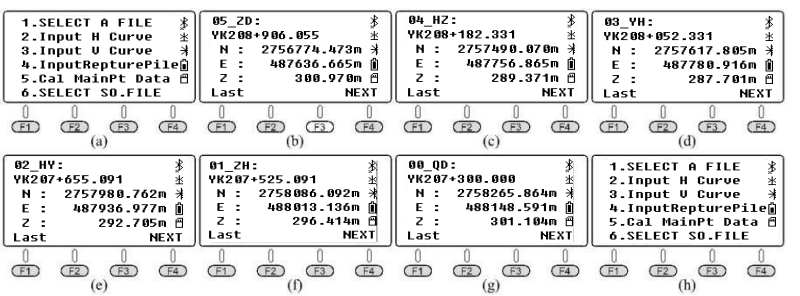
9.4.3.4 Input the data of Short-Chainage

Press 4.InputRepturePile to enter the list of Short-Chainage (pic a), press **[F4]ADD** to input a new data for Long-Chainage (pic b) as picture shown. Press **[F4]ENT** to the next page.



9.4.3.5 Calculate the data of main points

Press 5.Cal MainPt Data to calculate and get the result of pile number, coordinate and height for ending point (pic b).



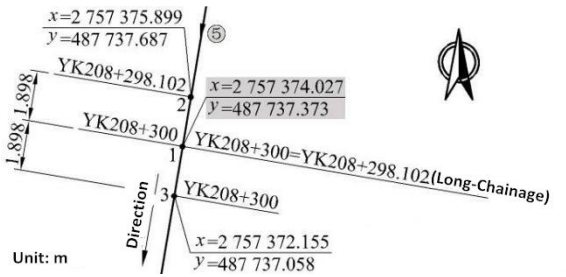
FORM 6-11: The comparison between calculated value and designed value for JD60

	Pile	*x*/m	*y*/m	α
Calculated	YK208+906.055	2 756 774.473	487 636.665	189°32'06"
Designed	YK208+906.056	27564774.472	487 636.665	189°32'06.05"
Differ	-0.001	0.001	0.000	-0°00'00.05"

9.4.3.6 Layout points

As PIC 6-50 shown, the Long-Chainage is located at 5th straight line. This chapter will describe how to calculate the coordinate of extra piles behind or after the Long-Chainage.

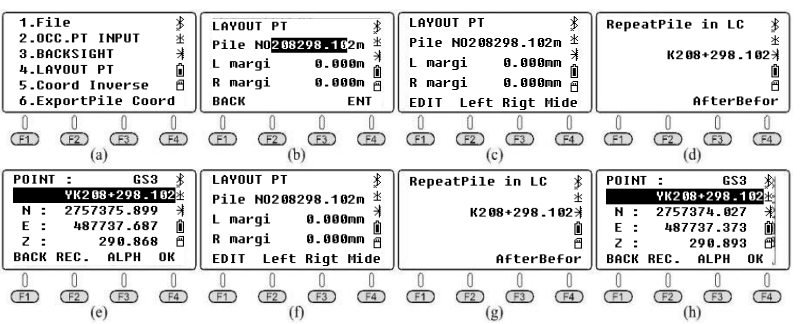
PIC 6-50: Drawing of the Long-Chainage on 5th straight line



①Calculate the coordinate of extra pile YK208+298.102 behind the Long-Chainage

Press 4.LAYOUT PT under Roads, press the pile number 208298.102 which located behind the Long-Chainage (pic b). Press **[F4]ENT** and **[F4]Mide** to check the confirmation the repeat piles in Long-Chainage (pic d).

Press **[F3]After** to select the pile number after the Long-Chainage (pic e). The coordinate of middle pile same to the coordinate of P2. Calculate the coordinate of pile 208298.102 before the Long-Chainage based on same steps, the result shown as pic h. The coordinate of middle pile same as P1.

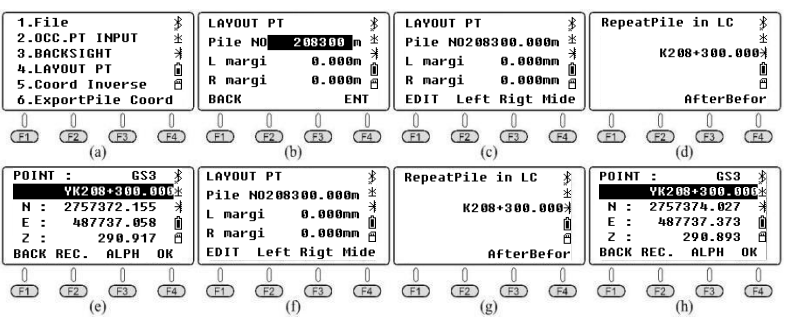


**Note: when calculate the coordinate of extra pile YK208+298.102, there are two points, P1 and P2 existed in the same time (PIC 6-50). Those two points are not overlapped but share the same pile number. That is because the extra pile YK208+298.102 is the back-pile from the Long-Chainage precisely.*

② Calculate the coordinate of extra pile YK208+300 before the Long-Chainage

Press **[ESC]-[F1]EDIT** to enter the pile number 208300 (pic b), press **[F4]ENT** and **[F4]Mide** (pic g). Press **[F3]After** to select the pile number after the Long-Chainage (pic e). The coordinate of middle pile same to the coordinate of P1.

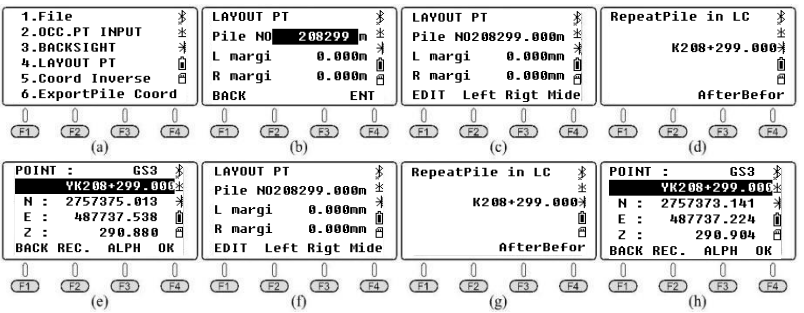
Calculate the coordinate of pile 208300 before the Long-Chainage based on same steps, the result shown as pic h. The coordinate of middle pile same to the coordinate of P3.



③ Calculate the coordinate of extra pile YK208+299 belonging the Long-Chainage

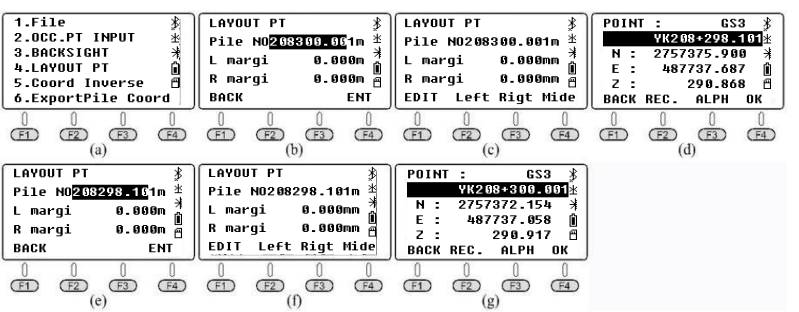
According to PIC 6-50, pile YK208+299 belonging to the Long-Chainage, it included two points back and front the repeat area.

Press 4.LAYOUT PT (pic a) under road menu, input the pile number 208299 (pic b), press **[F4]ENT**- **[F4]Mide**- **[F3]After** to select the repeat area (pic e). Calculate the coordinate of extra pile YK208+299 before the Long-Chainage area. The coordinate of those two points are not the same.



④ Calculate the coordinate of extra pile YK208+298.101

Press 4.LAYOUT PT under Roads, press the pile number 208298.101 (pic b). Press **[F4]ENT** and **[F4]Mide** to check the coordinate (pic d). The pile is located outside the Long-Chainage area, and only existed one point.



⑤ Calculate the coordinate of extra pile YK208+300.001

Press **[ESC]-[F1]EDIT** to enter the pile number 208300.001 (pic e), press **[F4]ENT** and **[F4]Mide** (pic g). The extra pile YK208+300.001 is located outside the Long-Chainage area, and only existed one point.

9.4.3.7 Inverse calculation

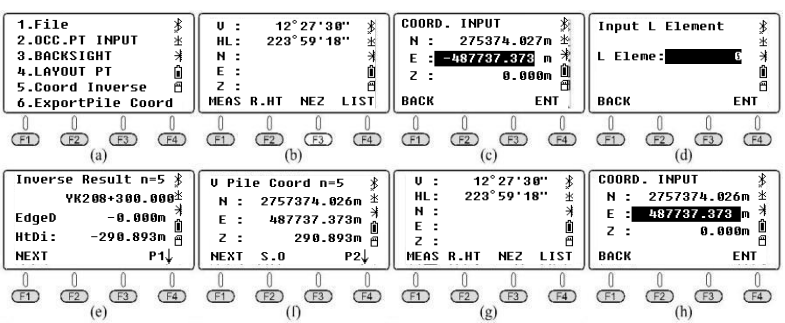
Input the coordinate of P1/P2/P3 to calculate the pile number and the coordinate of its middle pile.

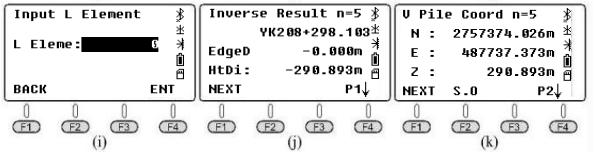
① Calculate the pile number of P1 based on its coordinate

Press 5.Coord Inverse (pic a) under the road menu. Press **[F3]NEZ** and input the coordinate of P1(pic c). Press **[F4]ENT** in two times to search the number of linear element in automatically (pic e/f). The pile number YK208_300 will show on the screen (pic e).

Press **[F1]NEXT** and **[F3]NEZ,** decrease the x coordinate of P1 to 0.001m (pic h). Press **[F4]ENT** in two times to search the number of linear element in automatically (pic j/k). The pile number of this vertical point should be YK208+298.103 (pic j).

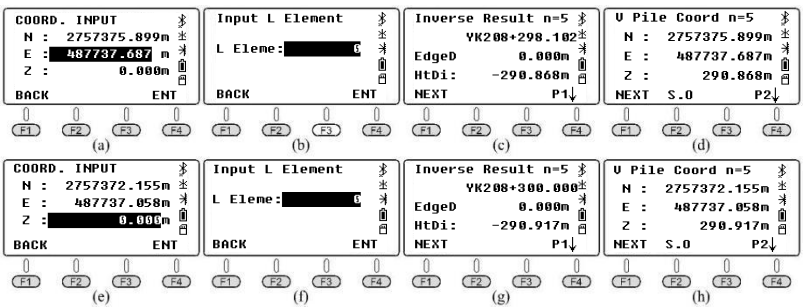
The difference of HD between those two points is 0.001m, but the difference of pile number is YK208+300−K208+298.103= 1.897m. That is caused by the vertical point of those two points crosses the Long-Chainage precisely.





② Calculate the pile number of P2/P3 based on its coordinate

Press **[F1]NEXT** under "Inverse Result" page (pic k), press **[F3]NEZ** to input the coordinate for the next point (pic a). Press **[F4]** two times to search the number of linear element in automatically (pic c/d). The pile number of the vertical point should be YK208+298.102 (pic c). Repeat the steps for P3, the result shown as pic g-h. The pile number of this vertical point is YK208+300 (pic g).

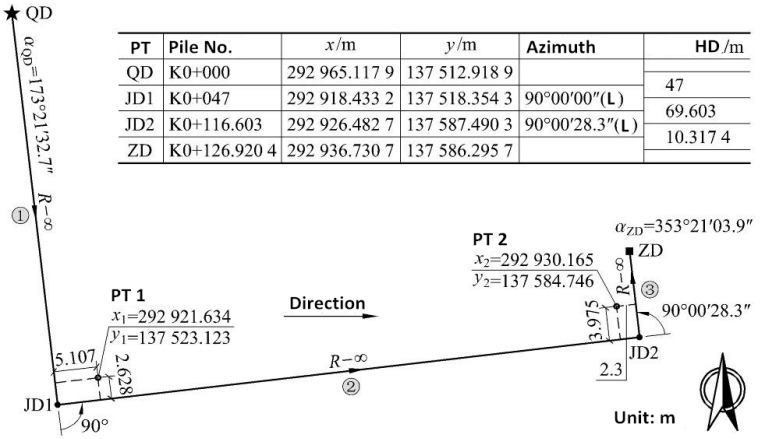


9.5 Case Study - Road in Residence Community

9.5.1 Design Drawing

The character of this case is that the road included two turning point JD1 and JD2, the angle turns left with nearly 90 degrees. In this chapter, we will calculate the data for P1/P2 as an example.

PIC 6-52: Design drawing for road in residence community from TianJin, China



PT	Pile No.	x/m	y/m	Azimuth	HD/m
QD	K0+000	292 965.117 9	137 512.918 9		
					47
JD1	K0+047	292 918.433 2	137 518.354 3	90°00′00″(L)	
					69.603
JD2	K0+116.603	292 926.482 7	137 587.490 3	90°00′28.3″(L)	
					10.317 4
ZD	K0+126.920 4	292 936.730 7	137 586.295 7		

9.5.2 Transfer the Form into Linear Elements

There are 3 line elements from PIC 6-57, including 2nd and 3nd direct-turning line. List the data below on FORM 6-12. Consider that the road turns left on JD1 and JD2, so the deviation (azimuth angle) should be minus.

FORM 6-12: Linear element

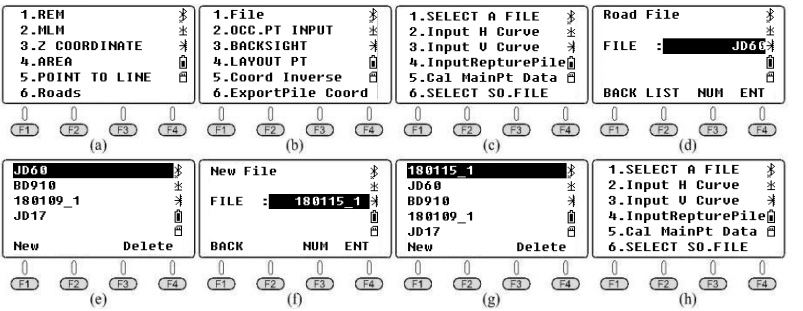
PT	Pile No.	x/m	y/m	Azimuth Angle α_{QD}
QD	K0+000	292 965.117 9	137 512.918 9	173°21′32.7″
No	R_s/m	R_e/m	L*/m	Note
1	0	0	47	Straight Line
2	0	0	69.603	Devi: -90°
3	0	0	10.3174	Devi: -90°00′28.3″

9.5.3 How to Use N6 to Calculate the Road

9.5.3.1 Create a new file as the current job.

Press 4.Programs, 6.Roads, 1.File and 1.Select a File to enter the file selection page (pic d). Press **[F2]LIST** and **[F1]NEW** to create a new

name “180115_1” (pic f), **[F4]ENT** to confirm and back to the file list. Move the cursor to line JD60 (pic g), press **[ENT]** to set (pic h).



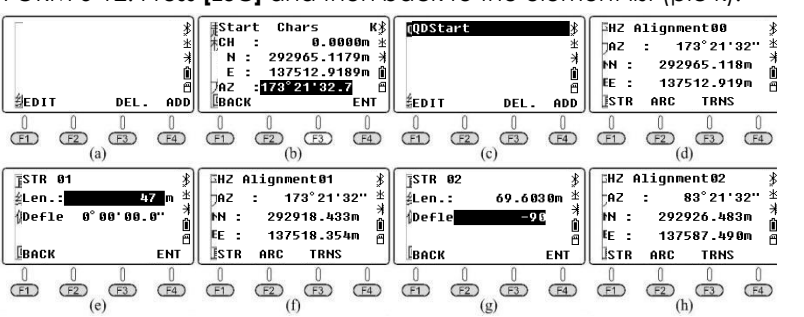
9.5.3.2 Input the designed value of horizontal curve

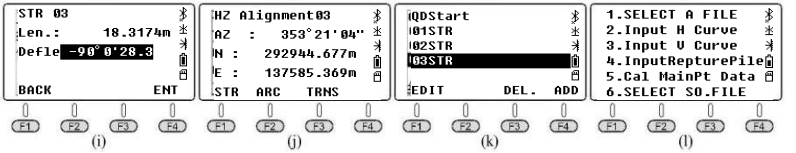
(1) Input the starting value

Press 2.Input H Curve in “Roads” and enter the elements list (pic a); Press **[F4]ADD** to add a new element (pic b) based on the FORM 6-12. Press **[F4]ENT** to confirm and back to the elements list (pic c). Press **[F4]ADD** to check the latest data of starting point (pic d).

(2)Input the value of linear elements

Pic e-j shows the steps to input the data of 1st - 3rd elements from FORM 6-12. Press **[ESC]** and then back to the element list (pic k).

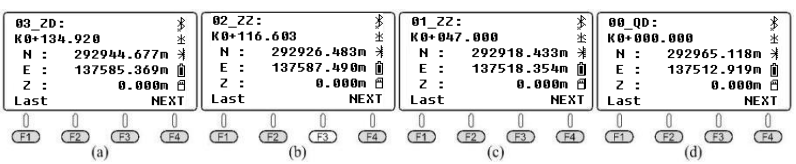




Note: After input the length of line in pic e, the cursor will not move to the deviation line by pressing **[ENT] or **[F4]ENT**. The system will skip to pic-f directly. Please press **[▼]** to move the cursor to the next line.*

9.5.3.3 Calculate the data of main points

Press 5.Cal MainPt Data to calculate the data of main point; the ending pile, coordinate of middle pile and height will show on the screen (pic a). Press **[F1]Last** to check the coordinate one by one (pic b - d).



FORM 6-13: The comparison between calculated value and designed value

	Pile No	*x*/m	*y*/m	α
Calculated	K0+126.920	292 936.731	137 586.296	353°21′04″
Designed	K0+126.9204	292 936.730 7	137 586.295 7	353°21′03.9″
Differ	-0.000 4	0.000 3	0.000 3	0°00′00.1″

9.5.3.4 Inverse Calculation

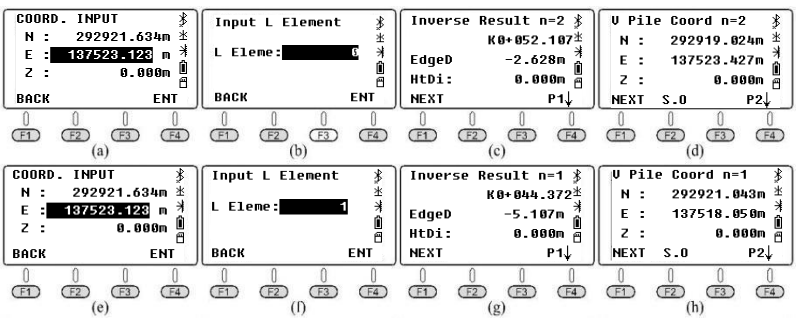
① Inverse calculation of P1

As PIC 6-57 shown, the vertical point of P1 existed on both 1st and 2nd straight line. N6 will select the minimum distance to calculate the vertical point in default, so the vertical point on 2nd line will show

on the screen instantly. If you input the linear element "1" before calculation, the result will be the vertical point on 1st line.

Press 5.Coord Inverse under the road menu. Press **[F3]NEZ** to input the coordinate of P1 (pic a). Press **[F4]ENT** in two times to search the number of linear element in automatically (pic c/d). The vertical point of P1 is located on 2nd line, distance -2.628m (pic c).

Press **[F1]NEXT** , **[F3]NEZ**, **[F4]ENT**, input the line element 1 and [F4]ENT to calculate (pic e - h). The vertical point of P1 is located on 1st line, distance -5.107m (pic g).



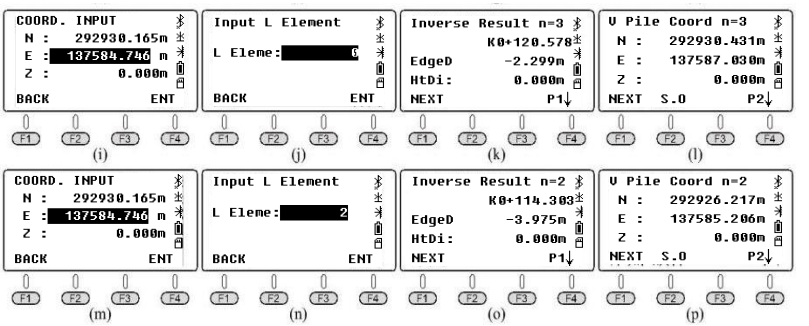
② Inverse calculation of P2

As PIC 6-57 shown, the vertical point of P2 existed on both 2nd and 3rd straight line. N6 will select the minimum distance to calculate the vertical point in default, so the vertical point on 3rd line will show on the screen instantly. If you input the linear element "2" before calculation, the result will be the vertical point on 2nd line.

Press **[F1]NEXT**, **[F3]NEZ** to input the coordinate of P1 (pic a). Press **[F4]ENT** in two times to search the number of linear element in

automatically (pic k - l). The vertical point of P2 is located on 3rd line, distance -2.299m (pic k).

Press **[F1]NEXT** , **[F3]NEZ**, **[F4]ENT**, input the line element 2 then press **[F4]ENT** to calculate (pic o - p). The vertical point of P2 is located on 2nd line, distance -3.975m (pic o).



9.6 Case Study - Roads in Tunnel

There is only one straight line included in this horizontal curve of tunnel. The linear elements listed on FORM 6-14. The vertical curve is an inclined line, with starting pile, ending pile and height, without changing point. The data listed on FORM 6-15.

FORM 6-14: the data in tunnel by linear elements method

PT	Pile No.	*x*/m	*y*/m	Azimuth Angle *α*	
QD	HK0+000	3 976 503.762	483 718.913	104°11'04"	
ZD	HK0+035.213	3 976 495.133	483 753.052	104°11'04"	
No	Rs/m	Re/m	L/m	Devi	Type
1	0	0	35.213	0	Line

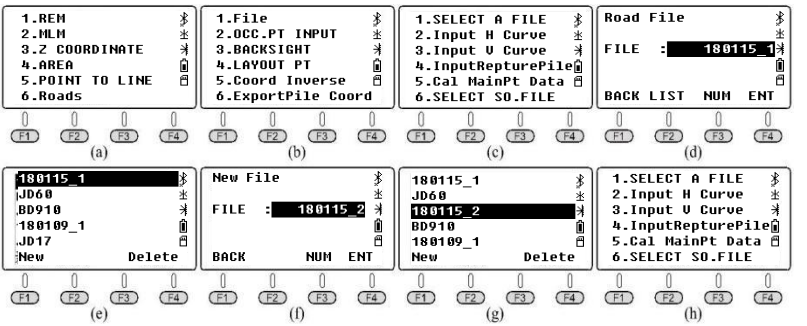
FORM 6-15: vertical curve and slope angle in tunnel

PT	Pile No.	*H*/m	*i*/%
SQD	HK0+000	1 024.612	5.198
SZD	HK0+035.213	1 026.4425	

9.6.1 Create a new file as the current job.

Press 4.Programs, 6.Roads, 1.File and 1.Select a File to enter the file selection page.

Press **[F2]LIST** and **[F1]NEW** to create a new name "180115_2" and set this file as the current job (pic h).



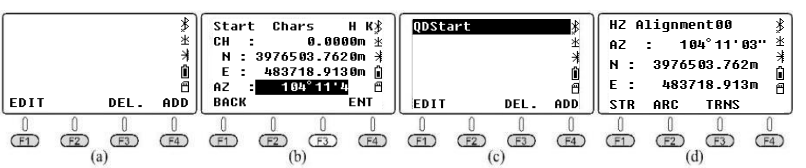
9.6.2 Input the designed value of horizontal curve

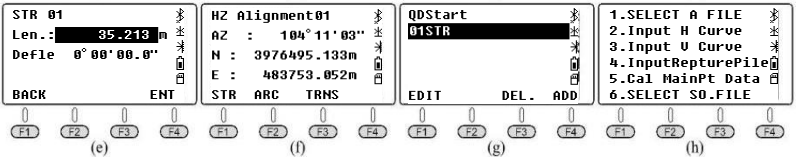
(1) Input the starting value

Press 2.Input H Curve in "Roads" and enter the elements list (pic a); Press **[F4]ADD** to add a new element (pic b) based on the FORM 6-14. Press **[F4]ENT** to confirm and back to the elements list (pic c). Press **[F4]ADD** to check the latest data of starting point (pic d).

(2)Input the value of straight line

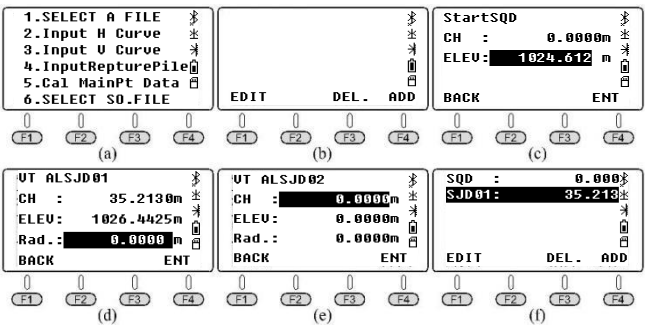
Pic e-f shows the steps to input the data of the sole line from FORM 6-12. Press **[ESC]** and then back to the element list (pic g).





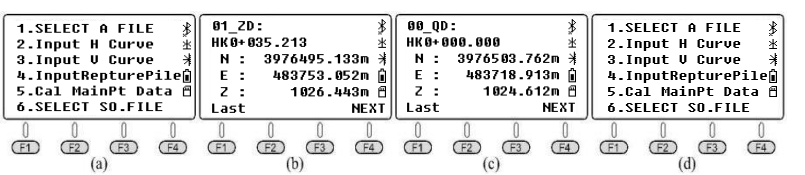
9.6.3 Input the designed value of vertical curve

Press 3.Input V Curve to enter the slope list (pic h). Press **[F4]ADD** to input the pile number and height of starting point, pile number and height of ending point as below:



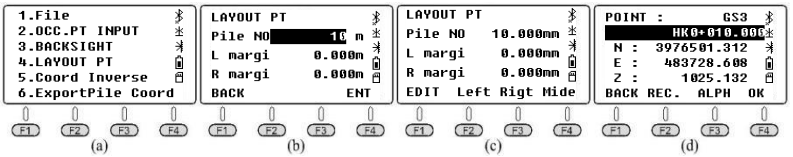
9.6.4 Calculate the data of main points

Press 5.Cal MainPt Data to calculate and get the result of pile number, coordinate and height for ending point (pic b). Press **[F1] Last** to check the main points (pic c).



9.6.5 Layout points

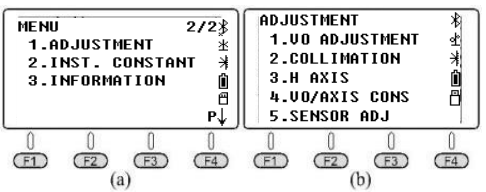
Press 4.LAYOUT PT under road (pic a), input the extra pile 10m (pic b). Press **[F4]ENT** and **[F4]Mide** to calculate the coordinate of middle pile (pic d).



10.ADJUSTMENT & INFORMATION

10.1 Adjustment

Press 1.ADJUSTMENT in 2nd page of Menu. It includes four commands: V0 Adjustment, Collimation, Horizontal Axis and V0/Axis Const. The last V0/Axis Const. Will display the results about the previous three commands. Please execute the last command before the 1st to 3rd command to clear the existed results.

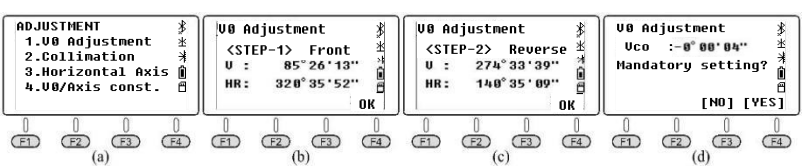


Please open the sensor and well-settled the total station before execute the commands. The horizontal angle should be HR (horizontal right), and V angle should be set as zenith 0.

10.1.1 V0 Adjustment (i Angle)

Calculate the error of vertical disk to adjust the vertical reading by measuring a clear target in both two sides.

Aiming at a target in HL, press 1.V0 Adjustment (pic b) and **[F4]OK**. Rotate the equipment to aim at the same point in HR (pic c), press **[F4]OK** to finish the adjustment. It will display the error value of vertical disk (pic d), press **[F4]YES** to confirm.



If the vertical angle is Zenith 0, i =(L+R-360°)/2

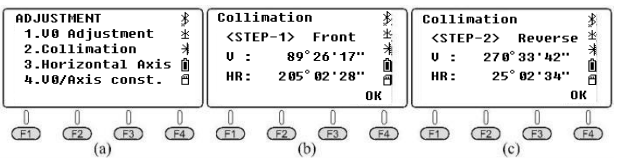
If the vertical angle is Horizontal 0, i =(L+R-180°)/2 or (L+R-540°)/2

10.1.2 Collimation (2C)

Calculate the error of 2C to adjust the horizontal reading, by measuring a clear target in two sides.

Aiming at a target in HL, press 2.Collimation (pic b) and **[F4]OK**. Rotate the equipment to aim at the same point in HR (pic c), press **[F4]OK** to finish the adjustment.

$$2C=L-(R\pm180°)$$

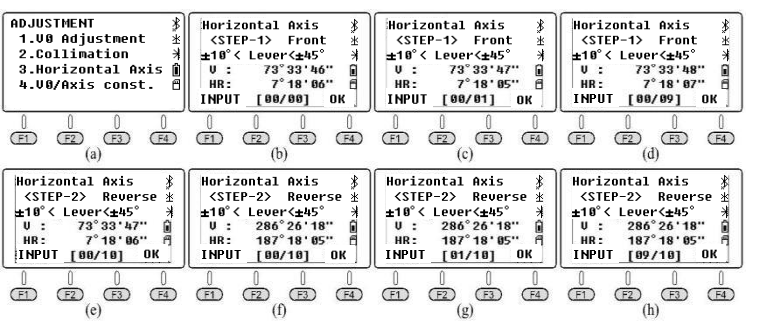


10.1.3 Horizontal Axis

Calculate the error of horizontal axis to adjust the horizontal reading, by measuring a target with vertical angle:±10°~±45°in both two sides.

Aiming a target in HL with vertical angle: ±10°~±45°, then press 3. to enter the Horizontal Axis page. (pic b). Press **[F4]OK** for 10 times.

Rotate the equipment to aim at the same point in HR (pic c), then press **[F4]OK** for 10 times to finish the adjustment.



**Please adjust the i angle, 2C and horizontal axis after the long-term shipment or any other vibrations.*

10.1.4 V0/Axis Const.

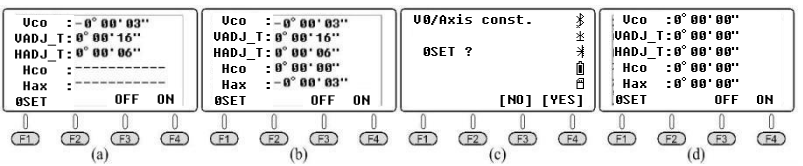
Press 4.V0/Axis Const under "adjustment" menu.

VADJ_T and HADJ_T refer to the sensor error when install the electric sensor.

Press **[F3]OFF** to close the adjustment of horizontal axis and 2C error.

Press **[F4]** to open.

Press **[F1]OSET** to clear the previous result to zero.



10.1.5 Sensor Adj.

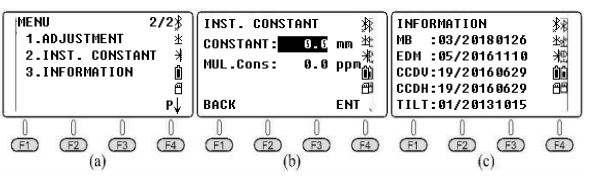
In Face 1, Aim on target center of collimator, then press SET

Rotate unit to face 2, Aim on same target again, then press SET. It will be done.

10.2 Instrument Constant & Information

10.2.1 Inst. Constant

Press 2.INST.CONSTANT in the 2nd page of Menu(pic b). Don't modify the value without the authorization.



10.2.2 Information

Press 3.Information in the 2nd page of Menu (pic c)

MB: 03/20180126 - Mainboard 03, update date is Jan.26th, 2018

EDM: 05/20161110 - EDM 05, update date is Nov.10th, 2016

CCDV: 19/20160629 - Horizontal Disk 19, update date is Jun.29th, 2016

CCDH: 19/20160629 - Vertical Disk 19, update date is Jun.29th, 2016

TILT: 01/20131015 - Tilt 01, update date is Nov.10th, 2016