Operation Manual

N6 Series

Electronic Total Station

INDEX

1. SPECIFICATIONS

1.1 EDM

Carrier Wave	0.65~0.69μm
Effective Range of Bluetooth	5m
Reflectorless Range	600m
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 <300m	$\pm(3+2\times10^{-6}\cdot D)$mm	0.3~3s in normal, less than 10s
Fine Mode >300m	$\pm(5+2\times10^{-6}\cdot D)$mm	
Tracking Mode	$\pm(10+2\times10^{-6}\cdot D)$mm	

Max. Range		
With Reflector	Single Prism	IR Sheet
*² Good Conditions	5000m	600m
Without Reflector	White*³	Gray Degree 0.18
*² Good Conditions	600m	300m
*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	1.4m
Resolving Power	3"
Compensator	
System	Dual axis liquid-electric
Working Range	±4'/6' optional
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	RS-232C/USB/SD Card/ Bluetooth
Battery	
Type	Rechargeable Lithium battery
Voltage	7.4V DC, 3100mAH
Continuous Operation Time	8 hrs
Working Environment	
Temperature	-20℃~+50℃
Dimension	
Size	160mm×150mm×330mm
Weight	5.2kg

2.BASIC OPERATIONS AND SETTINGS

2.1 Brief Introductions
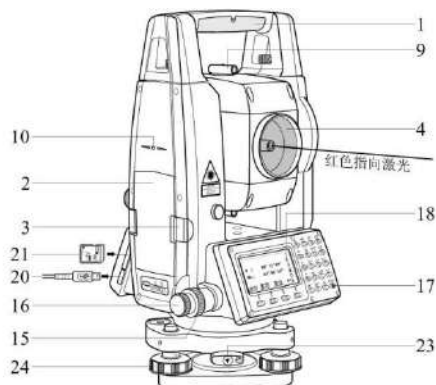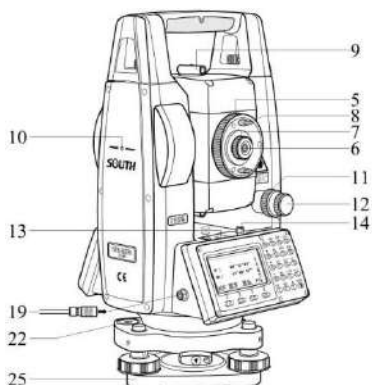
1	Handle	14	Vial Screw
2	Battery	15	Horizontal Clamp and
3	Battery Lock	16	Tangent Unit
4	Optical Unit	17	Power Key
5	Optical Focusing Ring	18	Display Unit
6	Eyepiece	19	RS-232 Comm Port
7	Eyepiece Focusing Ring	20	USB Comm Port
8	Eyepiece Handle	21	SD Card Slot
9	Collimator	22	Circle Bubble
10	Central Mark	23	Tribrach Lock
11	Vertical Clamp and Tangent	24	Leveling Screw
12	Unit	25	Base
13	Vial Bubble		

2.1.1 Basic Keys
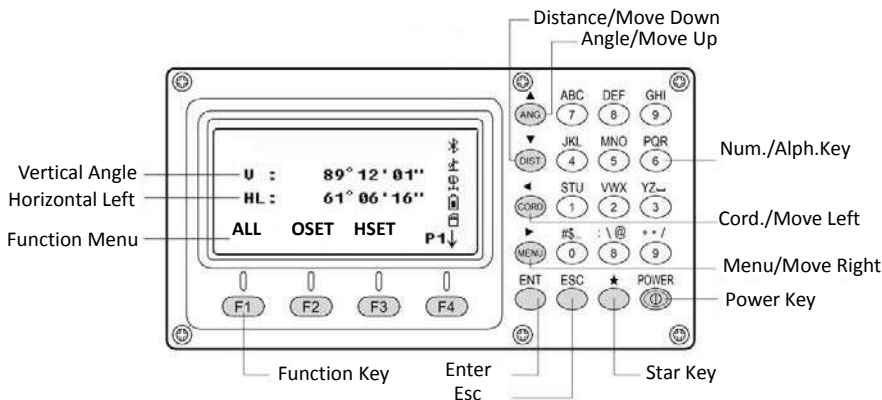
Key	Name	Function
★	Star key	Enter the star mode
ANG	Angle measuring	Enter to angle measurement mode
DIST	Distance measuring	Enter to distance measurement mode
CORD	Coordinate measuring	Enter to coordinate measurement mode
MENU	Menu	Enter to menu mode
ESC	Esc	Cancel operation,or return to the last page
⏻	Power key	Power ON/OFF
F1 ~ F4	Function key	Functions correspond to information displayed
0 ~ 9	Number keys	Input numbers/characters, or select items
◀ ▶ ▲ ▼	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

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✳	Sensor closed	★ F2 F3
✻	Bluetooth closed	MENU 5 (system setting) 5 (Bluetooth) 1 (Off)
✻	Bluetooth open	MENU 5 (system setting) 5 (Bluetooth) 2 (Open)
✳	Reflectorless mode	★ ►
⊡	Reflector mode	★ ► ►
⊠	Reflector sheet	★ ► ► ►
▯	Battery voltage	Display the battery voltage in real time
⊟	SD Card	SD Card inserted

2.1.2 Reflector

When measuring distance, a reflector prism needs to be placed at the target place. Reflector systems come with single prism and triple prisms, which can be mounted with tribrach onto a tripod or mounted onto a prism pole. Reflector systems can be self-configured by users according to job.

2.1.3 Tribrach

Use the straight screwdriver to loosen the fix screw on the tribrach, with 180° anti-clock wise direction. Then pull out the equipment.

RS-232 Comm Port

Directing Stub

Anchor Jaw

Directing Slot

Circular Bubble

Fix Screw

Locking Knob
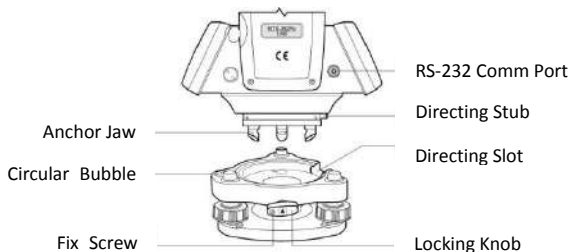
2.1.4 System Information

Hold the power key in 1s to power on. The initial page is the angle measurement mode (a), press ⓔⓢⓒ to enter the system information page (b). Press ⓜⓔⓝ ⓕ4 [3] Information to check the hardware information.

(a) (b) (c)
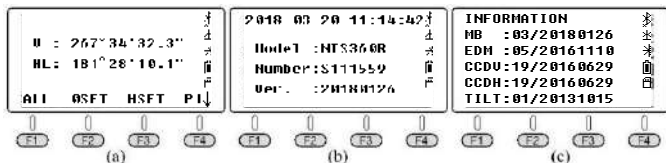
Hold the power key in 4s to power off.

2.1.5 Initial Settings

Mount the instrument to the tripod. Level and center the instrument precisely to ensure the best performance.

Operation Reference:

1. Leveling and Centering the Instrument by plumb bob

1) Setting up the tripod

① First of all, extend the extension legs to suitable length, make the tripod head parallel to the ground and tighten the screws.

② Make the centre of the tripod and the occupied point approximately on the same plumb line.

③ Step on the tripod to make sure whether it is well stationed on the ground.

2) Attaching the instrument on the tripod

Place the instrument carefully on the tripod head and slide the instrument by loosening the tripod screw. If the plumb bob is positioned right over the center of the point, slightly tighten the tripod.

3) Roughly leveling the instrument by using the circular vial

① Turn the leveling 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 .
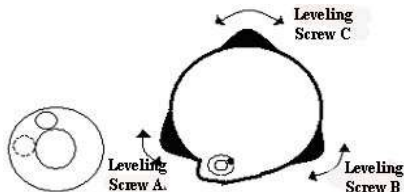
② Turn the leveling screw C to move the bubble to the center of the circular vial.
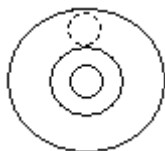
4) Precisely leveling by using the plate vial

① Rotate the instrument horizontally by loosening the Horizontal Clamp Screw and place the plate vial parallel to the line connecting leveling screw A and B, and then bring the bubble to the center of the plate vial by turning the leveling screws A and B.
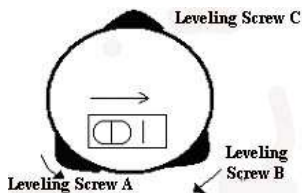
② Rotate the instrument 90º(100g) around its vertical axis and turn the remaining leveling screw or leveling C to center the bubble once more.
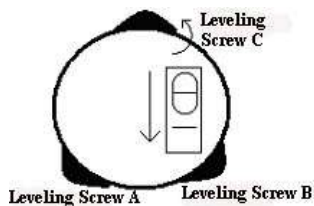
③Repeat the steps ①② for each 90º(100g) rotation of the instrument and check whether the bubble is correctly centered in all directions.

2. Centering by using the optical plummet

1) Set tripod

Lift tripod to suitable height, ensure equal length of three legs, spread and make tripod head parallel to the ground, and place it right above the measurement station point. Prop up tripod on the ground and fix one leg.

2) Install instrument and collimate the point

Set instrument carefully on tripod, tighten the central connecting screw and adjust optical plummet to make the reticle distinctly. Hold the other two unfixed legs with both hands and adjust position of these two legs through observation of optical plummet. As it approximately aims at the station point, make all three legs fixed on the ground. Adjust three leg screws of the instrument to make optical plummet collimate precisely to the station point.

3) Use circular vial to roughly level the instrument.

Adjust length of three legs of tripod; make the circular vial bubble of the instrument in the middle.

4) Use plate vial to level the instrument accurately.

① Rotate the instrument horizontally by loosening the Horizontal Clamp Screw and place the plate vial parallel to the line connecting leveling screw A and B, and then bring the bubble to the center of the plate vial by turning the leveling screws A and B.

② Rotate the instrument 90℃, make it perpendicular to the connecting line of level screws A and B. Turn level screw C to make the bubble of the plate vial in the middle.

5) Precisely centering and leveling

Through observation of optical plummet, slightly loosen the central connecting screw and move the instrument evenly (Don't rotate the instrument), making the instrument precisely aim to the station point. Then tighten the central connecting screw and level the

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instrument precisely again.

Repeat this operation till the instrument collimate precisely to the measurement station point.

2.1.6 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.
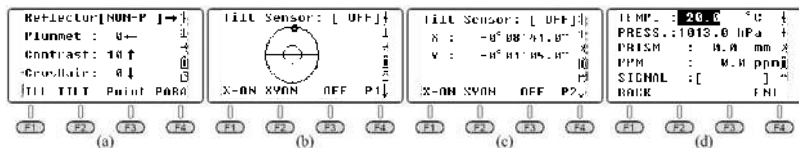
(1) Direction keys

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. The default value is 0. Press ▼ to switch the value among 0→1→2→3→4→0, 0 means off.

(2) Function keys

ILL: Illumination for LCD screen and keyboard. The default setting is on. Press F1 to open or close the illumination.

TILT: On/Off the tilt sensor. The default setting is dual-axis sensor. Press F2 to enter 1/2 page. Then press 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.

Point: On/off laser pointer. The default setting is off. Press F3 to switch the laser

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pointer between on and off.

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$^\circ C$, 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$^\circ C$~+60$^\circ C$, min. 0.1$^\circ C$ increase; Input range for atmosphere pressure560~1066hPa, min.0.1hPa increase. B) Input range for PPM is -999.9~999.9ppm.

(3) Reflecting Signal

When the deviation among line of sight and emitting & receiving axis is over-range, please adjust the emitting axis to the prism center.

Press ⭐ ▶ ▶ to select Prism mode, press F4 PARA then aim at the target center. It will show the intensity of signal by a column. The default prism constant is -30mm. Adjust the horizontal tangent unit or telescope focusing ring, the emitting axis will focus precisely to the target center when the reflecting signal reaches the maximum value.
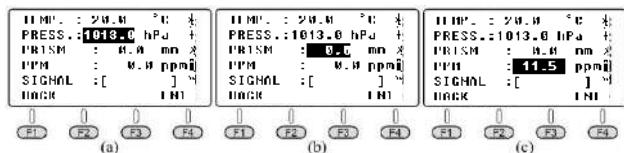
2.2 Angle Measurement

Press ⓘto power on the equipment, N6 will enter the angle measurement mode automatically. If the current mode is distance or coordinate measurement mode, press ⓐⓝⓖ to switch to angle measurement mode.
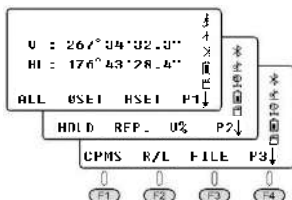
2.2.1 Function Menu in Page 1

2.2.1.1 (F1) ALL

ALL means measuring and saving. If the user need to change the current file or create a new file as the current file, please press (F3) **FILE** on page 3 at first.

When creating a new file, the equipment will create the .SMD and .SCD file under the same name automatically. SMD means South Measure Data, is used for record the data of horizontal disk, vertical disk and SD. SCD means South Coordinate Data, is used for record 3D coordinate for measured points.
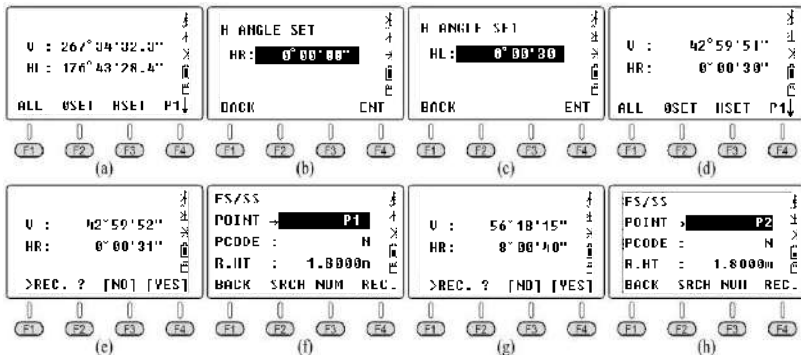
Q.: How to measure the horizontal angle for target B/C by multiple round observation?

a) Aim at target B in Horizontal Left (HL), press (F3) **HSET** then input value as 0° 00′ 30″. Press (F1) **ALL**, and (F4) **YES** to record the result. 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 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

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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	HL/HR	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 to SD card:

Press (F4) in twice to page 3, then (F3) **FILE** , (F2) **LIST**, (F3) **EXP** to export the data under the current file "180105_1" as below:
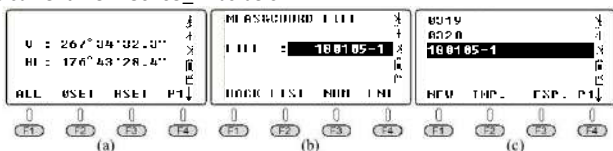
180105_1_600.txt   Format 600 file
180105_1_300.txt   Format 300 file
180105_1.dat   Coordinate file for SOUTH CASS
180105_1.csv   Coordinate file for SOUTH CASS

There are some differences between format 600 and format 300 file. 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.
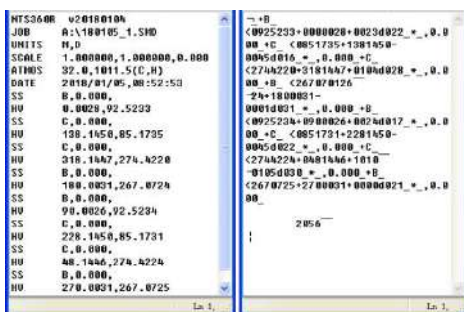
Note: Please double check that SD card has been inserted inside the equipment before export the data. The equipment will shown 📇 icon on the right side.

2.2.1.2 (F2) 0SET

Set the current horizontal angle, press (F2) **0SET** and (F4) **YES** to confirm.
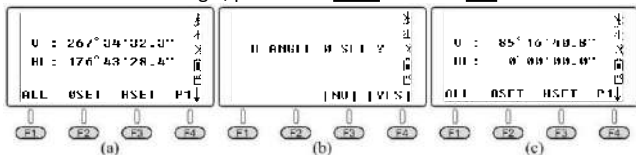
2.2.1.3 (F3) HSET

Set the current sight of view as the horizontal input value, the user can separate degrees/ minutes/ seconds by " . "

2.2.2 Function Menu in Page 2

2.2.2.1. (F1) HOLD

"HOLD" is used for holding the reading from horizontal disk when rotating the equipment.

Q.: How to "hold" the HL reading in 90 ° 00'35" for the target?
a) Rotate the equipment and make the horizontal angle near to 90 ° 00'35" , then adjust the tangent screw until it's fully reached the value.
b) Press (F1) **HOLD**, enter the H Angle Holding page. Then loosen the horizontal tangent screw, and aim at the target. In this moment, the horizontal angle will not change.
c) Press (F4) **YES** to confirm.
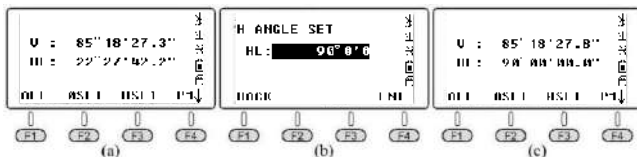
2.2.2.2. (F2) REP.

REP. Is the abbreviation of repeat measurement. It request the measurement under horizontal right, equals to the clockwise annotation on the horizontal disk.

Assume that the total station is settled on point A, the guide for ∠BAC's triple measure method shown as below:
a) Aim at target B in the first time, press (F2) **REP.** HR is 0 ° 00' 00"
b) Rotate the equipment in clockwise direction, aim at target C in the first time, press **HOLD** (F4)
(F3) tate the equipment in clockwise direction, aim at target B in the second time, press F3 **REL.** to release.
d) Rotate the equipment in clockwise direction, aim at target C in the second time, press (F4) **HOLD**, it will show the horizontal value of ∠BAC during this two times, the average

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value is 19° 28' 24"

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

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

g) Press (F2) **EXIT** and (F4) **YES** to exit the menu.
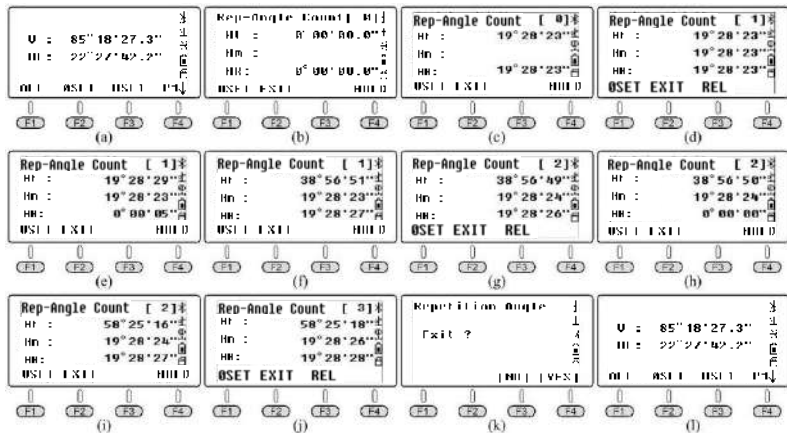
2.2.2.3 (F3) **V%**

Press (F3) **V%** to switch the reading of vertical angle from vertical degree to percent.
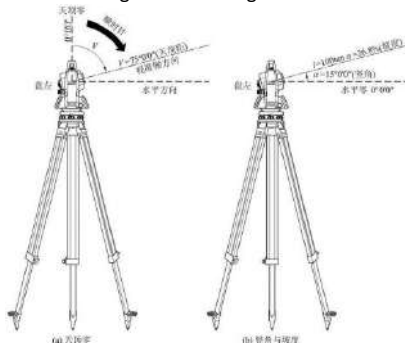
As picture shown, if the vertical reading has been set as Zenith 0, HL= 75° 00' 00".
α_L=90°−L=90°−75°00′00″ =15°00'00", the slope angle i=100×tan 15°00'00"=26.7949 % ≈26.79%. Same to the result.

2.2.3 Function Menu in Page 3
2.2.3.1 (F1) CPMS
CPMS is used for switching the display format of vertical angle. The angle of depression is negative number while the elevation angle is positive number.
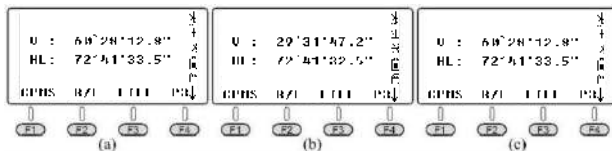
2.2.3.2 (F2) R/L.
R/L is used for switching the horizontal angle between Horizontal Right and Left. In same direction, HR + HL = 360°, also HL= 360° − HR.
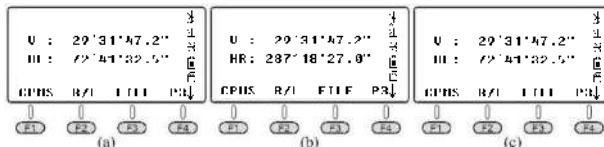
2.2.3.3 (F3) FILE
Change the current job, create new file, rename/ delete/ export files or import data into current file.Press (F3) **FILE** ,(F2) **LIST** to enter the profile list. Press (F4) to the next page.
a) NEW: Press (F1) **NEW** to create a new file, and name it as "180105_1"
b) Property, rename and delete: Keep the cursor on the current file, Line "180105_1". Press (F4) to the next page. (F1) **ATTR.** is attribute, equals to property, it will show the name, size, data, create time, create data for this profile.
Use direction key to move the cursor, press (F2) **RENAME**/(F3) **Delete** the current file.
   * Note: Under angle/distance/coordinate mode, and the Menu mode. If the current file name doesn't change, the equipment will save the data into the current profile.
c) Export to SD card: Press the direction key to move the cursor, press F3 EXP to export the files under SD card. .txt is the measurement data; .dat and .csv are for South CASS software.
d) Import coordinate files from SD card: This function is mainly used for import files including stake-out point.
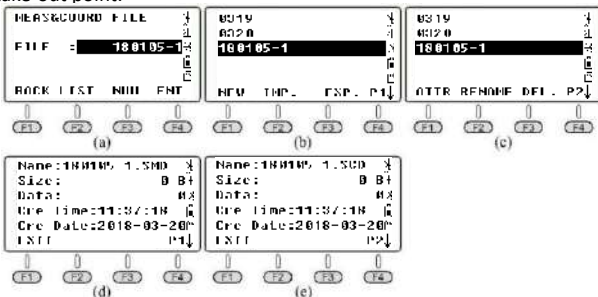
2.3 Distance Measurement

When the current mode is angle or coordinate measurement mode, press 🔘 to enter the distance measurement mode.

2.3.1 Function Menu in Page 1
2.3.1.1 (F1) ALL

Save the horizontal and vertical readings into current files. Same to the angle mode, please settle the current files before measurement and data saving.
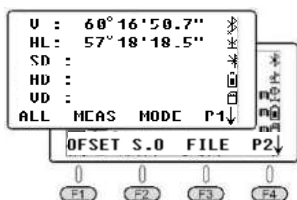
But the different thing is, the equipment will calculate the coordinate from the current coordinate, instrument height and target height together, then it will be saved coordinate and recorded from .SCD profile.
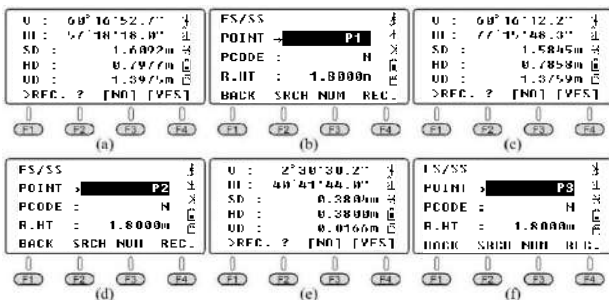
2.3.1.2 (F2) MEAS
Measure the current target without record saving.

2.3.1.3 (F3) MODE
The default measure mode is Fine(Single). Press (F3) to change the mode among Repeat, Triple/ Tracking and Fine measurement.
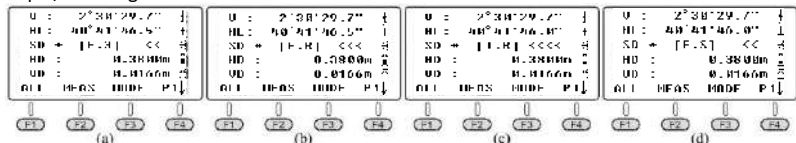
2.3.2 Function Menu in Page 2
2.3.2.1. F1 OFSET
① *Angle Offset*

(a)   (b)

If it is difficult to set up a prism directly, for example the center of a tree, this mode is helpful. It only needs to set the prism on the point which has the same horizontal distance to the instrument as that of the prism to the instrument.

Then define the instrument height/target height to start offset measurement, you can get the coordinates of the center of object.
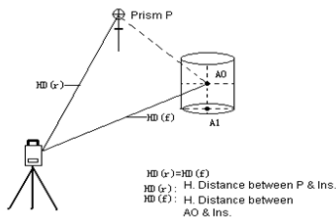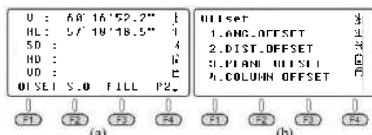
Steps:

A) Set the equipment at Occupied Point O, when Point A0 is hard to set the target, please set the target at Point P which is near to A0.

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

C) Press (CORD) to check the coordinate of Point A0. Press (DIST) to check the distance to A0.

D) Then press F1 **NEXT** to go on.

   * Note: Before offset measurement, please define the instrument height/target height at first.

(a)   (b)   (c)   (d)
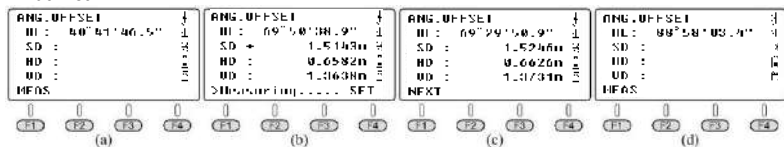
② *Distance Offset*

If the radius of the tree or lake is known, now to measure the distance and coordinates of the center, you need to input the oHD (offset distance) as the following graph and measure P1 under the mode of distance offset. the distance and coordinates of P0 will be displayed in the screen.
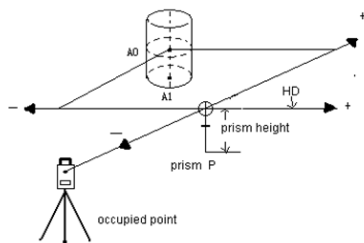
Steps:

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

B) Aim to prism P, press F1 **MEAS** , detail shown as below (pic e)

C) Press (CORD) to check the coordinate of Point A0. Press (DIST) to check the distance to A0.

D) Then press F1 NEXT to go on.

(a)   (b)   (c)

(d)   (e)   (f)
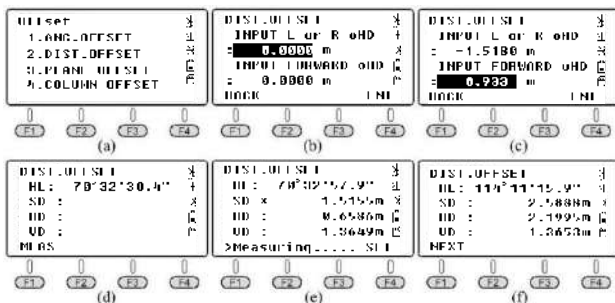
③ *Plane Offset*

Consider that Point P is on the edge of a plane, which cannot be measured directly through reflectorless mode.

Measure P1/P2/P3, the three random prism points on the same plane. Then aim at Point P, it will calculate the coordinate automatically.

P1, P2, P3 are three random prism points.

The prism height value of P1, P2 and P3 is automatically set to be 0.
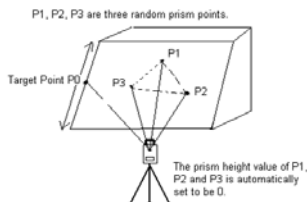
Steps:

A) Aim at P1 and press (F1) **MEAS**. Aim at P2 /P3 and press (F1) **MEAS**. (pic e)

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

C) Press ⊙ to check the coordinate of point P and press ⊙ to check the distance.(pic g)

D) Then press (F1) **NEXT** to go on.

(a)   (b)   (c)   (d)

(e)   (f)   (g)
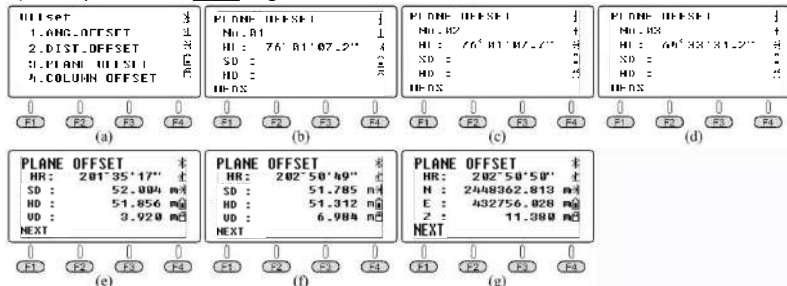
Note: in this case, the equipment has switched to "reflectorless mode" in advance. Please press (F1) **HT from the coordinate measurement menu to set the equipment height as 0.*

④ *Column Offset*

Column offset is widely used in measuring the center of a column. As the picture shown, assume that point P is the center of column.

Point P1 is the intersection of the straight line OP and the arc, and the P2 and P3 are the left and right end points of the cylindrical diameter. The equipment will calculate the 3D coordinate of point P automatically.
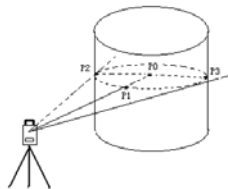
Steps:

A) Aim at point P1 and press (F1) **MEAS**. (pic c); aim at point P2 and press (F4) **SET**; aim at point P3 and press (F4) **SET.** (pic f)

B) Press (CORD) to check the coordinate of point P and press (DIST) to check the distance.(pic g)

C) Then press (F1) **NEXT** to go on.
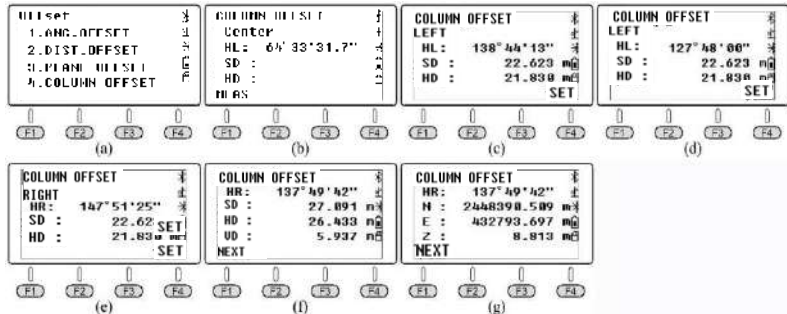
2.3.2.2. (F2) **S.O**

Stake out SD/VD/HD easily through N6's stake out menu.

Steps: Using HD as an example.

A) Input stake out value 2.0m, press (F4) **ENT** to confirm.

B) Rotate the equipment, to ensure that the reading of HR same to the stake-out HR.

C) Ask for the layout prism move to the sight of view. Aim at the layout prism and press (F2) **MEAS** from the first page, the result will shown as pic e.

D) dHD= actual HD - stake out HD = -6.8265m. It means that the layout prism should move away from the equipment in 6.8265m. After movement, press (F2) **MEAS** to confirm.
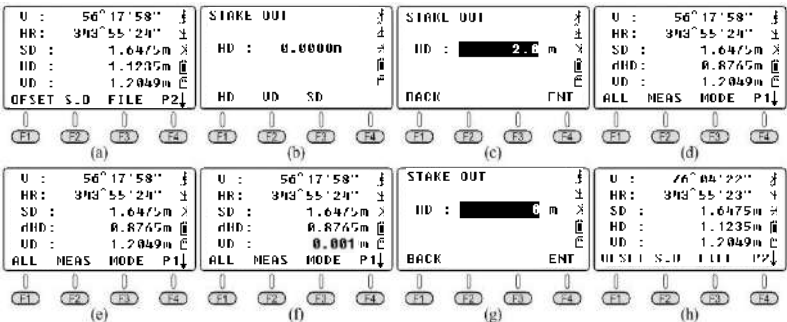
2.3.2.3 (F3) FILE

The operation guide for this menu is same as the one under the angle measurement mode. The users can change the current file, create a new file, rename, delete or export freely.

* Note: there are some differences between 600.txt and .dat.


```
HTS360R  v20180104
JOB      A:\180105_1.SMD
UNITS    M,D
SCALE    1.000000,1.000000,0
ATMOS    32.0,1011.5(C,H)
DATE     2018/01/05,08:52:53
STN      K1,1.450,1J
ENZ      432827.718,2448505.417,2.506
BS       K2,0.000,1J
ENZ      432700.488,2448453.713,2.661
SS       P1,0.000,
SD       65.2838,89.4534,75.958
SS       P2,0.000,
SD       70.4011,89.2129,81.557
SS       P3,0.000,
SD       104.5210,82.4520,16.044
                                    Ln 16,
```

```
P1,,432896.824,2448536.943,4.275
P2,,432904.672,2448532.412,4.870
P3,,432843.101,2448501.333,5.979
                                    Ln 3,
```

STN	K1,1.450,1J	——	Station Point K1, Station Height 1.45m, Code: 1J
ENZ	432827.718,2448505.417,2.506	——	Coordinates of station
BS	K2,0.000,1J	——	Backsight point K2, Target Height: 0, Code: 1J
ENZ	432700.488,2448453.713,2.661	——	Coordinates of backsight point
SS	P1,000	——	Measured point P1, Target Height 0
SD	65.2838,89.4534,75.958	——	Horizontal / Vertical value, HD of point P1

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

2.4 Coordinates Measurement

When the current mode is angle or distance measurement mode, 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 in SD card.
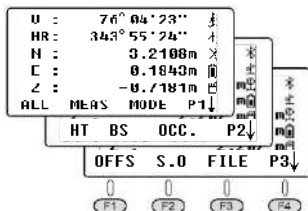
Insert SD card into total station, import the .csv profile into the existed FIX.LIB menu. It can be listed when the user need to settle the occupied point and backsight point in coordinate mode, data collection and stakeout program.

2.4.1 Import and Export from / to SD Card.

Import the Coordinates of Occupied Point into Known Project:
As picture shown,input the coordinates by the order of "Point Name; Code; E, N, Z". The maximum number of characters for code is 10.

Steps:
A) Save the file as .csv, it's a kind of txt format, the users can open it by excel.
B) Copy the CSV file under the root menu of SD card. Insert SD card 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 default name for SD card is "B:", the internal memory is "A:" (pic h)
E) Press (ESC) four times to exit the menu.
   *Note: the files import from SD card cannot be duplicated by same name.If there has duplicated point, the system will cover the old one automatically without any notice.
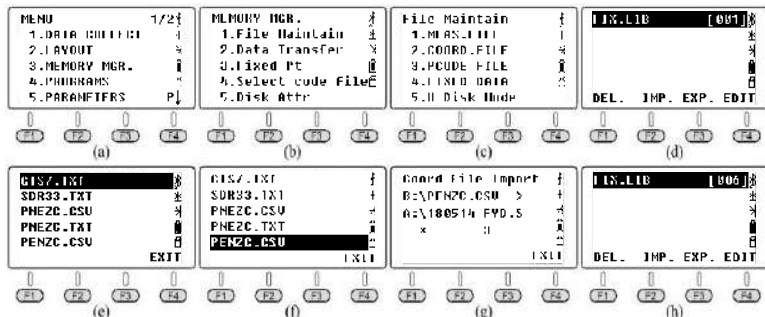
Import the known coordinates to SD card:
In "File Maintain" menu, press 4. FIXED DATA, (F3) **EXP**. To export the file FIX.LIB to SD card. One of the file, FIX.dat is SOUTH CASS format, the data can be recognized as "Point Name; Code; E, N, Z"; the other one FIX.dxf is graphics interchange format, which can be opened by AutoCAD and save as .dwg file.
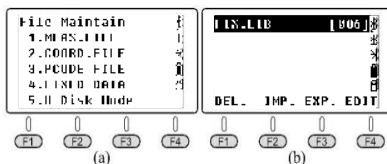
The below picture is the interface when open the FIX.dxf file by AutoCAD, the user should execute the "zoom/e" commend to view the whole map.
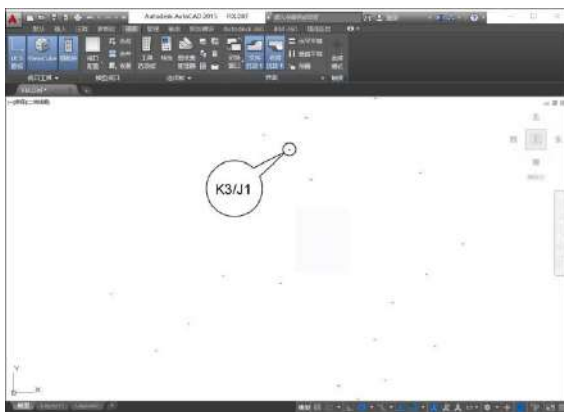
2.4.2 Function Key

The users can measure or stake out points under this coordinate menu. Please choose or create a new profile to save the coordinate, set the occupied point and back sight, input instrument height and target height. So this chapter will not introduce the function key by the order of pages.

Using the below building as an example to describe the steps of stake-out menu.
The coordinate of occupied point K1/K2/K3 as picture shown, has been imported into the equipment. Assume that the equipment has been settled at point K3, and K2 is back-sight point. The project need to know the location of stake-out point 1/2/3/4 on the field.

PT	CODE	x/m	y/m	H/m
1	FYD	2 448 486.865	432 767.706	3.121
2	FYD	2 448 438.569	432 780.647	3.121
3	FYD	2 448 446.333	432 809.625	3.121
4	FYD	2 448 494.630	432 796.684	3.121
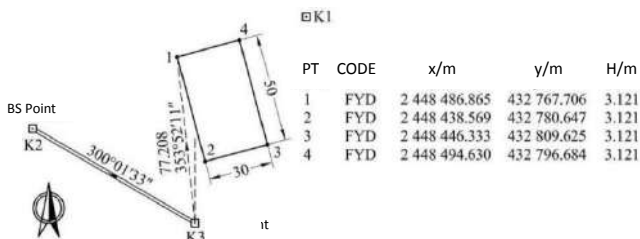
Edit the stake-out profile on PC: Input the requested coordinates for point 1/2/3/4, save as "4points.csv" and copy it under the root menu of SD card. Insert SD card into total station.

	A	B	C	D	E
1	1	FYD	432767.706	2448486.865	3.121
2	2	FYD	432780.647	2448438.569	3.121
3	3	FYD	432809.625	2448446.333	3.121
4	4	FYD	432796.684	2448494.63	3.121

|◄ ◄ ► ►|\4points/

2.4.2.1 (F3) FILE / P3

① List files or create a new one:

Press (F3) **FILE**, (F2) **LIST**, and (F1) **NEW** to create a new job. (pic c). Name the end of profile to FYD (pic d) Press (F4) **ENT** to confirm.
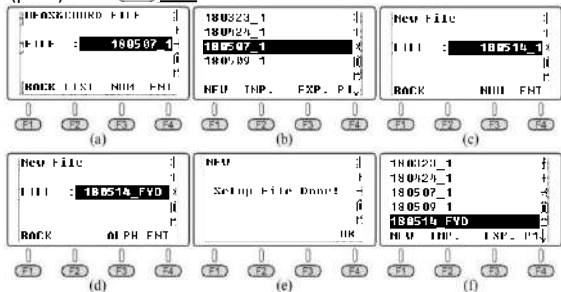
② Import:

Press (F2) **IMP**, the screen will show the profile list in the root menu of SD card.(pic a) Move the cursor to "PENZC.CSV"(pic b), press (ENT) to import stake-out coordinates.(pic c) When finish the profile import, move the cursor to Line"180105_FYD", press (ENT) to set it as the current file, then return to P3.

24
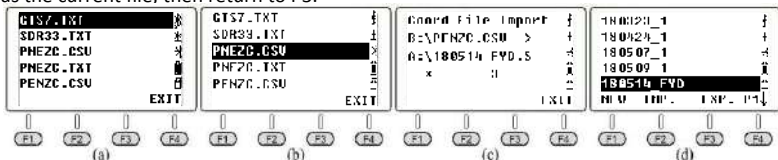
2.4.2.2 F3 OCC, Occupied Point/P2

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

The list of points will show the point from the known file at first, then the next one is the point from the current file. Move the cursor to K3 and press ENT, it will show the details for this point, including the codes and coordinates. Press F4 **ENT** and input the instrument height, press F4 **ENT** again to enter the backsight setting page. (pic e).
Press F4 **YES** to show the last backsight point (pic f). Consider that it should be same as the pre-settled one, press F4 **ENT** to enter the page which shown as pic g.

The horizontal reading HR should be the azimuth value form K3 to K2, which can be calculated from occupied point K3 and backsight K2.
Rotate the equipment, aim at prism K2, press F4 **YES** to set the horizontal angle same as the azimuth from point K3 to back sight point K2.(pic h)
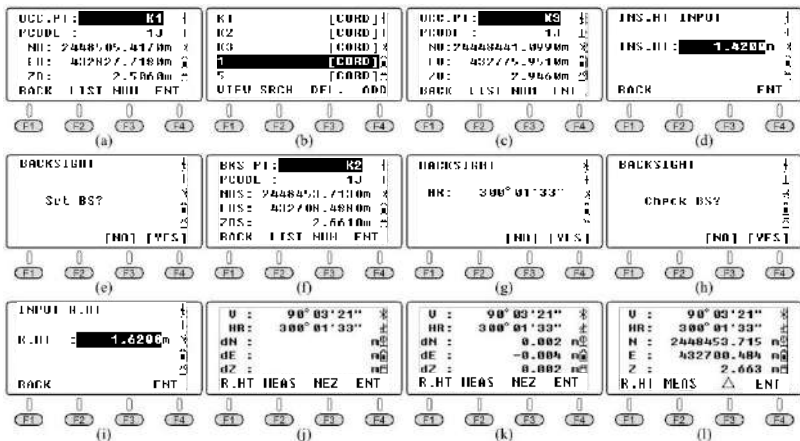
If you need to check the coordinates of back-sight point, press F4 **YES**, input the prism height on backsight point and press F4 **ENT**. (pic k) The equipment will check and calculate the difference between the known point K3 and the measured points from backsight checking measurement.

Press F3 **NEZ.** to switch the screen and display 3D coordinates for the measured points.
Press F3 (Δ) to switch the screen and display the coordinates difference.

2.4.2.3 F2 B.S, Backsight/P2

Use the backsight coordinate or angle to set the horizontal reading of backsight direction. When operate the "OCC" command, the equipment will set the coordinate of occupied point and the horizontal reading of backsight point in the same time. If there is any

question or hesitate about the backsight direction, please re-operate the "BS" command.

On the second page under the coordinate menu, press (F2) **B.S** to set the backsight point.(pic a). There are two methods:

a) Press 1(backsight by coordinate) to enter the backsight menu. Press (F2) **LIST** to call the existed point. The operation method is same to the "Occupied Point setting".

b) Press 2(backsight by angle). Input 300.1.33 to define the backsight angle 300° 1'33" (pic e), (F4)   **ENT** to the next step.

c) Rotate the equipment to aim at the target K2. Press (F4) **YES** to set the horizontal reading same to the direction from occupied point K3 → B.S point K2. Then back to the coordinate menu.
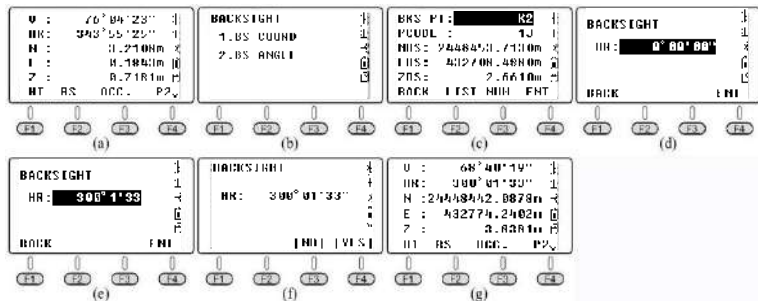
2.4.2.4 (F1) HT, Instrument Height and Target Height/P2
Turn to page 2 of the function menu under coordinate measurement mode, press (F1) to view or set the instrument height or target height.(pic b)
If it's not necessary to revise, press (ESC) to the last page.
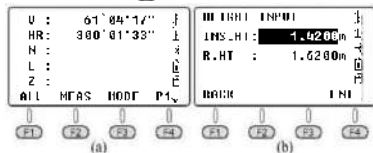
2.4.2.5 (F2) S.O, Stake out, as known as layout/P3
Press (F2) **S.O** into the stake-out function. In the 1/2 page(pic b), 1.OCC. PT INPUT, 2. BACKSIGHT is totally same as the OCC. and B.S menu under the coordinate measurement mode. So in the next part, this manual will use an example to describe in detail about 3.Layout PT - how to set the stake-out point directly.
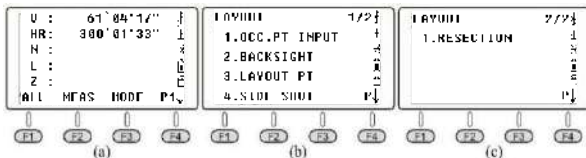
Step:
A) On the 1/2 menu, press 3.LAYOUT PT to enter the stake out function.
B) Press F2 **LIST** to show the list of points. The cursor will remain in the first page automatically. Press ENT to check the detail coordinate (pic d); Press F4 **ENT** and input target height, F4 again for confirming.
The equipment will show the HR and HD between the station K3 to point 1.(pic f).
C) Press F3 **GUIDE** to show the HD and requested azimuth (pic g). Rotate the equipment based on the guide until the value near to 0° 00′ 00″.(pic h)
D) Lead the prism to the layout point, aim at the center and press F1 **MEAS** to confirm the position(pic i).
E) Press F4 **NEXT** to repeat the steps until the layout finished.
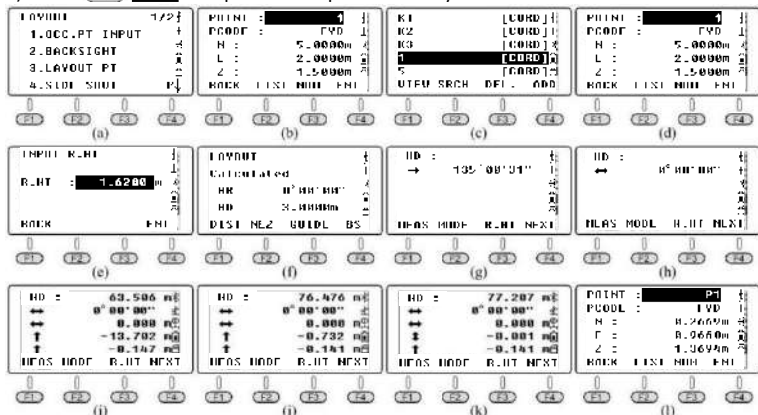
As the below picture shown, set the current prism point as 1′. In order to move the prism precisely to Position 1, the user should ask the people on prism side defining a position that 1m behind the prism point 1′, to confirm a azimuth point 1″. After using the tape to measure from 1′ to 1″, set the prism on the position of 0.732m.
Aim at the prism center, press F1 **MEAS**, as pic k. In this moment, the horizontal position of prism is the requested position for point 1. Mark this position to finish the stake-out of Point 1. Press F4 **NEXT** to calling the stake-out coordinate of Point 2. (pic i)
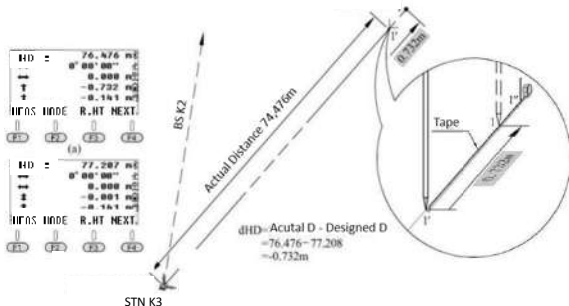
2.4.2.6 (F1) ALL /P1

In order to compare the difference between actual coordinates with the designed coordinates among point 1-4, the user can execute the "ALL" command to measure and save the coordinate under current job.

Export the current files to SD card, using Microsoft-Excel to open the csv file. Compare the difference between actual coordinates with the designed coordinates to double check the stake-out results.

Aim at the prism center on Point 1. Press (F1) **ALL** to record the data (pic a) and (F4) **YES** to rename. Measure the coordinate of point 2/3/4, as pic c~h shown.
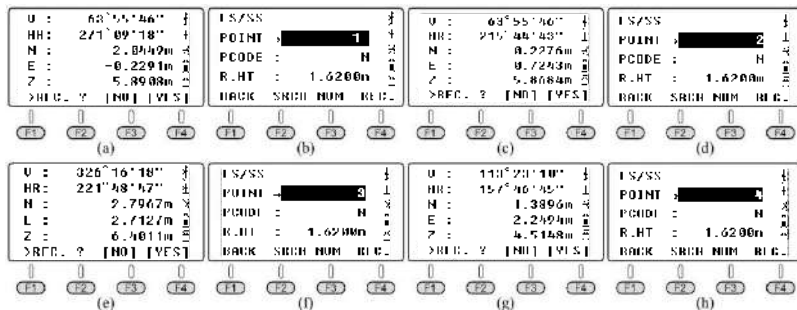
① Check the point list under the current job:
Press (F2) **S.O** in P3. Press 1.OCC. PT INPUT and (F2)**LIST** to view the list. (pic c)
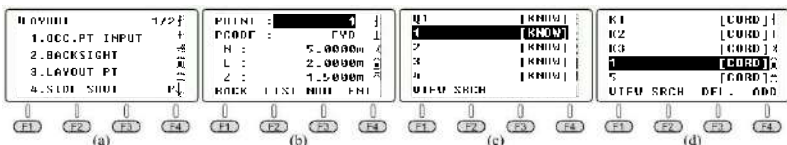
② Export the current job to SD Card:
Press (F3) **FILE** in P3 in "coordinate measurement" page. Press (F2) **LIST** and (F3) **EXP** to export the current job to the root menu in SD card.

The dat and csv file can be used in SOUTH CASS software; the dxf file is the graphics interchange format, which can be recognized in AutoCAD and save as dwg format.
The txt files are the raw data in format 300 and 600.
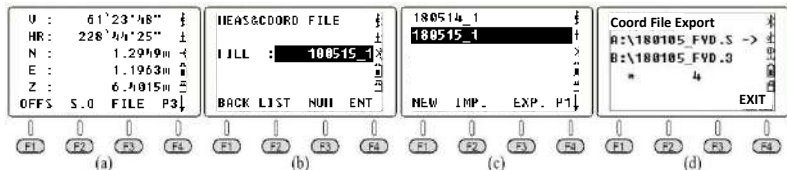
* You can open "dat" file by Windows TXT; "csv" by Microsoft Excel.

2.4.3 Side Shot

Press `F2` **S.O** in P3. If the view between the occupied point to stake-out point has been covered, the user can execute "Side Shot" or "Resection" command to add the occupied point.

Enter the Side Shot menu. 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.
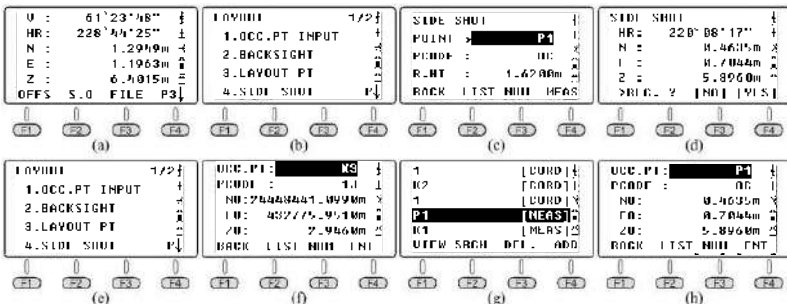
Move the total station to P1 and well-settled the position. Press 1.OCC. PT INPUT under stake-out menu, press `F2` **LIST** to enter the point list. Move the cursor to P1 and press `ENT` to view the detail. Press `F4` **YES** and the left steps same to the previous descriptions.

2.4.4 Resection

Resection also known as freedom station. Set the total station on an unknown point, it will calculate the coordinate of occupied point by distance measurement for around 2-7 known points or angle measurement for 3-7 known points.

2.4.4.1 Angle Resection

On the second page of stake-out function, press 1.RESECTION to enter the next page. The coordinate can be calculated after the measurement of at least 3 points.

Steps:

① Measure the 1st known point: Input P1 as the new station name, and the equipment height (pic b). Press `F4` **ENT** to the measure page. Input the known point Q1, press `F4` The system will call Q1's coordinate from the list and press `F4` **OK**. Aim at the prism center of Point Q1 (pic f). Press `F3` **ANG**. To finish the measurement. Then it will continue the measurement for the 2nd point.

② Measure the 2nd known point: as picture g-j shown.

③ Measure the 3rd known point, as picture k-m shown.

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). Press `F4` **NEZ** to show the result.

Then `F4` **YES** to record the data under the current job.

LAYOUT 2/2	NEW POINT	RESECTION	READ COORD.DATA
1.RESECTION	POINT → P1	No.01	N : 2448468.6860m
	PCODE : OC	POINT : Q1	E : 432809.5240m
	INS.HT : 1.605Mm		Z : 4.0040m
P↓	BACK LIST NUM ENT	BACK LIST NUM ENT	> OK ? [NO] [YES]
(a)	(b)	(c)	(d)

INPUT R.HT	No.01	RESECTION	READ COORD.DATA
	V : 61°23'01"	No.02	N : 2448352.7330m
R.HT : 1.6200m	HR: 328°38'54"	POINT : Q2	E : 432848.5890m
	SD :		Z : 14.3918m
BACK ENT	R.HI : 1.6200m	BACK LIST NUM ENT	> OK ? [NO] [YES]
(e)	>Sight ? ANG. DIST	(g)	(h)
	(f)		

INPUT R.HT	No.02	RESECTION	READ COORD.DATA
	V : 61°23'00"	No.03	N : 2448075.0120m
R.HT : 1.6200m	HR: 328°38'55"	PDINT : Q3	E : 432785.3810m
	SD :		Z : 4.602m
BACK ENT	R.HI : 1.6200m	BACK LIST NUM ENT	> OK ? [NO] [YES]
(i)	>Sight ? ANG. DIST	(k)	(l)
	(j)		

No.03	RESECTION	RESECTION	RESECTION
V : 61°23'00"	V : 61°23'42"	SD(n)- 0 mm	N0: 2448410.077 m
HR: 328°38'55"	HR: 5°29'42"	SD(e)- 0 mm	E0: 432775.946 m
XD :	SD :	SD(z)- 0 mm	Z0: 2.948 m
R.HI : 1.6200m	NEXT CALC	NL2	>REC. ? [NO] [YES]
>Sight ? ANG. DIST	(n)	(o)	(p)
(m)			

2.4.4.2 Distance Resection

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.

The method is similar to angle resection.

3.ADJUSTMENT & INFORMATION

The structure underlying the Menu system as below:

1.Collect Seq → 1.EDIT-MEAS/ 2.MEAS-EDIT
2.Data Confirm → 1.ON/ 2.OFF
3.Select SD/HD → 1.SD&HD/ 2.HD&VD

1.OCC.PT Input
2.Backsight
3.FS/SS
4.Resection
1.Config (2/2)

1.OCC.PT Input
2.Backsight
3.Layout PT
4.Side Shot
1.Resection (2/2)

1.File Maintain
2.Data Transfer
3.Fixed PT
4.Select Code File
5.Disk Attr

1.Meas.File
2.Coord.File
3.Pcode File
4.Fixed File
5.U Disk Mode

1.Send Data → 1.Meas. Data
2.Load Data → 2.Coord.Data
3.PCode Data
4.Fixed Data

1. Load Coord.
2.Load PCode
3.Load Fixed

View
Search
Delete
Add

Flash → Attrib
SD Card → Format

1.International
2.USA Survey

1.DEG
2.GON
3.MIL

1.Meter
2.Feet
3.Feet Inch

1.Temp. ℃/℉
2.Press

1.Angle Meas
2.Distance Meas
3.Coord.Meas

1.REM
2.MLM
3.Z Coordinate
4.Area
5.Point to Line
6.Roads

1.File
2.OCC.PT Input
3.Backsight
4.Layout PT
5.Coord. Inverse
6.Export Pile Coord

1.Feet
2.Angle
3.Distance
4.Temp.&Press

1.FINE[S]
2.FINE[N]
3.FINE[R]
4.TRACKING

1.NEZ
2.ENZ

1.Zenith 0
2.Horizontal 0

Page 1/2
1.Data Collect
2.Layout
3.Memory MGR
4.Programs
5.Parameters
Page 2/2
1.Adjustment
2.Inst. Constant
3.Information

1.Unit Set
2.Mode Set
3.Other Set
4.Format Parameter
5.Bluetooth OFF/ON

1.Power On Mode
2.Dist. Mode
3.NEZ/ENZ
4.V Angle Z0/H0

1.V0 Adjustment
2.Collimation
3.Horizontal Axis
4.V0/Axis Const.

1.Min Angle Read → 1s/5s/10s/0.1s
2.Min Dist Read → 1mm/0.1mm
3.Face in L or R → Differ/Equation
4.Auto Power Off → OFF/ON
5.H-Angle Buzzer → OFF/ON

1.Meas Buzzer (2/2) → OFF/ON
2.W-Correction → OFF/ON/0.2
3.Date&Time
4.Comm Parameters → Protocal
Baud
Format
5.Grid Factor

3.1 Adjustment

Press 1.ADJUSTMENT in 2nd page of Menu. It included 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.

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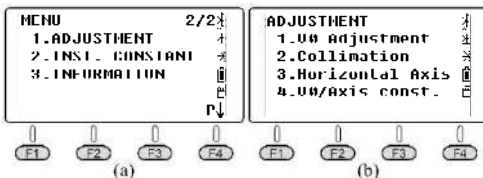
Please open the sensor and well-settled the total station before execute the commands. The horizontal angle should be HR (horizontal right), and V angle should be set as zenith 0.

3.1.1 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.

(a)   (b)   (c)   (d)
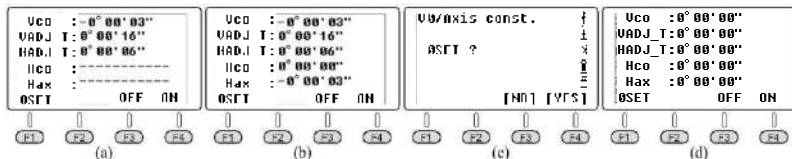
3.1.2 V0 Adjustment (i Angle)

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.

(a)   (b)   (c)   (d)
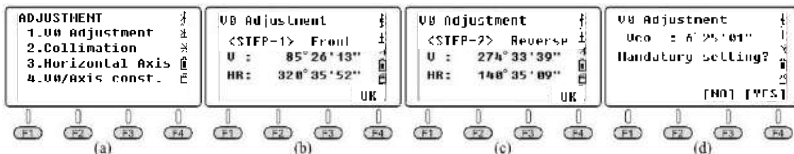
If the vertical angle is Zenith 0, i =(L+R-360°)/2
If the vertical angle is Horizontal 0, i =(L+R-180°)/2 or (L+R-540°)/2

3.1.3 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.

$$2C=L-(R\pm180°)$$
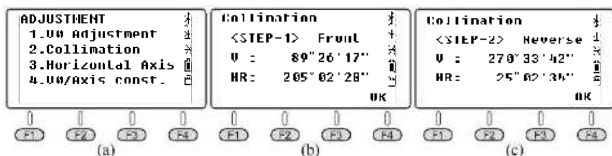
3.1.4 Horizontal Axis

Calculate the error of horizontal axis to adjust the horizontal reading, by measuring a target with vertical angle:$\pm10°\sim\pm45°$ in both two sides.

Aiming a target in HL with vertical angle: $\pm10°\sim\pm45°$, 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.
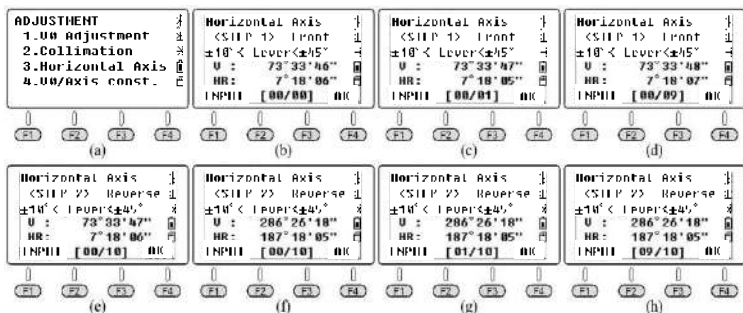
Please adjust the i angle, 2C and horizontal axis after the long-term shipment or any other vibrations.

3.2 Instrument Constant & Information

3.2.1 Inst. Constant

Press 2.INST.CONSTANT in the 2nd page of Menu(pic b). The default value is 0. Don't modify the value without the authorization.
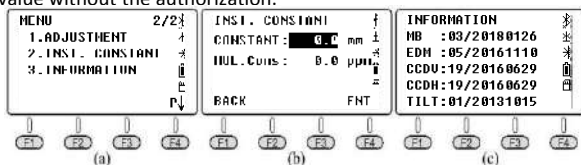
3.2.2 Information

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

①MB: 03/20180126 - Mainboard 03, update date is Jan.26th, 2018

②EDM: 05/20161110 - EDM 05, update date is Nov.10th, 2016

③CCDV: 19/20160629 - Horizontal Disk 19, update date is Jun.29th, 2016

④CCDH: 19/20160629 - Vertical Disk 19, update date is Jun.29th, 2016

⑤TILT: 01/20131015 - Tilt 01, update date is Nov.10th, 2016

3.3 Parameters

Press 5.Parameter in the 1st page of menu.
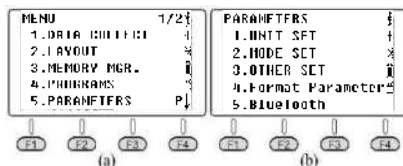
3.3.1 Unit Set

3.3.1.1 Feet

In "unit set" mode, press 1.**FEET** to select the feet between international feet and USA feet. 1 international feet = 0.999 845 6 USA feet.

3.3.1.2 Angle

In "unit set" mode, press 2.**Angle** to select the angle unit among DEG(degree), GON and MIL. The default select is DEG. 360 DEG = 400 GON = 6400MIL.

3.3.1.3 Distance

In "unit set" mode, press 3.**Distance** to select the distance unit among Meter, Feet and Feet.Inch. 1 Meter = 3.280839895 Feet, 1 Feet = 12 Inch.

3.3.1.4 Temp.&Press

In "unit set" mode, press 4.**Temp.&Press** to select the unit of temperature and pressure.

①Temperature Unit

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When the cursor remain at the 1st line, press (F1) ℃ or (F2) ℉, (F4) **OK** to confirm.
The default select is ℃
②Pressure Unit
When the cursor remain at the 2nd line, press (F1) **hPA**, (F2) **mmHg**, (F3) **inHg**, and press
OK to confirm. The default select is hPa.
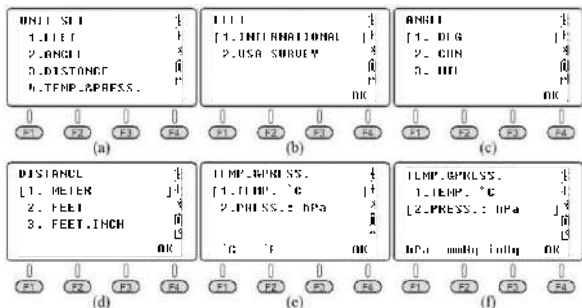
3.3.2 Mode Set
3.3.2.1 Power On Mode
Press 1/2/3 to select the initial page when power on the equipment. The default select is
"Angle Meas"

3.3.2.2 Dist Mode
Press 1/2/3/4 to select the measure mode among Fine[S] (single), Fine[N] (3 times), Fine[R]
(Repeat) and Tracking mode. Press (F4) **OK** to confirm. The default set is Fine[S]

3.3.2.3 NEZ/ENZ
Press 1/2 to 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.

3.3.2.4 V Angle Z0/H0
Press 1/2 to set the vertical angle as zenith 0 or horizontal 0. Press (F4) **OK** to confirm. The
default set is zenith 0.
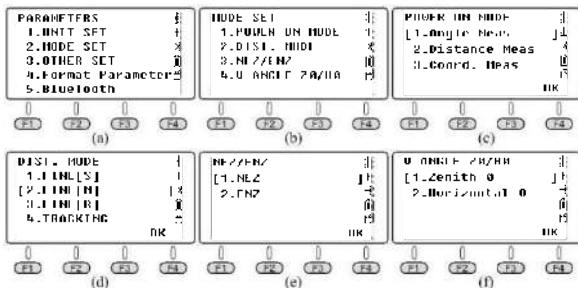
3.3.3 Other Set

3.3.3.1 Min Angle Read

In the 1st page of "Other Set", press 1.Min.Angle Read to set the minimum angle reading. Press 1/2/3/4 to select 1s/5s/10s/0.1s. The default set is 1s.

3.3.3.2 Min Dist Read

In the 1st page of "Other Set", press 2.Min.Dist Read to set the minimum distance reading. Press 1/2 to select 1mm/0.1mm. The default set is 1mm.

3.3.3.3 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 and HR direction. The default set is Equation.

If the equipment has been set as "Equation". In HR measurement, the system will use HR $\pm 180°$ 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.

3.3.3.4 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.

3.3.3.5 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° $\pm4°$ 30', 90° $\pm4°$ 30', 180° $\pm4°$ 30', 270° $\pm4°$ 30', the equipment will activate the buzzer. The default set is OFF.
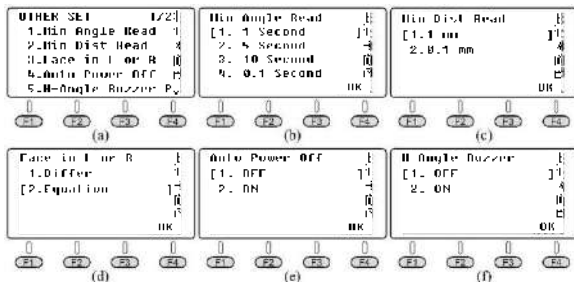
3.3.3.6 Meas Buzzer

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.

3.3.3.7 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.

3.3.3.8 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.

(a)　　　　(b)　　　　(c)　　　　(d)
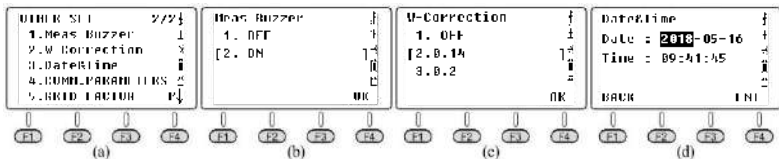
3.3.3.9 Comm Parameters
Set the protocol, baud rate and format under "Comm Parameters" page. Press the (▼)(▲) to move the cursor, (◀)(▶) to select the option.
①Protocol: One way, Ack/Nak
②Baud: 1200/2400/4800/9600/19200/38400/57600/115200
③Format

Baud rate is only available for the RS-232C connection. Not for USB port and Bluetooth.

3.3.3.10 Grid Factor
The default value of grid factor is μ =1.

(a)　　　　(b)　　　　(c)
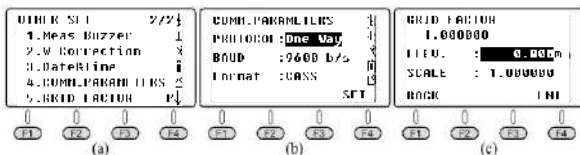
3.3.4 Format Parameter
Press 4.Format Parameter to recovery to initial settings.

3.3.5 Bluetooth
Press 1/2 to OFF/ON the Bluetooth. The default set is OFF.

(a)　　　　(b)　　　　(c)　　　　(d)
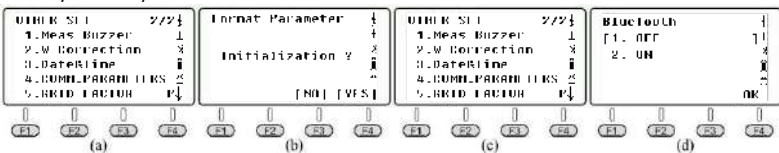
4.DATA COLLECT, STORAGE & STAKE OUT

4.1 Data Collect

The "Data Collect" in the first page of menu, is used for measure and save the 3D coordinates under the current coordinate file, and save the observation data under the current measure file.
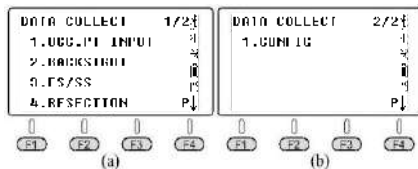
4.1.1 New Job

Press 1.Data Collect in the first page of menu, enter the file selecting page, the equipment will show the latest file name on the screen.

Press (F2) LIST and (F1) NEW to start a new job. The system will name the new job as "Date_Num". Press (F4) ENT to confirm. Move the cursor to the new job and press ENT to set the new file as the current job.

1) In file selecting menu (pic b), you can also input new name by numeric key and press ENT to confirm. System will create a new job automatically.
2) Press 3.FS/SS to measure the angle, distance and coordinate under the current file.
3) In 1.OCC. PT INPUT, or 2.BACKSIGHT page, you can use the call the known point from the existed files as the occupied point or backsight point.
4) N6 add the fix.lib file in the internal memory of equipment as the known coordinate file. You can press 3.MEMORY MGR in menu page, then 1.File Maintain, 4.FIXED DATA and (F2) **IMP** to import the coordinate of occupied point from SD card to the equipment.
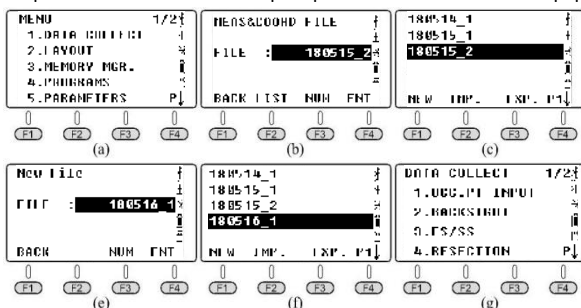
4.1.2 Set the OCC Point and BS Point

Assume that the user already import the coordinates into the file FIX.LIB. (The detail steps refers to Chapter 2.4.1)

4.1.2.1 Set the Occupied Point

Press 1. OCC.PT INPUT under the "Data Collect" menu (pic a), it will display the latest occupied point on the screen. (pic b is the default setting)

A. Press (F2) **LIST** to enter the point list (pic c), move the cursor to the known point K3, press (ENT) to view the coordinate of K3(pic d), Press (F4) **ENT**.

B. Input the instrument height (pic e)and press (F4) **ENT** to confirm. The equipment will skip to the backsight setting page (pic f). Press (F4) **YES**. It will shown the latest backsight point. (pic g is the default setting)

C. Press (F2) **LIST** to enter the point list, move the cursor to the known point K2 (pic h), press (ENT) to choose and (F4) **ENT** to confirm, the equipment will calculate the angle from K3 to K2 (pic i)

D. Aim the target center of backsight point, press (F4) **YES** to for orientation(pic j).

E. Input the target height and press (F4) **YES** to confirm.(pic l)

F. Press (F2) **MEAS** to start the distance measurement(pic m), the equipment will show the difference(pic n).

G. Press (F3) **CORD** to switch to the real-time coordinate of backsight point(pic o).

H. Press (F3) △ to back to the page of coordinate difference. Press (F4) to confirm.
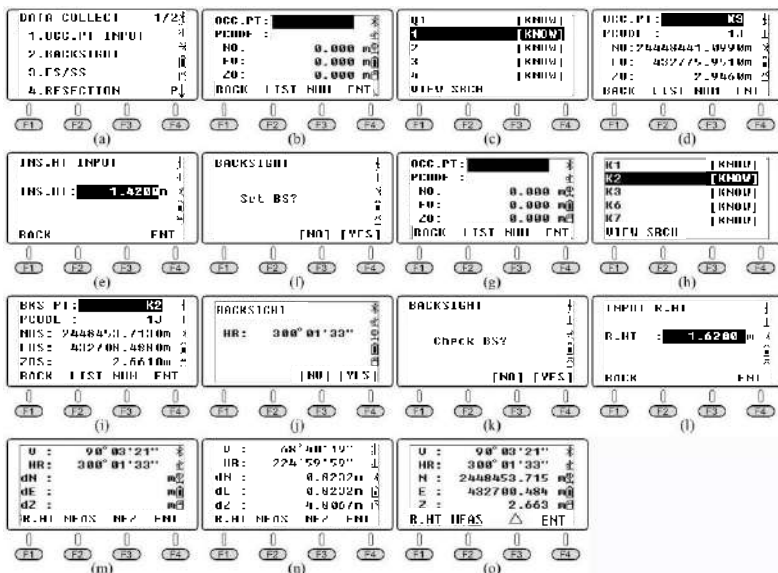
4.1.2.2 Set the Backsight Point

Based on the previous description, you can input or call the known point as the backsight after the setting of occupied point. If the backsight point is unknown, only the backsight direction is available, or if there is any question or hesitation about the changes, please

execute the backsight setting separately.

① BS COORD

A. Press 2.BACKSIGHT and 1.BS COORD under the "Data Collect" menu(pic b), the screen will show the latest backsight point(pic c). Press F4 **ENT** to confirm. The equipment will calculate the angle from occupied point K3 to backsight point K2.

B. Aim at the target center of backsight point K2. Press F4 **YES** to set(pic d). The equipment will ask whether the backsight checking is necessary. Press F3 **NO** (pic e)and back to "Data Collect" menu.
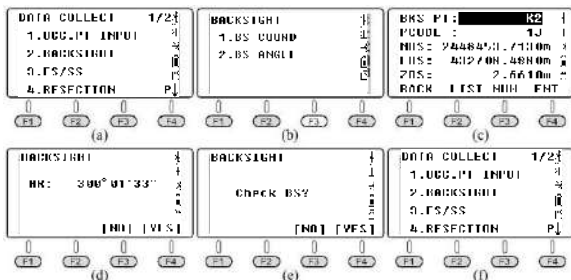
② BS ANGLE

A. Press 2.BACKSIGHT and 2.BS ANGLE under the "Data Collect" menu (pic b), input the angle from K3 to K2: 300°01'33"(pic c). Press F4 **ENT** to confirm and skip to the next page(pic d).

B. Aim at the target center of K2, press F4 **YES** to set the horizontal angl F4 the backsight angle(pic e). Press F4 **YES** to confirm the angle(pic f) and then press **REC** to start the distance measurement (pic g).
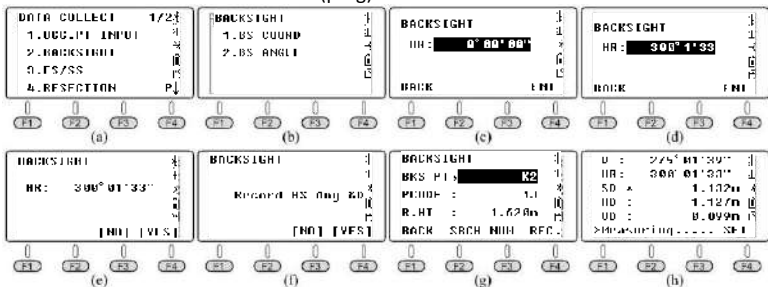
4.1.3 FS/SS

Measure and save the coordinate of detail points by the latest occupied point and backsight point.

A. Press 3.FS/SS under the "data collect" menu(pic a), press F1 **INPUT** to input the point name, code and target height (R.HT) and F4 **ENT** to confirm(pic c).

B. Press F3 **MEAS** and F3 **NEZ** to measure the distance, example shown as pic e.

C. Press (F4) **YES** to save the data to the current file and back to FS/SS page(pic f).

D. The point name will increase automatically, for example from 1 to 2. Finish the measurement of four points based on previous steps.
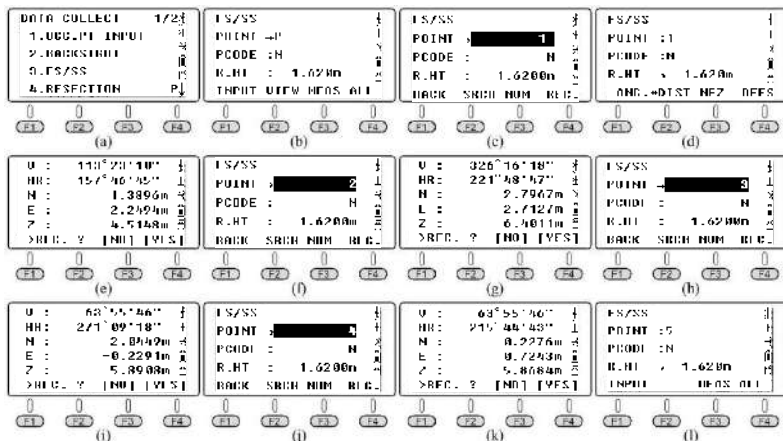
After the measurement of 4 detail points, press (ESC) and back to "Data Collect" menu.

A. Press 3.FS/SS (pic b) and (F2) **VIEW** to enter the point list (pic b). Move the cursor to point 1 (pic c) and press (F1) **VIEW** the coordinate(pic d). Press (F4) **P1 ↓** to the next page (pic e).

B. Press (▼) continuously to check the coordinate from point 2 to point 4 (pic f-h).
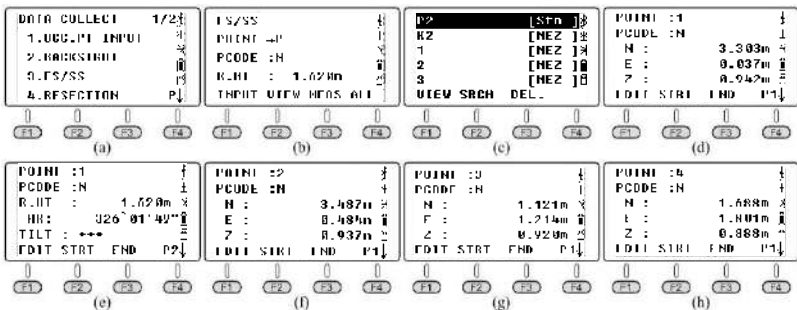
4.1.4 Resection

Set the equipment on an unknown point, calculate the occupied point by measure the azimuth or distance by several known points. Please check chapter 2.4.4 to review the detail.

4.1.5 Config of Data Collect

Press 1.Config on the 2nd page of Data Collect menu.

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4.1.5.1 Collect Sequence

In "Config" page, press 1.Collect Seq to 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.

4.1.5.2 Data Confirm

In "Config" page, press 2.Data Confirm to 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.

4.1.5.3 Select SD/HD

In "Config" page, press 3.Select SD/HD, the default value is 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
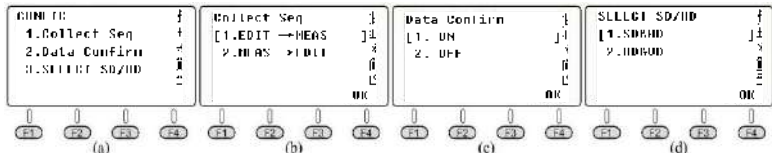
4.1.6 Export the file to SD card

Press 1.Data Collect in the first page of menu, enter the "Meas & Coord File" page (pic b). Press F2 **LIST** to enter the profile list (pic c), the cursor will remain in the line of current file. Press F3 **EXP.** to export the current file "180107_1" into SD card with the following formats:

180107_1_600.txt	Measure file in 600 format
180107_1_300.txt	Measure file in 300 format
180107_1.dat	Coordinate file in CASS format
180107_1.csv	Coordinate file in CASS format
180107_1.dxf	Drawing eXchange Format
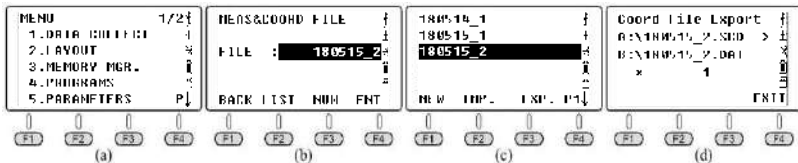
Open the file "180107_1_600.txt" and "180107_1.dat" by Windows TXT.

4.2 Memory Management

The "Memory MGR" in the first page of menu, press 3. to enter the management mode.
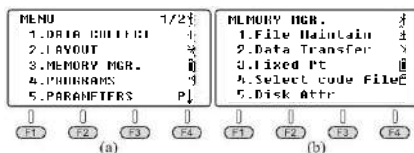
4.2.1 File Maintain

Press 1.File Maintain under the "Memory MGR" page.

4.2.1.1 MEAS. FILE

Press 1.MEAS.FILE under "File Maintain" page, the cursor will remain in the line of current file. Press (F4) turn to the next page. Press (ENT) to show the point list of the selected file. Move the cursor to point 1 (pic d), press (F1) **VIEW** to check the coordinate data of point 1(pic e), press (F4) turn to the next page (pic f). The horizontal angle is the azimuth from station to point 1; press (▼) to the next point (pic g).
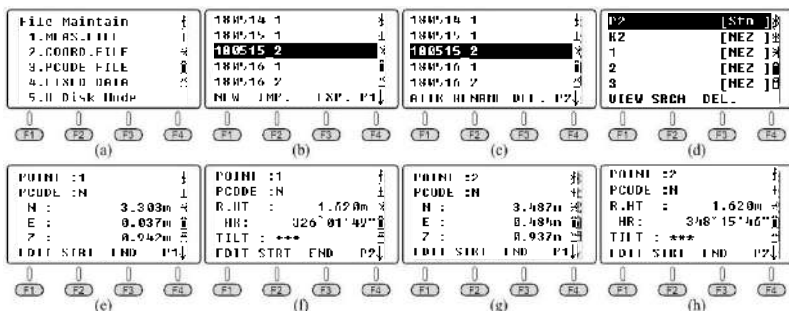
①NEW: Press (F1) **NEW** to start a new file, the system will create two files, "SMD" and "SCD". "SMD" for measurement data, while "SCD" for coordinate data.

②IMP: Press (F2) **IMP** to import the coordinate file "SCD" from SD card to equipment.

③EXP: Press (F3)**EXP** to export the "TXT", "DAT", "CSV" and "DXF" to SD card.

④ATTR: Press (F1) **ATTR** in the second page to view the attribute for the current file. Including the name, size, quantity of data, create time and date.

⑤RENAME: Press (F2) **RENAME** in the second page to rename the file which has been selected.

⑥DEL: Press (F3) **DEL** in the second page to delete the file which has been selected. Please notice that "SMD" and "SCD" file will be deleted in the same time.

4.2.1.2 COORD. FILE

Press 2.COORD.FILE to enter the file list. The function description same to chapter 4.2.1.2 MEAS. FILE.

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4.2.1.3 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 SD card to he equipment, as below picture shown:

Press 3.PCODE FILE under "File Maintain" menu (pic b); Press `F1` **NEW** and input the code name "CODE1" (pic c) and press `ENT`and back to the file list (pic d); Press `F2` **IMP** to view the file list under the root directory of SD card, 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); Press `ENT` to view the codes (pic h).

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.
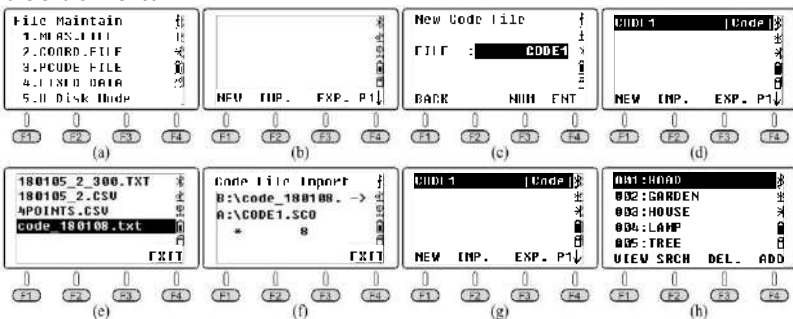
Eg. Press 3.FS/SS under "Data Collect" menu (pic a), the point name is 6. Assume that the code for this point should be street lamp: Move the cursor to the code line, press `F2` **LIST** to the requested code file (pic b) and press `ENT` to select. Move the cursor to "004: LAMP" (pic c) and press `ENT` to confirm. Code LAMP has been used for point 6 successfully.

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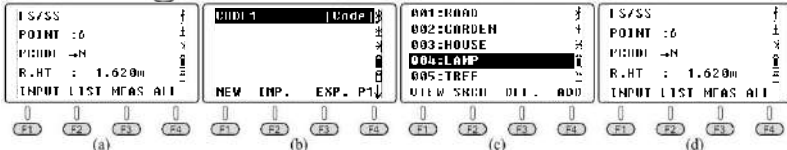
4.2.1.4 FIXED DATA

Press 4.FIXED DATA 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.

Press F4 **EDIT** or ENT to view the list of known points.
A) Press F1 **VIEW** to check the coordinate of the first known point (pic d), press ▲ or
F3 **END** to check the last point (pic e), F2 **STRT** to check the first point (pic h); Press F1 **EDIT** to edit the selected point.
B) Press F3 **DEL** and F4 **OK** to delete the selected point.
C) Press F4 **ADD** to add a new occupied point by manual, but the point name should be different to the existed points.
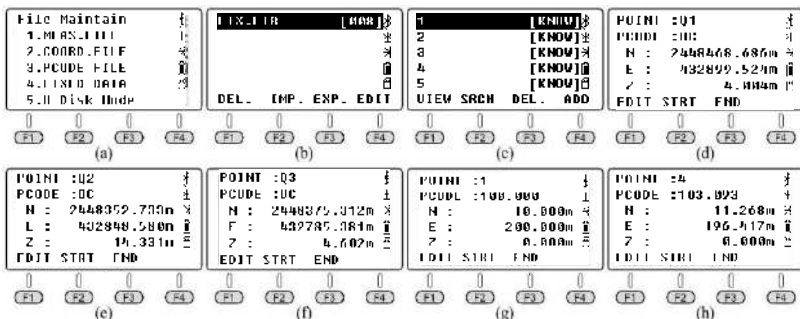
The coordinate file FIX.LIB can save 200 points in maximum, if the name of new-imported points are same to the existed points, the system will cover the existed points automatically without notification for each point.

* the file imported from SD card 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 fault format is CASS.

4.2.1.5 U Disk Mode

Press 5.U Disk Mode under "File Maintain" menu (pic b), connect the equipment by mini USB port. Users can manage and edit the files in SD card directly as a new disk.
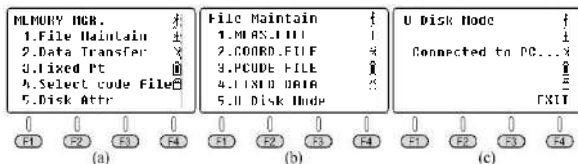
4.2.2 Data Transfer

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

(a)   (b)   (c)   (d)
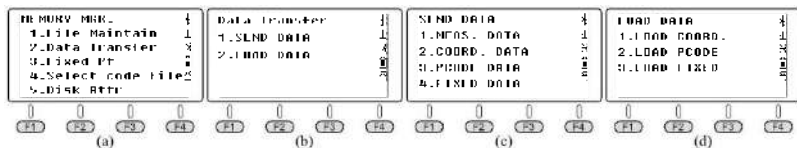
4.2.2.1 Connection between N6 and PC

① By USB

Connect N6 and PC by USB cable, activate the transform software "NTS-360LNB.exe". The software shown as below picture:
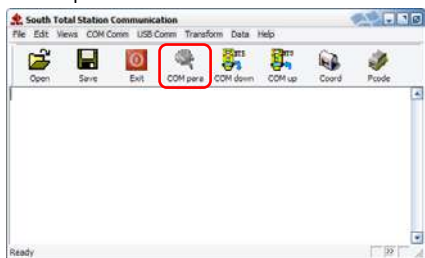
Click "COM para" button on toolbar to activate the connection, the status bar will show the COMM port it used for this connection.

* Windows System will prompt you install the driver for USB cable after connection, copy the folder "Virtual COM Port Driver" from SD card to PC, and set the driver as this folder. Windows system will install the driver for you automatically.

* Please also confirm the Baud Rate and Comm Port is matched.

② 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 "0000".

Open the data transfer software. Click "COMM para" button on toolbar to activate the connection, the status bar will show the COMM port it used for this connection.

4.2.2.2 Send Data

N6 can transfer four types of data to PC: measure data, coordinate data, Code data and fixed data. The data is saved in flash memory under the format of file. 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.
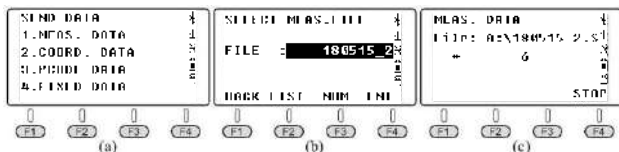
Click "COM down" button on PC before press F4 **ENT** on N6 to send the selected file.

Click "Save" button to save the file after receiving data from total station.
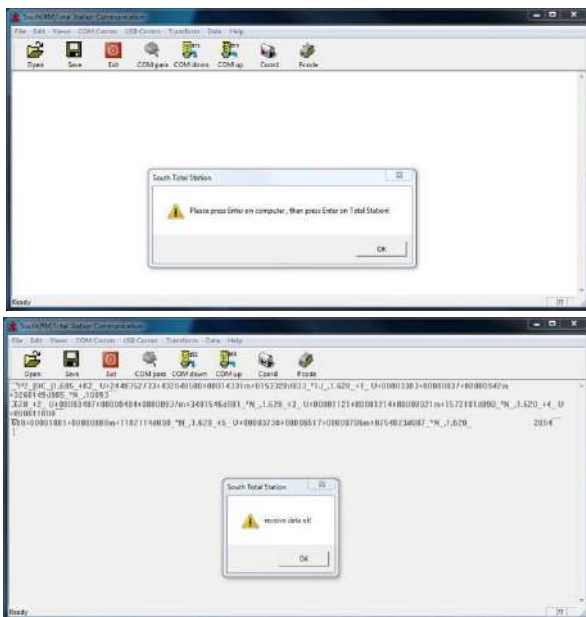
4.2.2.3 Load Data

N6 can transfer three types of data from PC: coordinate, Code and fixed data. 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 "Folder" button and select the file "4points.csv". Then click "COM up" button 🖳 .

② Press 1.LOAD COORD. Under "LOAD DATA" menu (pic a) and enter the page for file selection (pic b). Press (F2) **LIST**, (F1) **NEW** and (F4) **ENT** to create a new file by current date. Move the cursor to the new file (pic e). Press (ENT) to confirm the data loading (pic f).

(a)   (b)   (c)

(e)   (f)   (g)
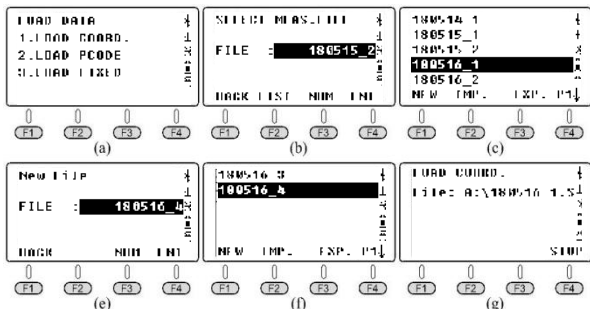
③ Click "OK" button on PC to activate the software, the equipment will show the process for data loading in real-time (pic g).

④ The equipment will back to the interface of "LOAD DATA" after process finished (pic h).

The point name under FIX.LIB should not be duplicated. Otherwise the system will cover the exited points.

4.2.3 Edit the Known Coordinates

Press 3.Fixed Pt under the "MEMORY MGR" to enter the point list (pic b), the steps are totally same as Chapter 4.2.1.1.

Move the cursor to the point which need to be edited, press (F1) **VIEW** to check the coordinate and press (F1) **EDIT** to edit the selected point.

(a)   (b)   (c)

4.2.4 Select the Code File

Press 4.Select code file under the "MEMORY MGR" menu (pic a) to enter the interface for file selection (pic b). Press (F2) **LIST** to view the code list (pic c). Press (F4) to the next page. The meanings for function key F1-F4 are same to chapter chapter 4.2.1.3 PCODE FILE.

The only difference is when the cursor remain in the code file (pic c-d), press (ENT) to set the selected code file as the current file before skip back to the "MEMORY MGR" menu

(ENT)

(pic a). But in PCODE FILE, press   to view the contents of code file.
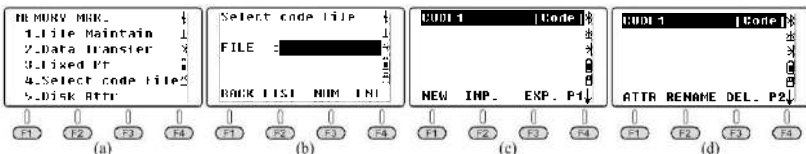
4.2.5 Disk Attribute

Press 5.Disk Attr under the "MEMORY MGR" menu (pic b), the cursor will remain in the first line "FLASH" in default.

Press (F1) **ATTRIB** or (ENT) to check the attribute of flash memory (pic c), the capacity for N6 is 4.00MB. Press (F4) **EXIT** or (ESC) to exit.

Move the cursor to SD card, check the used space, free space and capacity by same steps (pic d).

Press (F2) **FORMAT** to formatting the flash memory or SD card.
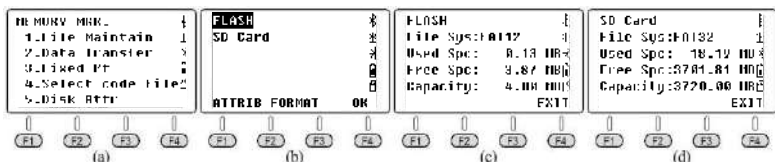
4.3 Layout

The layout function in this chapter is almost same to the S.O (Stake Out) function under the page of coordinate measurement (chapter 2.4.2.5).

Assume that the coordinate of 19 occupied points has been imported to the file "FIX.LIB" in flash memory, the designed points has been imported to the file "180514_FYD".

Press 2.LAYOUT in the first page of menu (pic a) and enter the selection page (pic b).
Press (F2) LIST to view the file list (pic), move the cursor to "180514_FYD" and press (ENT) .
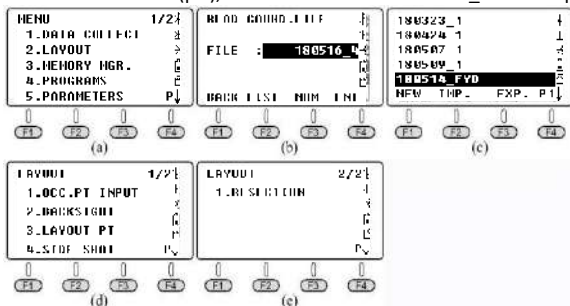
4.3.1 Set the Occupied Point and Backsight Point

The steps same as Chapter 4.1.3 Set the Occupied Point and Backsight Point.

4.3.2 Set the Layout Point

Press 3.Layout PT under "LAYOUT" menu (pic b). Press F2 **LIST** to enter the point list (pic d), the cursor will remain in the first point automatically (pic c). Press ENT to view the detail information for the selected point.

The description of this chapter is same to Chapter 2.4.2.5 S.O

Press F4 **ENT** to input the instrument height (pic e).
Press F4 **ENT** again, the equipment will calculate the HR and HD from occupied point K3 to point 1 (pic f).

Press F3 **GUIDE** to show the HD between the current azimuth to the designed azimuth,
➡ -53°50'36" means the equipment should turn right in 53°50'36" to 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", 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); Guide the prism and move -13.702m, the minus distance means the prism should move backwards in 13.702m. Aim at the target center and press F1 **MEAS** again after the movement (pic j)

50
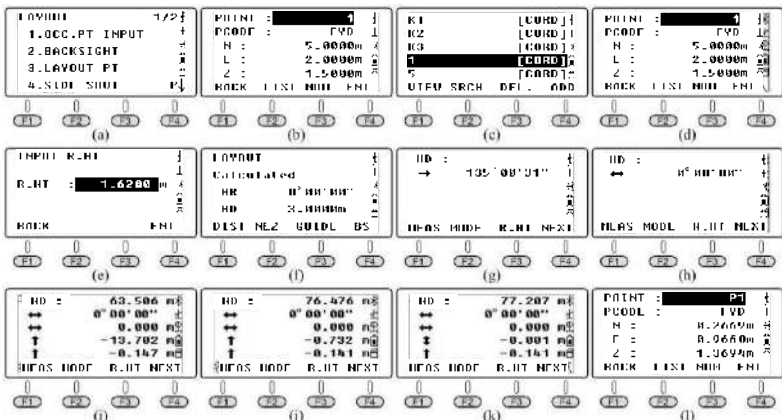
4.3.3 Side Shot

If the view between the occupied point to stake-out point has been covered, the user can execute "Side Shot" or "Resection" command to add the occupied point.

Please check Chapter 2.4.3 Side Shot as the reference.

Press 4.Side Shot in the first page of LAYOUT to enter the Side Shot menu (pic a). Input P1 as the point name, aim at the target center. Press (F4) **MEAS** to measure the coordinate of point P1(pic c). Then press (F4) **YES** to record (pic d). Press (ESC) to back the LAYOUT menu (pic e).

Move the total station to P1 and well-settled the equipment. Press 1.OCC. PT INPUT under stake-out menu to view the coordinate of the latest occupied point (pic f), press (F2) **LIST** to enter the point list. Move the cursor to P1 (pic g) and press (F4) **ENT** to view the detail (pic h). The steps for the other points are same to the previous description.

(a)   (b)   (c)   (d)

(e)   (f)   (g)   (h)
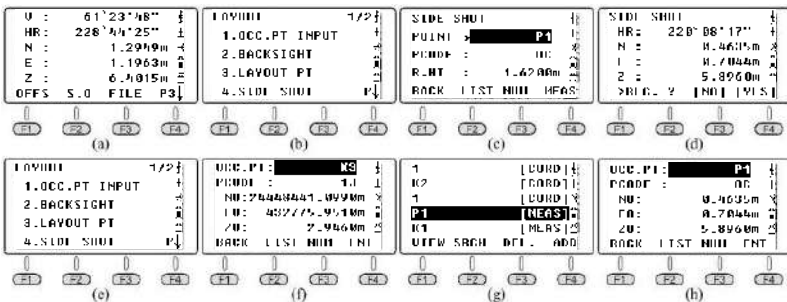
4.3.4 Resection

Set the equipment on an unknown point, the system will calculate the coordinate based on the distance measurement of 2-7 known points, or angle measurement for 3-7 known point.

Please check Chapter 2.4.4 Resection as the reference.

5.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.

(a)　　　　　　(b)
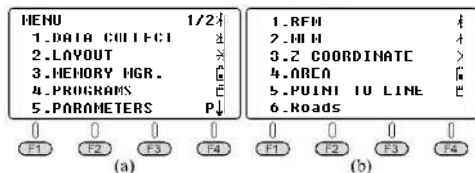
5.1 REM

REM function is mainly used to measure the vertical height for tiny objects, for example the high-tension cable and impending cable.
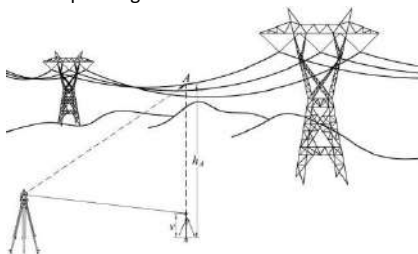
Set a prism on the plumbing line below the target, measure the prism height *v*.

Press 1.REM and 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.
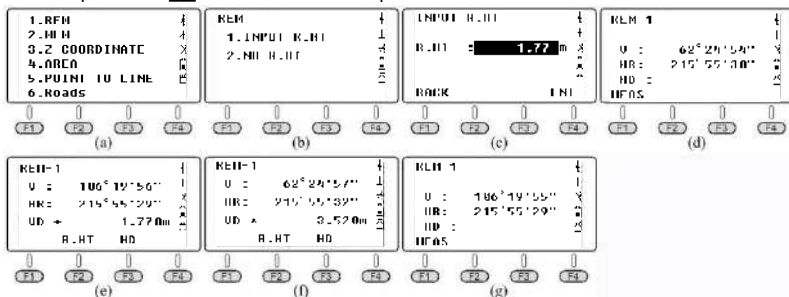
5.2 MLM

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.

Press 2.MLM in program menu (pic a) to select the coordinate file (pic b). Press (F4) **ENT** to select the file and enter the MLM page(pic c). There included two options, MLM-1 (A-B A-C) and MLM-2 (A-B B-C).
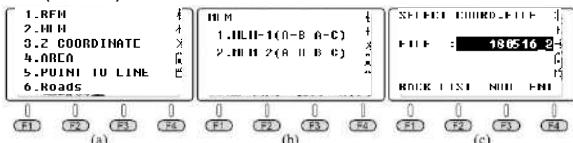
MLM-1 (A-B A-C) is used for measure the HD/VD/SD/HL/HR from start point A to arbitrary point B,C...., MLM-2 (A-B B-C) is used for measure the HD/VD/SD/HL/HR from two nearly points.
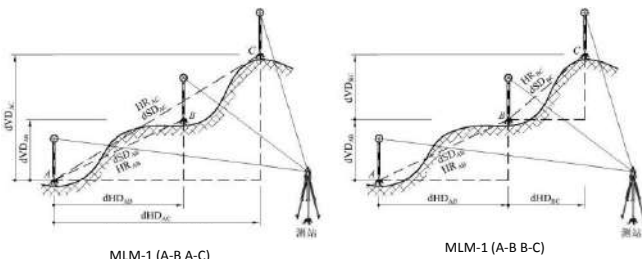
MLM-1 (A-B A-C)   MLM-1 (A-B B-C)

5.2.1 MLM-1 (A-B A-C)
5.2.1.1 Calculate by distance measurement.
Press 1.MLM-1(A-B, A-C) to enter the step-1 (pic b); Press (F2) **R.HT** to input the prism height (pic c), press (F4) **ENT** to confirm; Aim at target A and press (F1) **MEAS** and enter 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).

53
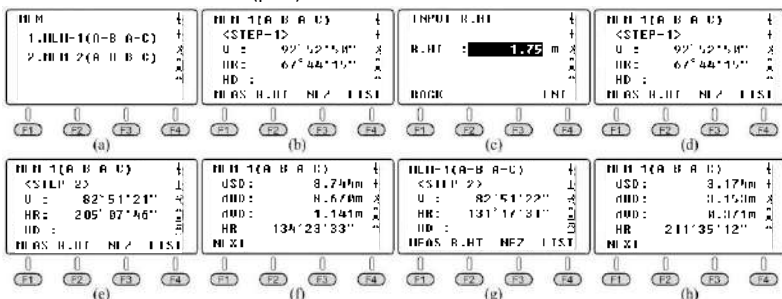
Press (F1) **NEXT** to repeat step-2 and aim at the target center of point C (pic g). Press (F1) **MEAS**, the dSD, dHD, dVD and HR from point A to C will be shown on the screen (pic h) Press (F1) **NEXT** to repeat the steps, press (ESC) to exit.

5.2.1.2 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.

Unit: m
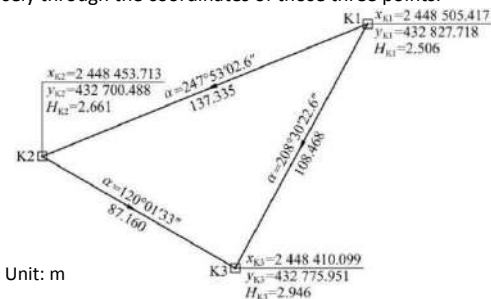
Use the coordinate of K1/K2/K3 as point A/B/C to calculate the edge.
Press 1.MLM-1 (A-B A-C) to enter the step-1 (pic b), press (F4) **LIST** to enter the point list. The cursor will remain in the first line K1 (pic c), press (ENT) to view the detail for K1 (pic d). Press (F4) **YES** to step-2 (pic 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 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.

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

5.2.2.1 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.

(a) (b) (c)

(d) (e) (f)
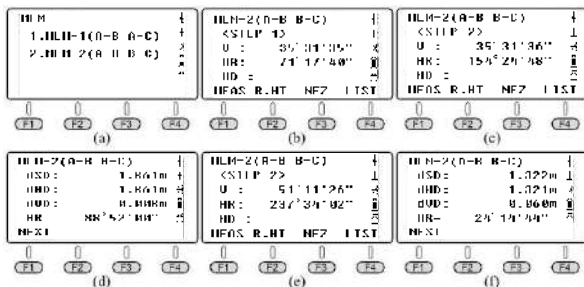
5.2.2.2 Calculate by coordinate invoking

Press 2.MLM-2 (A-B B-C) to enter the step-1. Press (F4) **LIST** to enter the point list, the cursor will remain in the first known point K1 (pic c)

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 (ENT) to view 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.

```
HLM
1.HLM-1(A-B A-C)
2.HLM 2(A B C)
```
(a)

```
HLM-2(A-B B-C)
<STEP 1>
U :    35°31'05"
HR:    71°17'40"
HD :
MEAS R.HT   NEZ   LIST
```
(b)

```
5           [KNWD]
U1          [KNWD]
U2          [KNWD]
U3          [KNWD]
K1          [CORD]
VIEW SRCH
```
(c)

```
READ COORD.DATA
N :  2448505.417m
E :   432827.718m
Z :          2.586m
> OK ?    [NO] [YES]
```
(d)

```
HLM-2(A-B B-C)
<STEP 2>
U :    35°31'36"
HR:   154°24'48"
HD :
MEAS R.HT   NEZ   LIST
```
(e)

```
K2          [CORD]
K3          [CORD]
K4          [CORD]
K5          [CORD]
VIEW SRCH
```
(f)

```
READ COORD.DATA
N :  2448653.718m
E :   432700.488m
Z :          2.601m
> OK ?    [NO] [YES]
```
(g)

```
HLM-2(A-B B-C)
dSD:      137.335  m
dHD:      137.335  m
dUD:        0.155  m
HR=   247°53'02"
NEXT
```
(h)

```
HLM-2(A-B B-C)
<STEP 2>
U :    35°31'36"
HR:   154°24'48"
HD :
MEAS R.HT   NEZ   LIST
```
(i)

```
K3          [CORD]
K4          [CORD]
K5          [CORD]
VIEW SRCH
```
(j)

```
READ COORD.DATA
N :  2448411.009m
E :   432775.951m
Z :          2.946m
> OK ?    [NO] [YES]
```
(k)

```
HLM-2(A-B B-C)
dSD:       87.160  m
dHD:       87.160  m
dUD:        0.285  m
HR=   128°01'33"
NEXT
```
(l)

5.3 Z Coordinate

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

```
1.REM
2.MLM
3.Z COORDINATE
4.AREA
5.POINT TO LINE
6.Roads
```
(a)

```
SELECT COORD.FILE
FILE =  180517_1
BACK LIST   NUM  ENT
```
(b)

```
Z COORDINATE
1.OCC.PT INPUT
2.REF.MEAS
```
(c)
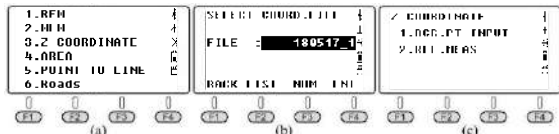
Press 1.OCC PT INPUT to input or call the occupied point. Press 2.REF MEAS to calculate the Z coordinate inversely by distance measurement. And using the calculated coordinate to replace the current one. Please also set the backsight based on the guidance.

Press 1.OCC PT INPUT under "Z Coordinate" menu (pic b), Point 1 will be shown on the scree. You can press F1 **INPUT** or F2 **LIST** to input or call the occupied point.

Press F4 **ENT** to view the coordinate of point 1, press F4 **YES** to confirm.
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 and press ENT to view the coordinate of point 4 (pic h).
Press F4 **YES** and input the R.Ht 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).

∠ COORDINATE		OCC.PT: ▮ 1		READ COORD.DATA		INS.HI INPUT
1.OCC.PT INPUT		PCODE : 100.000		N : 2448486.865 m		
2.REF.MEAS		N0: 10.000m		E : 432767.706 m		INS.HI: 1.420m
		E0: 200.000m		Z : 3.121 m		
		Z0: 0.000m				
		BACK LIST NUM ENT		> OK ? [NO] [YES]		BACK ENT

| F1 F2 F3 F4 | F1 F2 F3 F4 | F1 F2 F3 F4 | F1 F2 F3 F4 |
| (a) | (b) | (c) | (d) |

∠ COORDINATE		∠ COORDINATE		KG [CORD]		READ COORD.DATA
1.OCC.PT INPUT		No.01		KO4 [CORD]		N : 2448494.630m
2.REF.MEAS				K5 [CORD]		E : 432796.684m
		PDINT : 1		1 [CORD]		Z : 3.121m
		BACK LIST NUM ENT		4 [CORD]		> OK ? [NO] [YES]
				VIEW SRCH		

| F1 F2 F3 F4 | F1 F2 F3 F4 | F1 F2 F3 F4 | F1 F2 F3 F4 |
| (e) | (f) | (g) | (h) |

INPUT R.HI		REF.MEAS		REF.MEAS		∠ COORDINATE
		R.HT : 1.750m		HR: 74°59'56"		AZ : 74°59'57"
R.HI : 1.750m				SD : 137.232 m		Z : 10.332 m
		>Sight ?		HD : 137.060 m		dZ: 0.000 m
				VD : -6.881 m		
BACK ENT		[NO] [YES]		NEXT CALC		SET

| F1 F2 F3 F4 | F1 F2 F3 F4 | F1 F2 F3 F4 | F1 F2 F3 F4 |
| (i) | (j) | (k) | (l) |

BACKSIGHT		∠ COORDINATE
		1.OCC.PT INPUT
HR: 74°59'57"		2.REF.MEAS
[NO] [YES]		

| F1 F2 F3 F4 | F1 F2 F3 F4 |
| (m) | (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.

5.4 Area

Through the actual measurement for vertex, Area is used for area and perimeter calculation for polygon.

Press 4.AREA under "Program" menu (pic a). Aim at the prism center of point 1, press (F1) **MEAS** to measure the distance (pic c), the coordinate will be shown on the screen and skip to the next point (pic d); Aim at the prism center of point 2, press (F1) **MEAS** to measure the distance (pic e), the perimeter and the coordinate of point 2 will be shown on the screen (actual it is the HD from point 1 to point 2), without area (pic f); Aim at the prism center of point 3, press (F1) **MEAS** to measure the distance (pic g), the coordinate of point 3 and the area & perimeter among point 1-2-3 will be shown on the screen (pic 4).
Aim at the prism center of point 4, press (F1) **MEAS** (pic i), the coordinate of point 4 and the area & perimeter among point 1-2-3-4 will be shown on the screen (pic j)

You can measure the left vertexes, and the equipment will calculate the area and perimeter based on the current points. The measurement of vertexes should based on the order of point 1→point 2→point 3...., by clockwised or anti-clockwised direction.

After the measurement, press F3 **UNIT** to change the unit for area or perimeter.

```
1.REM          ↕     PUINIS :   BBBH{      PUINIS :   BBBH{      PUINIS =   BBB1{
2.HIM          ↕    AREA           ↓    HR:  149°23'B9"  ↑    AREA           ↓
3.Z COORDINATE >    :          m²  ↓    N +      N.749m  ↓    :          m²  ↓
4.AREA         ↕    Girth          ▓    E :     2BB.74Bm ↓    Girth          ▓
5.PUINI IU LINE ↕                       Z :     -B.B5Ym  ↑
6.Roads        ↕    MEAS       UNIT     >Measuring.... SET   MEAS       UNIT
```
(a)   (b)   (c)   (d)

```
  PUINIS :   BBB1{      PUINIS :   BBB2{      PUINIS :   BBB2{      PUINIS :   BBB3{
HR:  215°35'12"   ↑    AREA           ↓    HR:  305°04'52"  ↓    AREA           ↓
N +      N.B12m   ↓    :          m²       N x     11.496m  ↓    :        2.B95 m² ↓
E :    199.15Bm   ▓    Girth    1.591m ▓    L :    197.87Bm  ▓    Girth    B.5B9m  ▓
Z :     -B.B52m   ↑                        Z :      B.BB7m   ↑
>Measuring..... SET    MEAS       UNIT     >Measuring.... SET    MEAS       UNIT
```
(e)   (f)   (g)   (h)

```
  PUINIS :   BBB3{      PUINIS :   BBB3{      PUINIS =   BBB4{      PUINIS :   BBB5{
HR:  AB°66'25"    ↑    AREA           ↓    HR:  231°94'2B"  ↓    AREA           ↓
N +     13.152m   ↓    :       11.135 m²   N x      3.791m  ↓    :        3.23B m² ↓
E :    2B2.71Bm   ▓    Girth   14.52Bm ▓    E :    192.BB5m  ▓    Girth   3B.951m  ▓
Z :     -B.B4Ym   ↑                        Z :      B.355m   ↑
>Measuring..... SET    MEAS       UNIT     >Measuring.... SET    MEAS       UNIT
```
(i)   (j)   (k)   (l)

5.5 Point to Line

As picture shown, the theory of point to line is: 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.
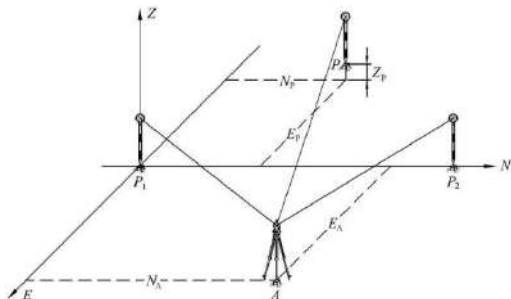
Set the equipment on point A. Press 5.Point to Line under "Program" menu (pic a) and enter the coordinate list (pic b), press F4 **ENT** to select the file and enter the page for 1st point (pic c). Press F2 **R.HT** to input the instrument height and reflector height (pic d). Press F4 **ENT** to confirm.

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.

Press ⟨F1⟩ **EXIT** or ⟨ESC⟩ to exit the function of point to line.
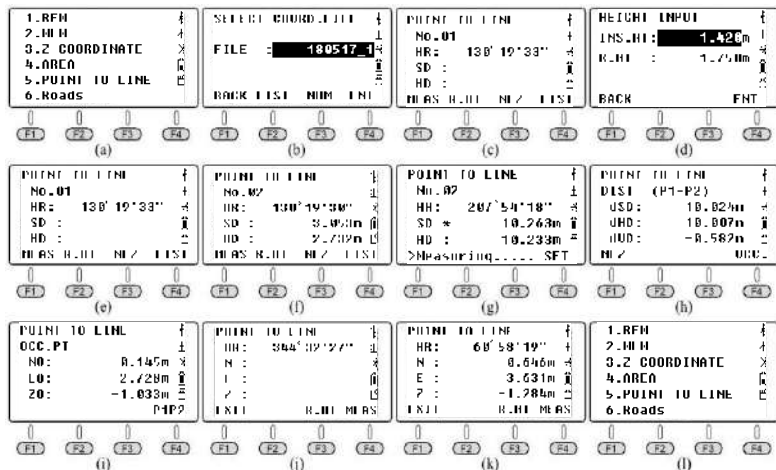
6.Roads

Roads in N6 system 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.

6.1 Case Study - Horizontal & Vertical Curve in Ramp

6.1.1 Design Drawing for Horizontal &Vertical Curve

Pic 6-1 on the below is a flat curve from an e-ramp road, shown by linear data sheet. 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.

PIC6-1: Designed Drawing of An E-ramp Road in Zhejiang, China
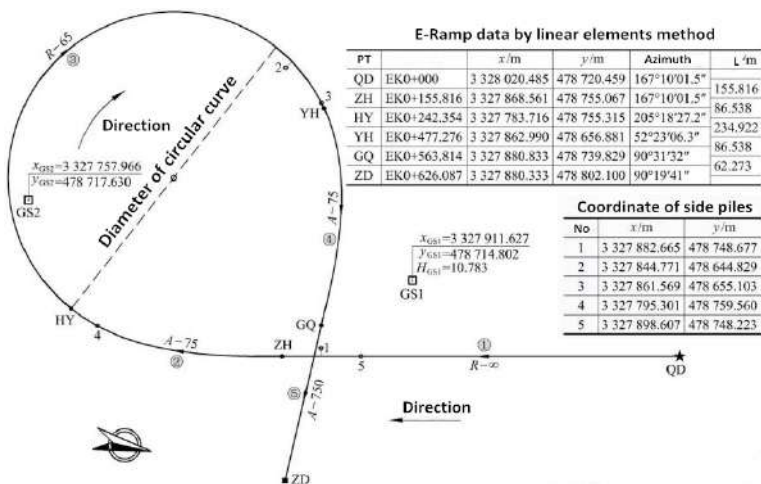
FORM6-1: Data Sheet for Vertical Curve & Slope

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.

6.1.2 How to Use N6 to Calculate the H&V Curve in Ramp
6.1.2.1 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 set. Back to the last page.
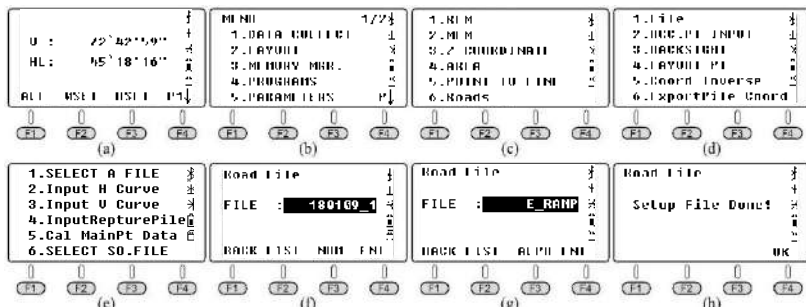
* you can also press (F2) **LIST** to call an existed file as the current file.

6.1.2.2 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.
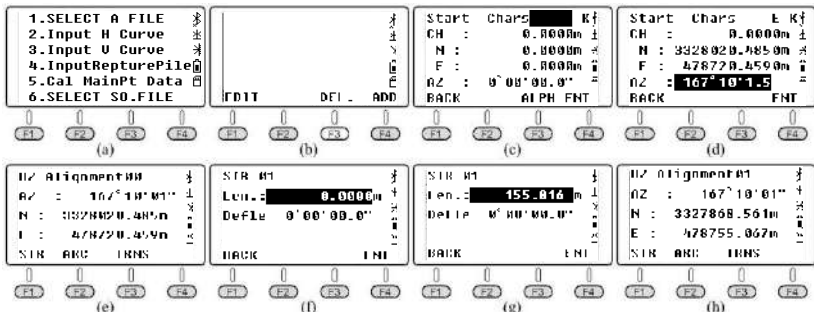
(2) Input the designed value of 1st line

Press F1 **STR** to input the designed value of straight line (pic f). When the 2nd line share the same asix 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).
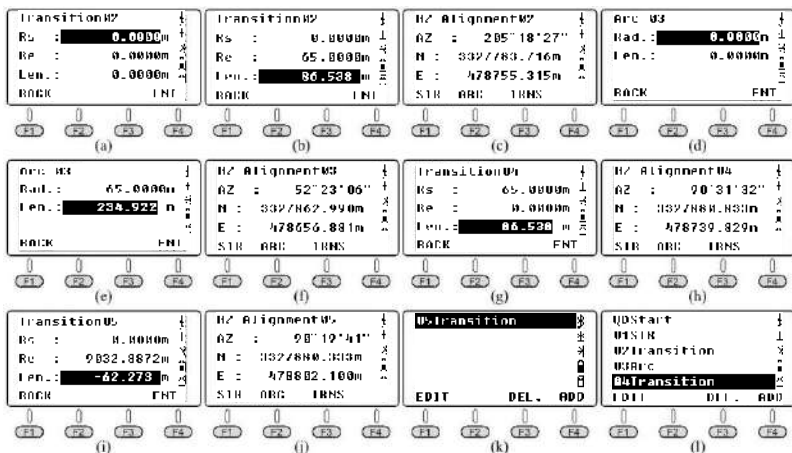
(4) Input the designed value of 3rd circular curve

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

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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 to delete the last element, not the selected one.

6.1.2.3 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 F4 ENT to confirm. Repeat the steps until the slope points are all included in the system.
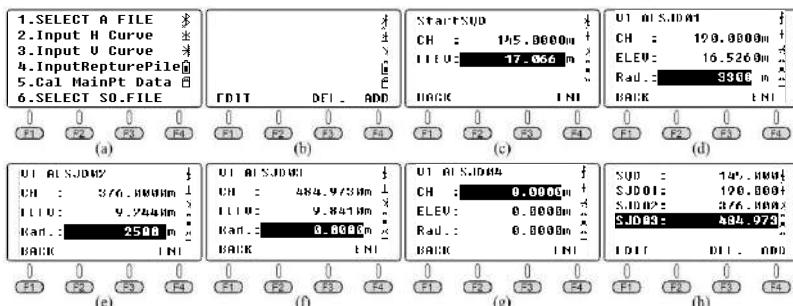
Press ESC back to the elements list, the cursor will remain at the last element in default. Press F1 **EDIT,** F3 **DEL** or F4 **ADD** to edit, delete or add the elements.

   * please notice that F3 **DEL** is used to delete the last element, not the selected one.

6.1.2.4 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).

1.SELECT A FILE	05_ZD:	04_GU:	03_YH:
2.Input H Curve	FK0+626.087	FK0+563.814	FK0+472.276
3.Input V Curve	N : 3327888.333m	N : 3327880.833m	N : 3327862.990m
4.InputReptrePile	F : 478802.100m	F : 478739.829m	F : 478656.881m
5.InputMainPt Data	Z : 0.000m	Z : 0.000m	Z : 9.799m
6.SELECT SO.FILE	Last NEXT	Last NEXT	Last NEXT

(a)   (b)   (c)   (d)

02_HV:	01_ZH:	00_QD:	1.SELECT A FILE
FK0+242.354	FKM+155.816	EK0+000.000	2.Input H Curve
N : 3327783.716m	N : 3327608.561m	N : 3327820.485m	3.Input V Curve
F : 478755.315m	F : 478755.867m	F : 478720.459m	4.InputReptrePile
Z : 14.475m	Z : 16.919m	Z : 0.000m	5.Cal MainPt Data
Last NEXT	Last NEXT	Last NEXT	6.SELECT SO.FILE

(e)   (f)   (g)   (h)

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).

6.1.2.5 Export the data

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.

1.SELECT A FILE	1.File	ExportPile Coord	ExportPile Coord
2.Input H Curve	2.OCC.PT INPUT	Pile Sp 0.0n	Pile Sp 5.0n
3.Input V Curve	3.BACKSIGHT	L margi 0.000n	L margi 0.75Mn
4.InputReptrePile	4.LAYOUT	R margi 0.000n	R margi 9.75 n
5.Cal MainPt Data	5.Coord Inverse		
6.SELECT SO.FILE	6.ExportPile Coord	BACK ENT	BACK ENT

(a)   (b)   (c)   (d)

ExportPile Coord	ExportPile Coord	ExportPile Coord
	B:\E_RAMP.DAT(.DXF)	Pile Sp 5.0n
Exp Pile design ht		L margi 0.75Mn
	* 35	R margi 9.75 n
[NO] [YES]	EXIT	BACK ENT

(e)   (f)   (g)

The data can be transferred by SD card, Bluetooth or mini USB. Please check Chapter 4.2.2 Data Transfer as a reference.

①Connect PC and N6 total station by Bluetooth or USB cable.

②Open the Communication software, then click [icon] to connect the equipment. Click OK to close the dialog.

③Click [Receive] to activate the data receiving from N6. Click OK to
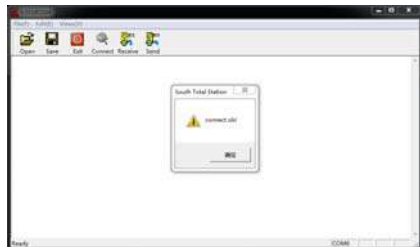
close the dialog.
④The coordinate of main points and middle pile will shown on the screen.
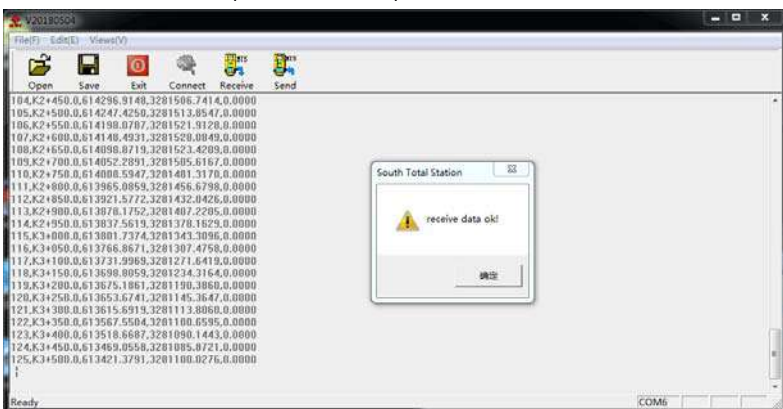
N6 will export all the coordinate of main points before the piles. Each line on the screen shows the coordinate of point on the curve one by one. The format is South CASS format, in "Point Number, Pile Number, Y, X, H ".
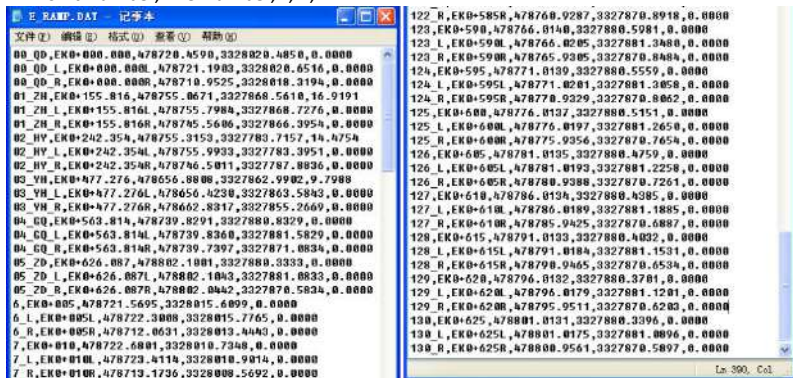
Use Windows TXT to open the file E_RAMP.dat (export via SD card)

* Note: if SD card already inserted into N6 when execute the export command, the program will export the data via communication port and SD card in the same time. But the dxf file will be transferred via SD card only.

6.1.2.6 Use AutoCAD to open the dxf file
Open the E_RAMP.dxf by AutoCAD, you can save the file as dwg.
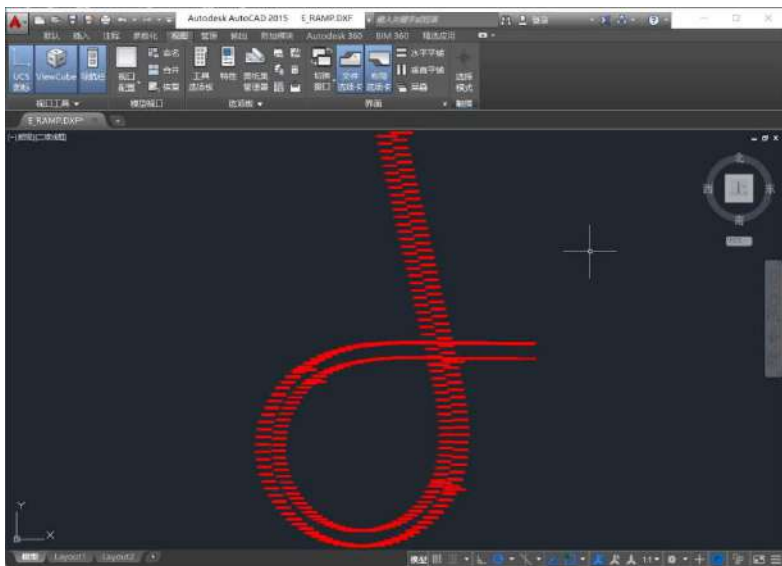
6.1.2.7 Layout points

① Input occupied point under existed file

Before the piles S.O, please input the occupied point GS1 and GS2 from PIC6-1 under existed file as the STN and BS point.

Press (MENU) ③ Memory MGR to manage the memory (pic c), press 3. Fixed PT to enter the point list (pic d). Press (F4) **ADD** to input the coordinate of GS1 (pic e), (F4) **ENT** to confirm and back to the point list (pic f). Repeat the steps to add GS2.
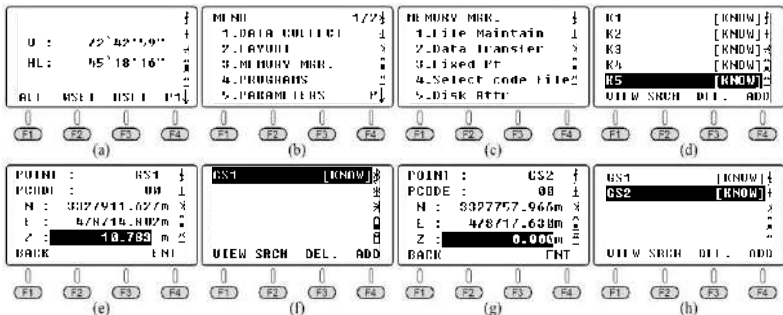
② Set the STN and BS

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 ⒠ⓃⓉ and ⒡F4 **ENT** to select. Input the instrument height (pic g) and ⒡F4 **ENT** to confirm.

MENU 1/2⇕ 1.DATA COLLECT ↓ 2.LAYOUT ⇕ 3.MEMORY MGR. ⁞ 4.PROGRAMS ⇕ 5.PARAMETERS ▶↓	1.REM ⇕ 2.MLM ↓ 3.Z COORDINATE ⇕ 4.AREA ⁞ 5.POINT TO LINE ⇕ 6.Roads	1.File ⇕ 2.OCC_PT INPUT ↓ 3.BACKSIGHT ⇕ 4.LAYOUT PT ⁞ 5.Coord Inverse ⇕ 6.ExportPile Coord	OCC_PT: K3 ⇕ PCODE : 1J ↓ NO: 2448410.022m ⇕ EO: 432775.951m ⁞ ZO: 2.946m ⇕ BACK LIST NUM ENT
(a)	(b)	(c)	(d)

K3 │KNOW│ ⇕ K4 │KNOW│ ↓ K5 │KNOW│ ⇕ **GS1 │KNOW│** GS2 │KNOW│ ⇕ ▼ SRCH	OCC_PT: GS1 ⇕ PCODE : B0 ↓ NO: 3327911.627m ⇕ EO: 478714.882m ⁞ ZO: 10.783m ⇕ BACK LIST NUM ENT	INS_HT INPUT ⇕ INS_HT: 1.420 m ↓ ⇕ BACK ENT	BACKSIGHT ⇕ Set BS? ⇕ │NO│ │YES│
(e)	(f)	(g)	(h)

BKS PT: K2 ⇕ PCODE : 1J ↓ NBS: 2448453.713m ⇕ EBS: 432700.488m ⁞ ZBS: 2.661m ⇕ BACK LIST NUM ENT	K3 │KNOW│ ⇕ K4 │KNOW│ ↓ K5 │KNOW│ ⇕ GS1 │KNOW│ ⁞ **GS2 │KNOW│** ▼ SRCH	BKS PT: GS2 ⇕ PCODE : B0 ↓ NBS: 3327757.966m ⇕ EBS: 478717.630m ⁞ ZOS: 8.000m ⇕ BACK LIST NUM ENT	BACKSIGHT ⇕ HL: 181°03'15" ⁞ ⇕ │NO│ │YES│
(i)	(j)	(k)	(l)

Press ⒡F4 **YES** to set the BS, ⒡F2 **LIST** to call GS2 from the point list (pic j). Press ⒠ⓃⓉ and ⒡F4 **ENT** to select. 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.

③ 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).

1.File ⇕ 2.OCC_PT INPUT ↓ 3.BACKSIGHT ⇕ 4.LAYOUT PT ⁞ 5.Coord Inverse ⇕ 6.ExportPile Coord	LAYOUT PT ⇕ Pile NU 0.000m ↓ L margi 0.080m ⇕ R margi 0.080m ⁞ BACK ENT	LAYOUT PT ⇕ Pile NU 205_000m ↓ L margi 0_75m ⇕ R margi 9.75 m ⁞ BACK ENT	LAYOUT PT ⇕ Pile NU 205_000m ↓ L margi 9_75mm ⇕ R margi 9_75mm ⁞ EDIT Left Rigt Midd
(a)	(b)	(c)	(d)

POINT : GS2 ⇕ **EK0+205.000**⇕ N : 3327828.096 ↓ E : 478762.515 ⇕ Z : 15.864 ⁞ BACK REC_ ALPH OK	Roads ⇕ Calculated ↓ HR= 152°28'58" ⇕ HD= 183.264m ⁞ ⇕ DIST NEZ GUIDE RS	LAYOUT PT ⇕ Pile NU 205_000mm ⁞ L margi 9_75mm ↓ R margi 9_75mm ⁞ EDIT Left Rigt Midd	POINT : GS2 ⇕ **EK0+205.000**⇕ N : 3327828.053 ↓ E : 478763.265 ⇕ Z : 8.000 ⁞ BACK REC_ ALPH OK
(e)	(f)	(g)	(h)

Roads ⇕ Calculated ↓ HR= 152°06'48" ⇕ HD= 183.687m ⁞ ⇕ DIST NEZ GUIDE RS	LAYOUT PT ⇕ Pile NU 205_000mm ↓ L margi 9_75mm ⇕ R margi 9_75mm ⁞ EDIT Left Rigt Midd	POINT : GS2 ⇕ **EK0+205.000**⇕ N : 3327819.959 ↓ E : 478762.765 ⇕ Z : 8.000 ⁞ BACK REC_ ALPH OK	Roads ⇕ Calculated ↓ HR= 157°30'13" ⇕ HD= 99.218 m ⁞ ⇕ DIST NEZ GUIDE RS
(i)	(j)	(k)	(l)

Press (F4) **MIDE** to check the coordinate of middle pile (pic e). Press (F4) **OK**, it will shown the HR/HD difference from STN GS1 to pile EK0+205 (pic f). Please check Chapter 4.3 LAYOUT 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 shown 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 shown 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.

6.1.2.8 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 layout (S.O) this point are same to previous chapter.

* Note: In S.O step (pic h), press (▲) to move the cursor toward the line of point name. Input the point name, press (F2) REC to record this point under current file.

As the drawing shown on PIC6-1, 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 (F2) **S.O** steps.
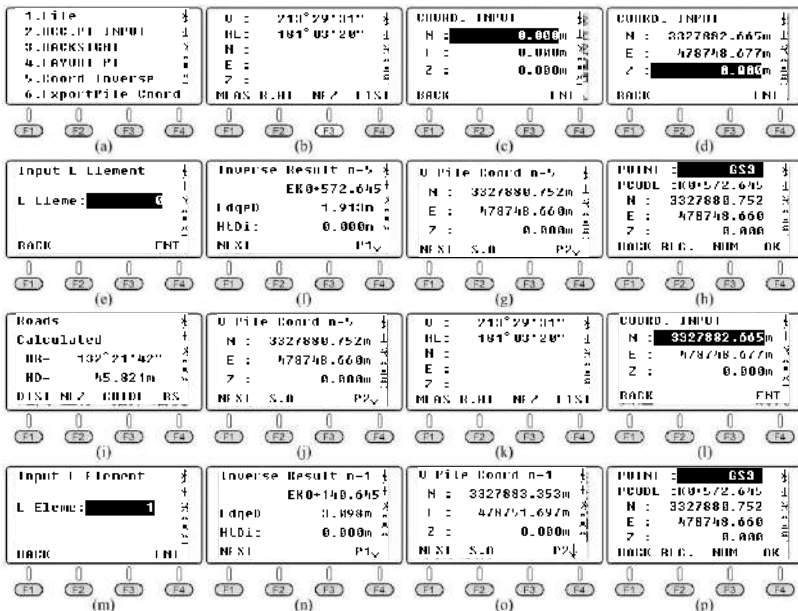
② Coordinate inverse calculation from point 2-5

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 by manual and calculate the vertical point on road (pic e-h). The pile number EK0+475 belonging to the range of vertical curve, so the height will be shown on the screen.

Input the coordinate of P4 by manual and calculate the vertical point on road (pic i-l). The pile number EK0+230 belonging to the range of vertical curve, so the height will be shown on the screen.

Input the coordinate of P5 by manual and calculate the vertical point on road (pic m-p). The pile number EK0+125 is out of the range of vertical curve, so the height will be shown as 0.

(a) (b) (c) (d)
(e) (f) (g) (h)
(i) (j) (k) (l)
(m) (n) (o) (p)
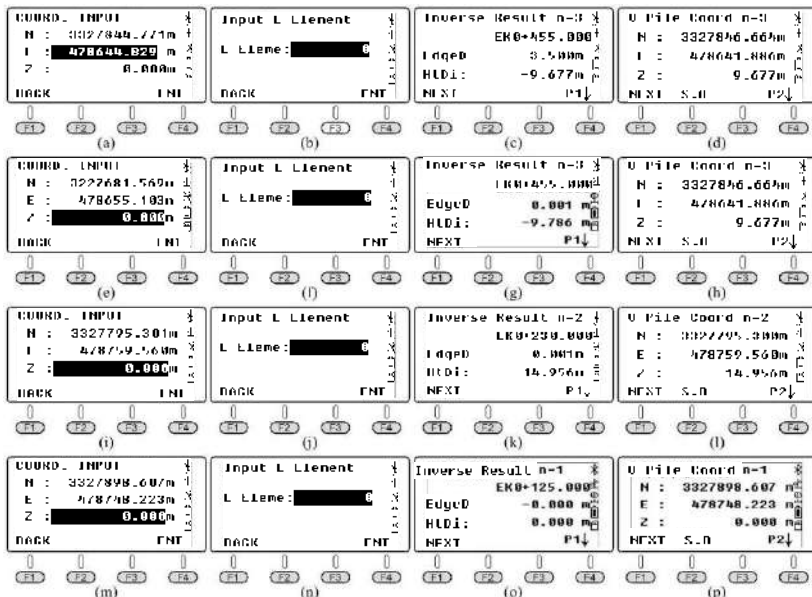
Note: User can draw the coordinate P1-5 on AutoCAD; command LINE to draw the vertical line from P1-5 to middle line of the ramp; command di to measure the distance; command id to check the coordinate of vertical point.

6.1.2.9 Layout the middle and side piles

Press 6.Export Pile Coord under road menu (pic b). Export the file E_RAMP.dat to SD card. You can also import those data into current coordinate file, and then stake-out the points in LAYOUT/MENU page.

① Import the coordinate of piles into current file
Press 2.LAYOUT 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 SD card, move the cursor on dat file you needed (pic i) and (ENT) to import the data into internal memory of N6. After the data import, the screen will shown as pic l. Press (ENT) to set E_RAMP as the current file.
Note: N6 can save 37,500 points in internal memory in maximum. 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.
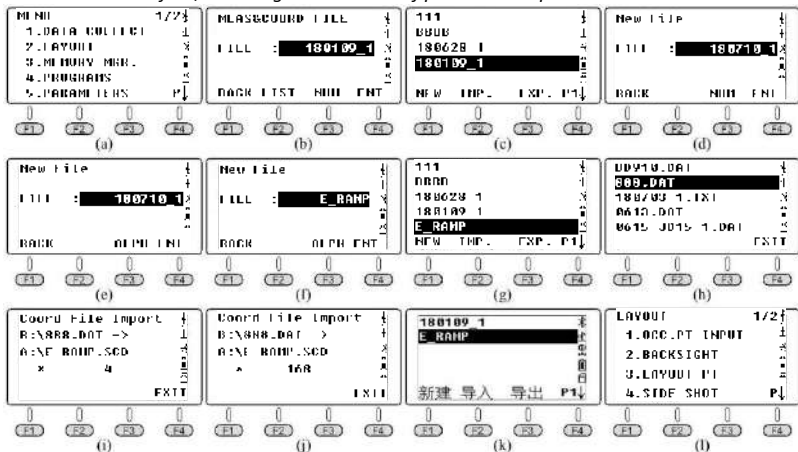
② Call the S.O point from current file

Press 3.LAYOUT PT under LAYOUT 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 shown the HR/HD difference from STN GS1 to point 01_ZH (pic h)

71
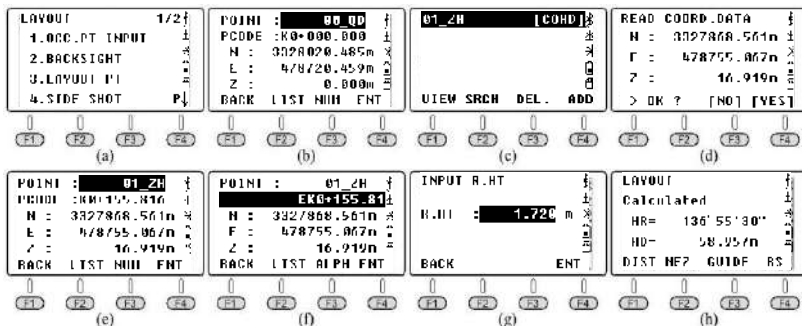
6.2 Case Study - H Curve in Renovation Project

6.2.1 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	Radius	Features /m				Straight Line
					Transit Parameter	Transit Length	Tangent Length	Total Length	
QD	P	K11+349.420	$\alpha_{QD\text{-}JD17}$=307°23′38.35″ (Inverse calculation by QD and JD17)						0
	N	2 626 870.231							
	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		
	E	50 246.397							95.746
ZD	P	K11+714.614	$\alpha_{JD17\text{-}ZD}$=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.

6.2.2 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

6.2.3 How to Use N6 to Calculate the Road in H Curve

6.2.3.1 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).

(a) (b) (c) (d)

(e) (f) (g) (h)
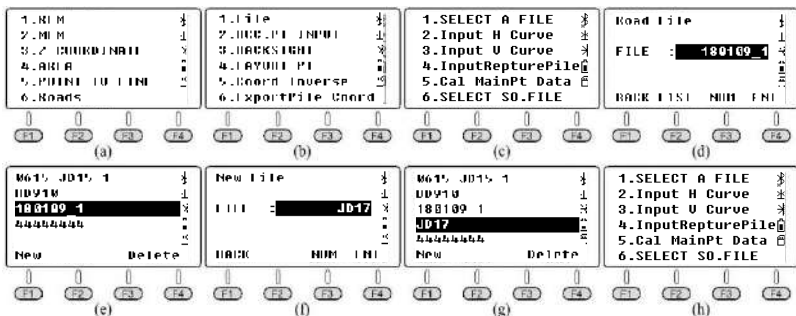
6.2.3.2 Input the designed value of the horizontal curve

(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 shown 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 shown 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 ⓔ and back to the elements list (pic k), press ⓔ and 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″

6.2.3.3 Export the data to SD card

Press 6. Export Pile Coord (pic a), input the interval between center piles(5m). If the interval from left and right keep 0, the equipment will not export the side pile to SD card. Press (F4) **ENT** to confirm and export the data "JD17.dat".

(a)   (b)   (c)   (d)
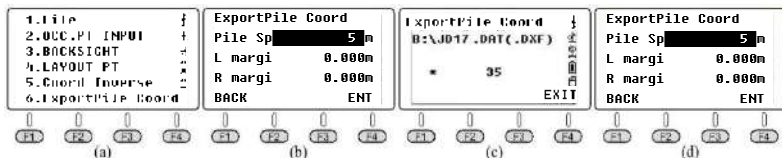
Open the "JD17.dat" by Windows TXT as below picture shown. Consider that this file doesn't including the data of vertical curve, the height of all those points will keep 0.
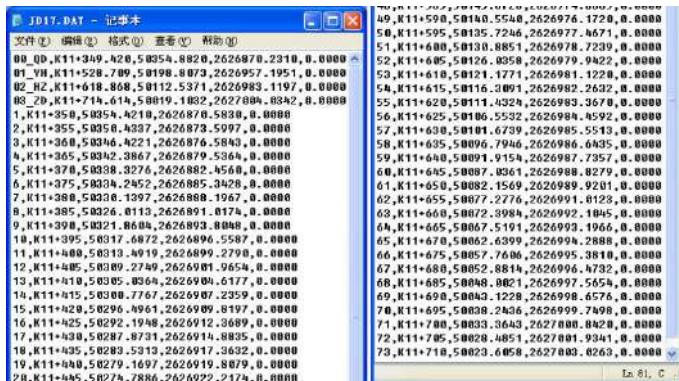
6.2.3.4 Inverse calculation

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. The detail method of inverse calculation is similar to chapter 6.1.

(a)   (b)   (c)   (d)

(e)   (f)   (g)   (h)

(i)   (j)   (k)   (l)
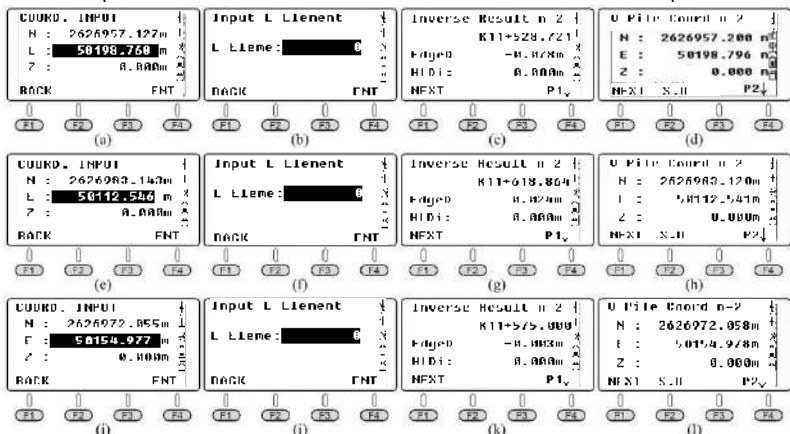
6.3 Case Study - Vertical Curve in Road Project

6.3.1 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		Azimuth	Radius	Transit Parameter	Transit Length	Tangent Length	Total Length	Straight Line
QD	P	K28+543.561	$\alpha_{QD-JD39}$=26°32'18.38"						
	N	3 246 012.339							
	E	442 908.051							353.741
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	0	50.276		
	E	443 088.565 2							0
JD40	P	K29+069.848	15°18'36.1"(L)	260	114.017 5	50	59.992	119.475	
	N	3 246 471.122			114.017 5	50	59.992		
	E	443 140.375 7							291.44
JD41	P	K29+420.771	71°23'04.4"(R)	0	0	0	0	0	
	N	3 246 813.934			0	0	0		
	E	443 217.731 8							551.268
JD42	P	K30+022.507	0°02'53.5"(R)	120 000	0	0	50.468	100.936	
	N	2 627 004.034			0	0	50.468		
	E	50 019.103							1 034.163
JD43	P	K31+291.423	17°38'48"(R)	800	309.838 7	120	184.285	366.394	
	N	3 247 005.146			309.838 7	120	184.285		
	E	445 078.585 2							339.572
ZD	P	K31+813.103	$\alpha_{JD43-ZD}$=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				

6.3.2 Transfer the Data into Linear Elements

As picture shown, 4th circular curve is a kind of basic curve named JD40, the length L_y = L -

$L_{h1} - L_{h2}$ = 119.475-50-50=19.475m; The 11th circular curve is a kind of basic curve named JD44, the length L_y = L - L_{h1} - L_{h2} = 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

6.3.3 How to Use N6 to Calculate the Road

6.3.3.1 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** and (F1) **NEW** to create a new name "180114_1" (pic f), (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).
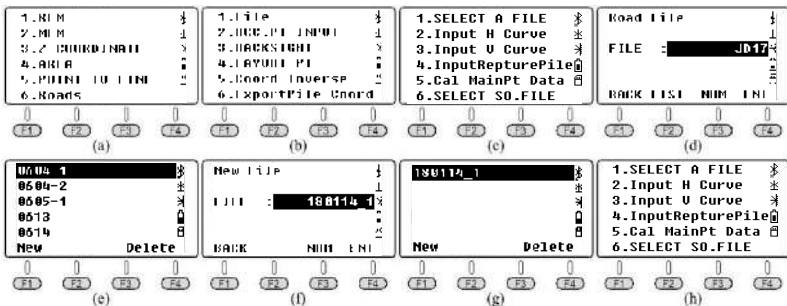
6.3.3.2 Input the designed value of horizontal curve

(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. Press(ESC) and then back to the element list (pic w).
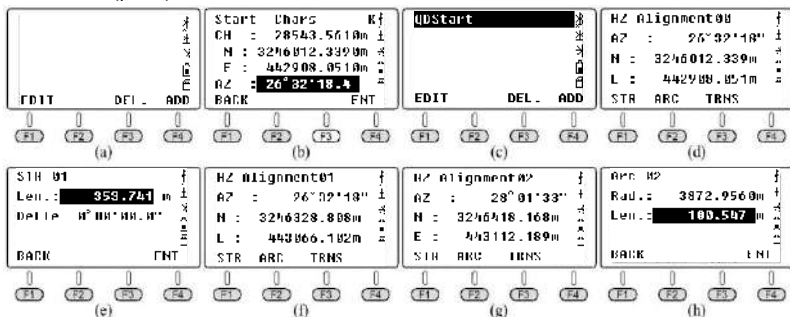
6.3.3.3 Input the value of vertical curve

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.
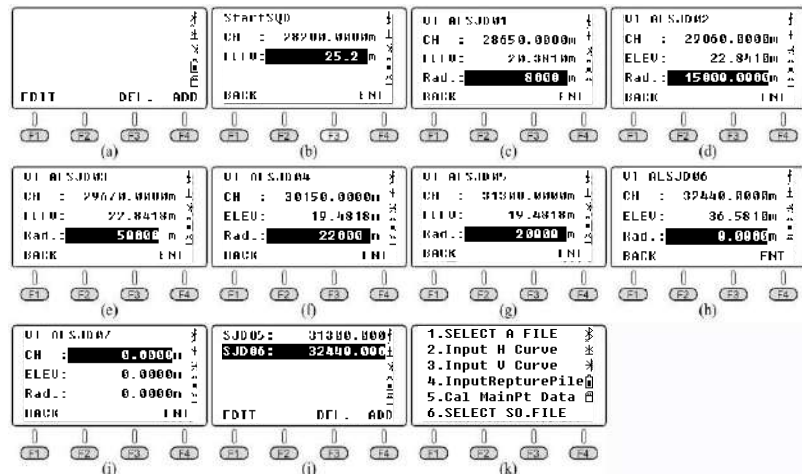
6.3.3.4 Input the data of Short-Chainage

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.
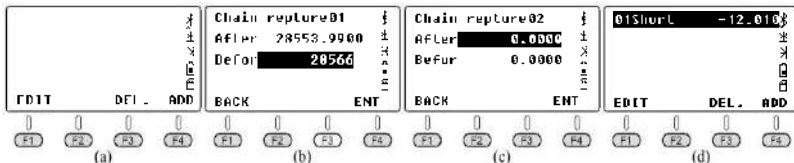
6.3.3.5 Calculate the coordinate of main points

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″

Press F1 **LAST** to check the data one by one, as pic c - o shown.
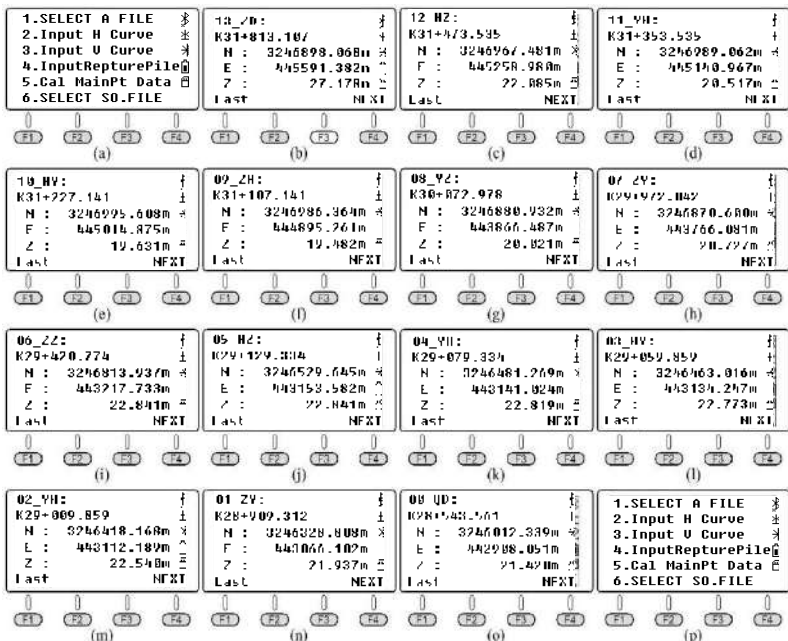
6.3.3.6 Export the data to SD card

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.

(a) (b) (c) (d)
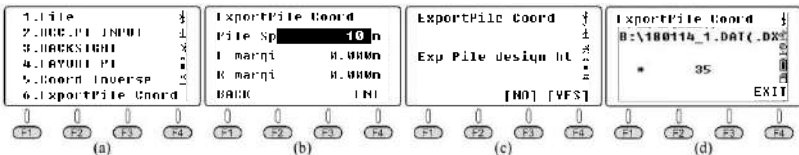
Open the file "180114_1.dat" by Windows TXT as below:
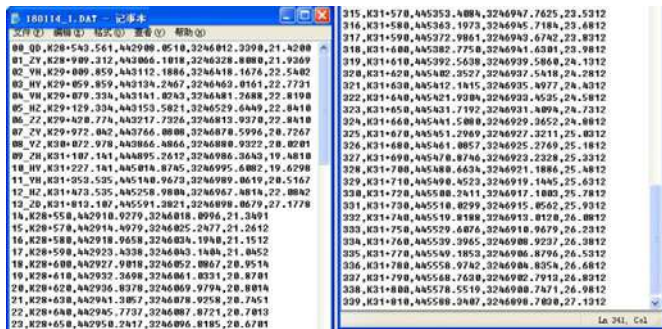
6.3.3.7 Use AutoCAD to open the dxf file

When export the data from N6 to SD card, it will generate a DXF file automatically. Open the file "180114_1.dxf" by AutoCAD 2015. You can save the file as dwg format.
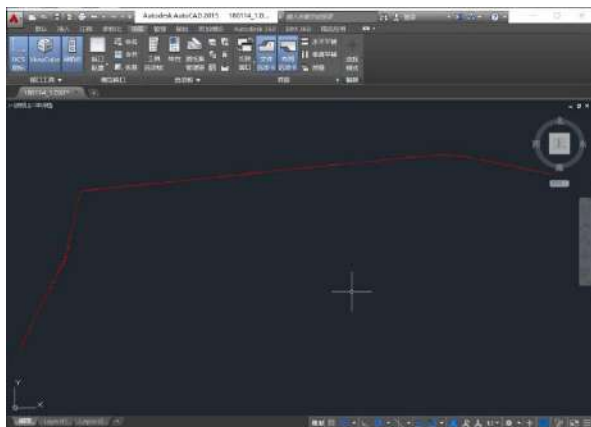
6.3.3.8 Layout points

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).
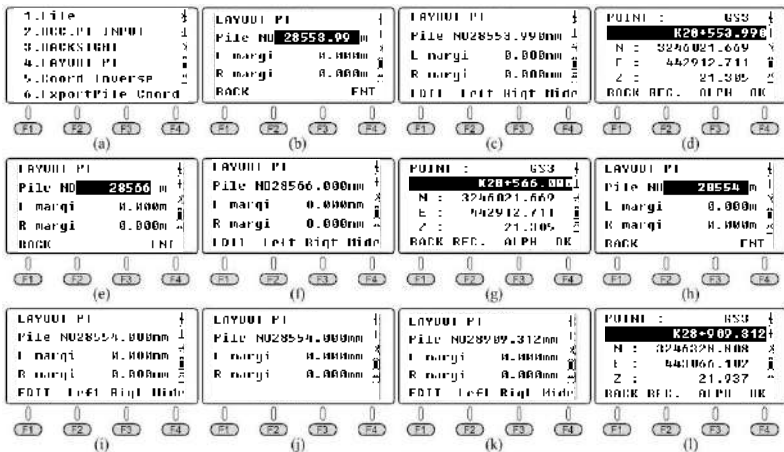
③ Calculate the coordinate among the Short-Chainage

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.

6.3.3.9 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. These two points across the Short-Chainage in coincidence.

1.Tile	U : 138°22'03"	U Pile Coord n 1	Input L Element
2.OCC.PT INPUT	HT : 14°82'52"	N : 3246821.667m	
3.BACKSIGHT	N :	L : 442912.710m	L Llne: 0
4.LAYOUT P1	F :	2 : 21.385m	
5.Coord Inverse	2 :		
6.ExportPile Coord	MEAS R.HT MEZ TTXT	NEXT X.0 P2	BACK FNT
(a)	(b)	(c)	(d)

Inverse Result n 1	CUURD. INPUT	U : 138°22'43"	COURD. INPUT
K28+566.002	N : 3246821.667m	HT : 14°82'55"	N : 3246821.671m
LdgeD 0.000m	L : 442912.710m	N :	L : 442912.712m
HtDi: 21.385m	2 : 0.000m	F :	2 : 0.000m
NEXT P1	BACK FNT	2 :	BACK FNT
		MEAS R.HT MEZ TTXT	
(e)	(f)	(g)	(h)

Input L Element	Inverse Result n 1	U Pile Coord n-1
	K28+566.002	N : 3246821.671m
L Llne: 0	LdgeD 0.000m	F : 442912.712m
	HtDi: 21.385m	2 : 21.385m
BACK FNT	NEXT P1	NEXT S.0 P2
(i)	(j)	(k)

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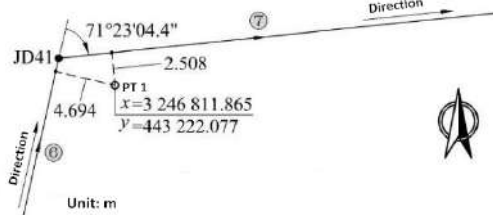
If the linear element is lacked (L Eleme: 0), N6 will calculate the vertical point on 7th straight line in automatically, with edge distance 2.508m; when L Element is 6, N6 will calculate the vertical point on 6nd straight line, with edge distance 4.694m.

COURD. INPUT	Input L Element	Inverse Result n 7	U Pile Coord n 7
N : 3246811.865m		K29+424.882	H : 3246814.359m
L : 443222.077m	L Llne: 0	LdgeD 2.508m	F : 443221.819m
2 : 0.000m		HtDi: 22.841m	2 : 22.841m
BACK FNT	BACK FNT	NEXT P1	NEXT S.0 P2
(a)	(b)	(c)	(d)

COURD. INPUT	Input L Element	Inverse Result n-6	U Pile Coord n 6
N : 3246811.865m		K29+419.789	N : 3246812.898m
L : 443222.077m	L Eleme: 6	LdgeD 4.694m	F : 443221.808m
2 : 0.000m		HtDi: 22.841m	2 : 22.841m
BACK FNT		NEXT P1	NEXT S.0 P2
(e)	(f)	(g)	(h)

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

6.4.1 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

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

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				

6.4.2 Transfer the Form into Linear Elements

JD60 is a symmetrical horizontal curve, 1st and 2nd transit curve is complete with length $L_{h1} = L_{h2}$ =130m. The full length of curve: L = 657.24m. So the length of circular curve is L_y = L - L_{h1} - L_{h2} = 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

6.4.3 How to Use N6 to Calculate the Road

6.4.3.1 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).
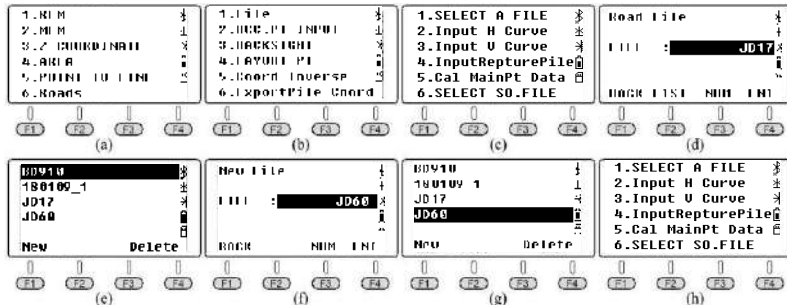
6.4.3.2 Input the designed value of horizontal curve

(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).
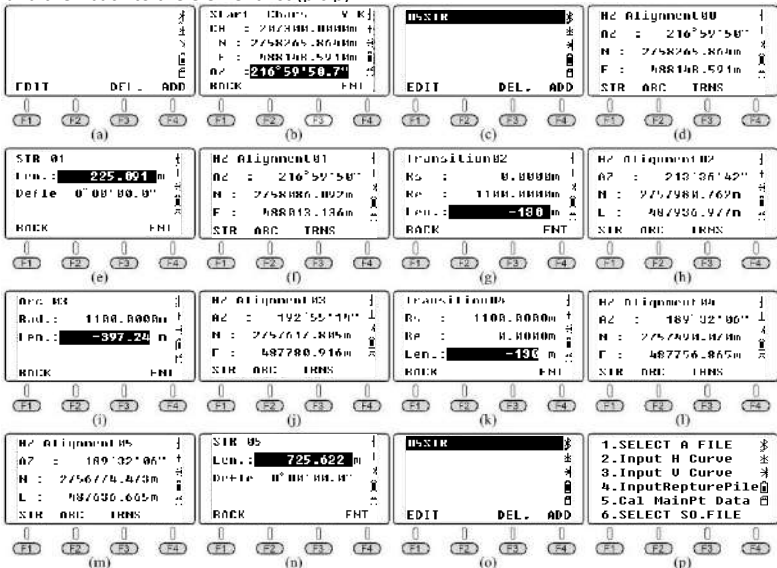
6.4.3.3 Input the value of vertical curve

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.
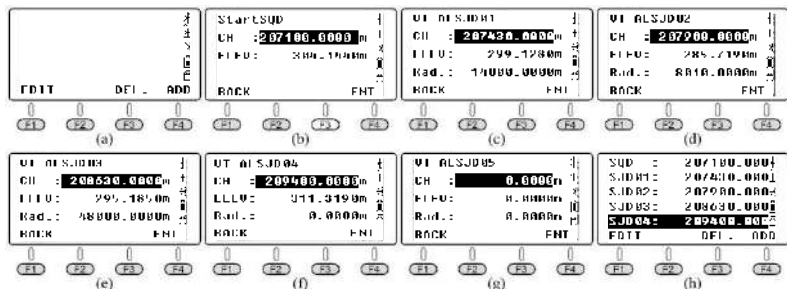
6.4.3.4 Input the data of Short-Chainage

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.
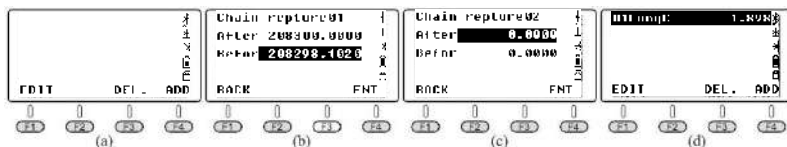
6.4.3.5 Calculate the data of main points

Press 5.Cal MainPt Data to calculate and get the result of pile number, coordinate and height for ending point (pic b).
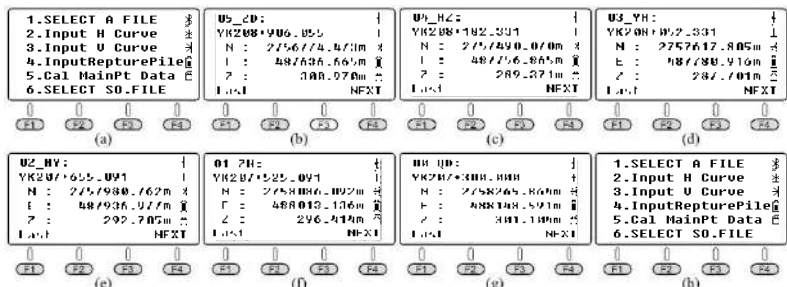
FORM 6-11: The comparison between calculated value and designed value for JD60

	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"

85

Press F1 **LAST** to check the data one by one, as pic c - g shown. Press ESC to back to the main menu (pic a).

6.4.3.6 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
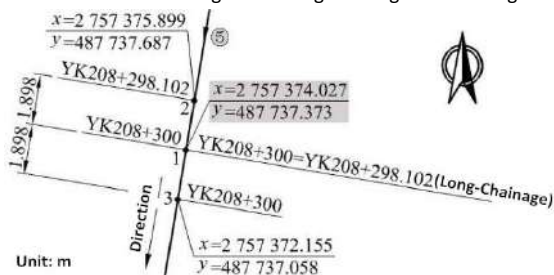
①Calculate the coordinate of extra pile YK208+298.102 behind the Long-Chainage
Press 4.LAYOUT PT under Roads, press the pile number 208298.102 which located behind the Long-Chainage (pic b). Press F4 **ENT** and F4 **Mide** to check the confirmation the repeat piles in Long-Chainage (pic d).

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** and (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.
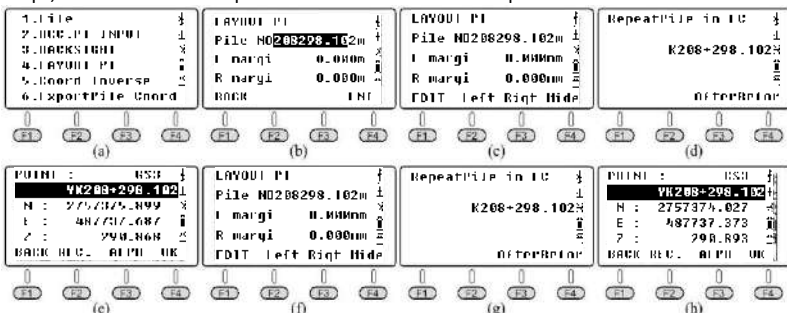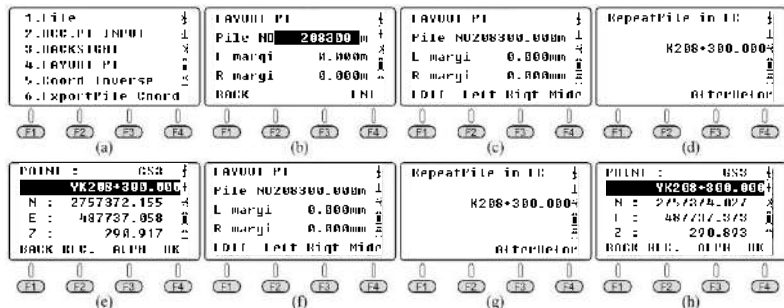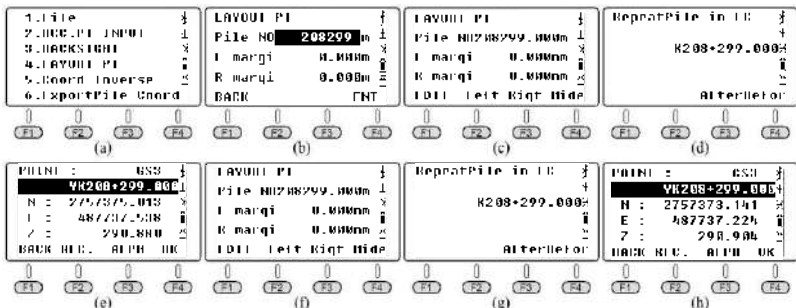
④ Calculate the coordinate of extra pile YK208+298.101

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.

(a)   (b)   (c)   (d)

(e)   (f)   (g)
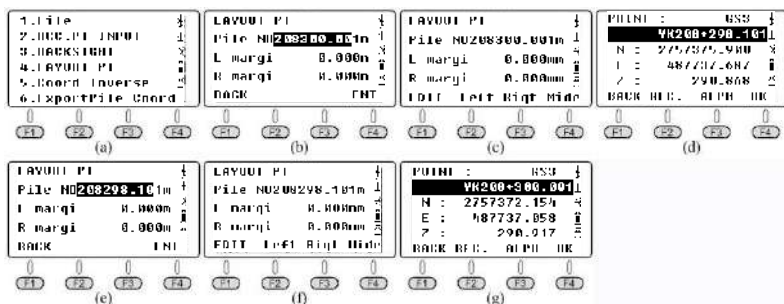
⑤ Calculate the coordinate of extra pile YK208+300.001

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.

6.4.3.7 Inverse calculation

Input the coordinate of P1/P2/P3 to calculate the pile number and the coordinate of it's middle pile.

① Calculate the pile number of P1 based on it's 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 shown 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.

(a)   (b)   (c)   (d)

(e)   (f)   (g)   (h)
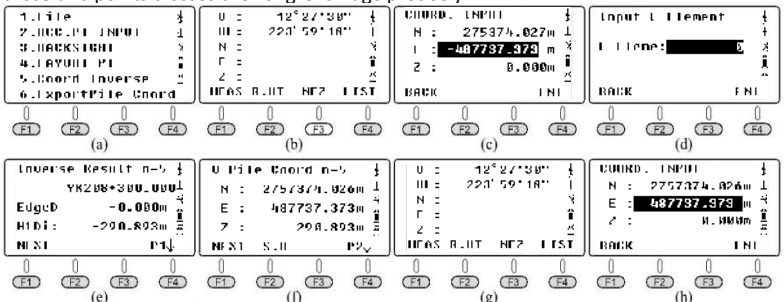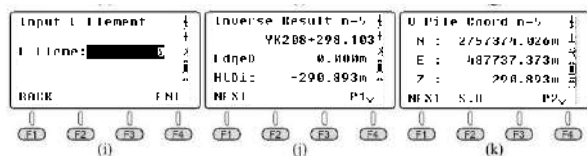
② Calculate the pile number of P2/P3 based on it's coordinate

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).
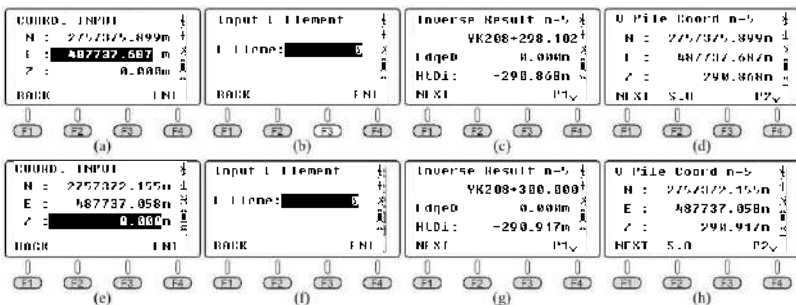
6.5 Case Study - Road in Residence Community

6.5.1 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 (part)

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		
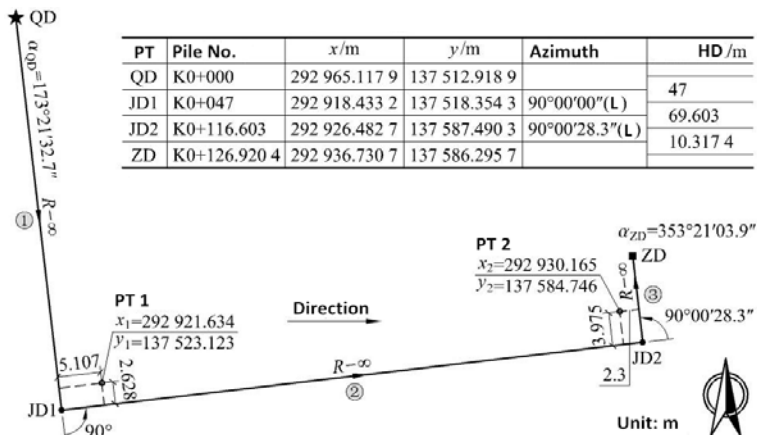
6.5.2 Transfer the Form into Linear Elements

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"

6.5.3 How to Use N6 to Calculate the Road

6.5.3.1 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), (ENT) **ENT** to confirm and back to the file list.Move the cursor to line JD60 (pic g), press (F4) to set (pic h).

(a) screen:
1.RIM
2.MI N
3.2 COORDINATE
4.AREA
5.POINT TO LINE
6.Roads

(b) screen:
1.File
2.OCC.PT INPUT
3.BACKSIGHT
4.LAYOUT PT
5.Coord Inverse
6.ExportPile Coord

(c) screen:
1.SELECT A FILE
2.Input H Curve
3.Input V Curve
4.InputRepturePile
5.Cal MainPt Data
6.SELECT SO.FILE

(d) screen:
Road File
FILE   :   JD6B
BACK LIST   NUM   ENT

(e) screen:
JD6B
BD910
180109_1
JD17
New   Delete

(f) screen:
New File
FILE : 180115_1
BACK   NUM   ENT

(g) screen:
180115_1
JD6B
BD910
180109_1
JD17
New   Delete

(h) screen:
1.SELECT A FILE
2.Input H Curve
3.Input V Curve
4.InputRepturePile
5.Cal MainPt Data
6.SELECT SO.FILE

6.5.3.2 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).
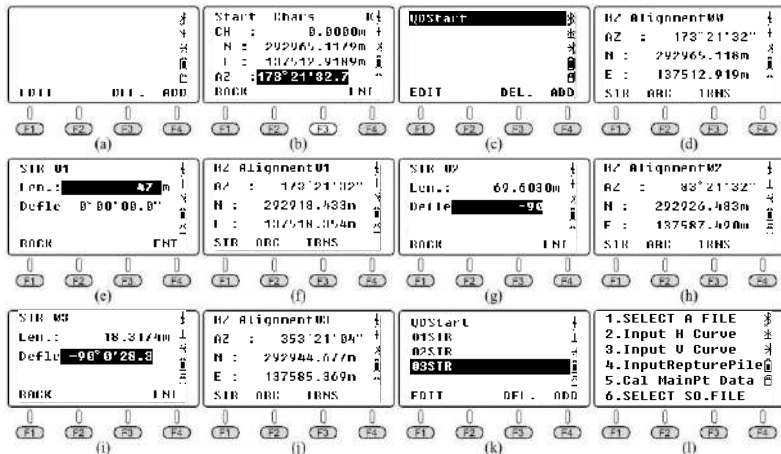
(2) Input the value of linear elements

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).

(a) screen:
Start Chars
CH :   0.0000m
N : 292965.1179m
E : 137512.9189m
AZ : 178°21'32.7
EDIT   DEL.   ADD

(b) screen:
QDStart

EDIT   DEL.   ADD

(c) screen:
QDStart

EDIT   DEL.   ADD

(d) screen:
HZ AlignmentQD
AZ :   173°21'32"
N :   292965.118m
E :   137512.919m
STR   ARC   TRNS

(e) screen:
STR Q1
Len.:   47 m
Defle   0°00'08.8"
BACK   ENT

(f) screen:
HZ AlignmentQ1
AZ :   173°21'32"
N :   292918.433m
E :   137591.354m
STR   ARC   TRNS

(g) screen:
STR Q2
Len.:   69.6030m
Defle   -90
BACK   ENT

(h) screen:
HZ AlignmentQ2
AZ :   83°21'32"
N :   292926.483m
E :   137587.490m
STR   ARC   TRNS

(i) screen:
STR Q3
Len.:   18.3174m
Defle -90°0'28.3
BACK   ENT

(j) screen:
HZ AlignmentQ3
AZ :   353°21'04"
N :   292944.077m
E :   137585.369m
STR   ARC   TRNS

(k) screen:
QDStart
Q1STR
Q2STR
Q3STR
EDIT   DEL.   ADD

(l) screen:
1.SELECT A FILE
2.Input H Curve
3.Input V Curve
4.InputRepturePile
5.Cal MainPt Data
6.SELECT SO.FILE

*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.*

6.5.3.3 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 shown on the screen (pic a). Press F1 **Last** to check the coordinate one by one (pic b - d).
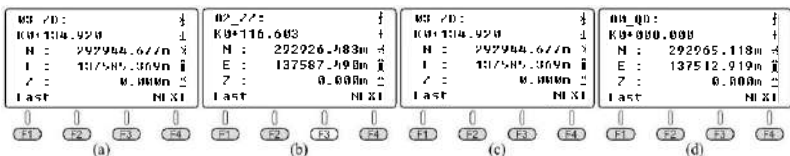
FORM 6-13: The comparison between calculated value and designed value

|	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″

6.5.3.4 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 shown 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).
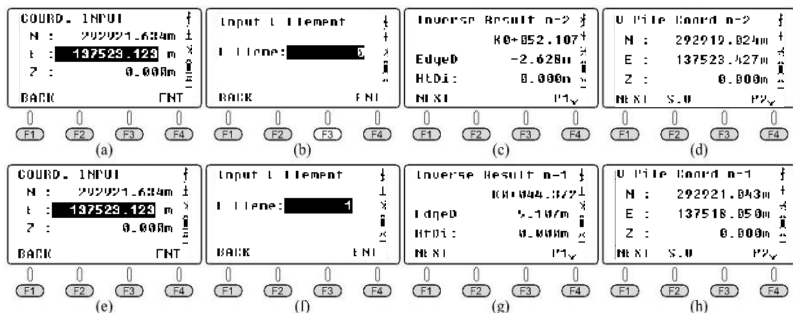

② Inverse calculation of P2

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 shown 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 and F4 **ENT** to calculate (pic o - p). The vertical point of P2 is located on 2nd line, distance -3.975m (pic o).
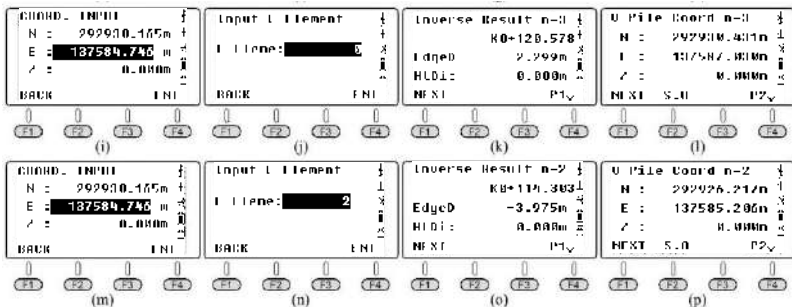
6.6 Case Study - Roads in Tunnel

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	

6.6.1 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).
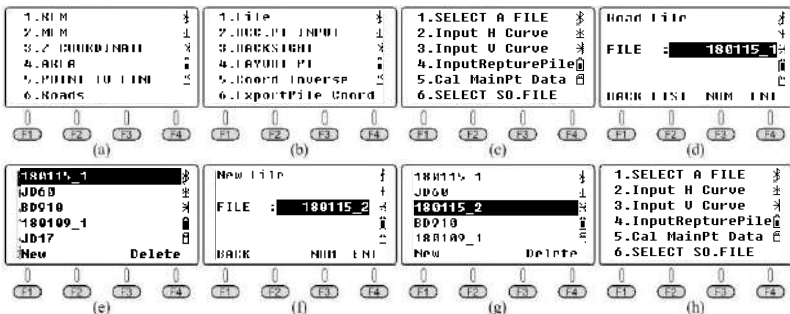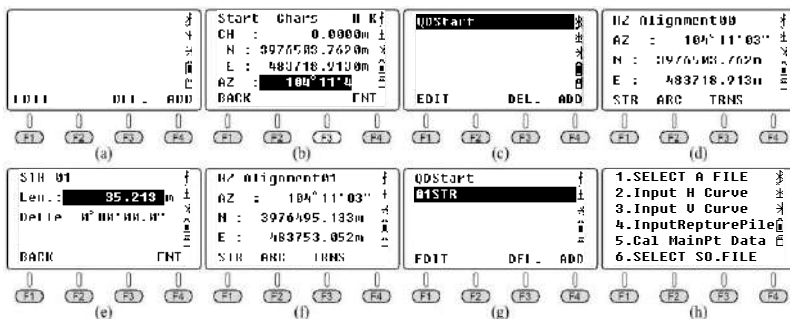

6.6.2 Input the designed value of horizontal curve

(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).


6.6.3 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:

(a)   (b)   (c)

(d)   (e)   (f)
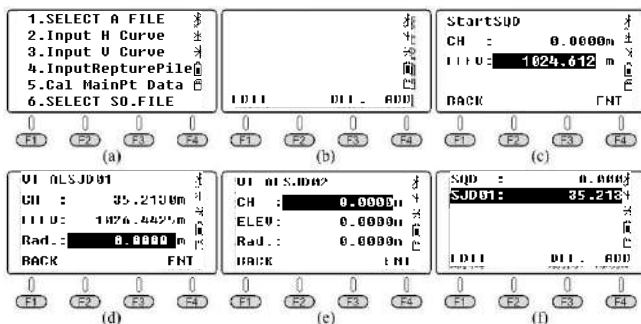
6.6.4 Calculate the data of main points

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).

(a)   (b)   (c)   (d)
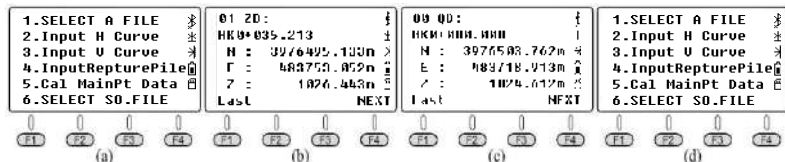
6.6.5 Layout points

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).

(a)   (b)   (c)   (d)