Discussion on the Application of GPS Using in Marine Construction Survey

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***Abstract*— The application of GPS technology using in Marine construction survey was discussed in this paper. The artificial island project in Nantong Yangkou was taken as example in this paper, had introduced the major tasks of positioning in mattresses laying under the water, the specific processes and the problems and solutions to problems which should be paid attention to in the course of job, and introduced about some methods of using GPS in the hull dolosse installment localization and the seabed, the island wall monitoring in detail. And some useful experiences were got about application of GPS technology in Marine construction survey.**

***Keywords*—GPS, soft-body mattresses laying, positioning accuracy, marine monitoring, transverse section**

Nowadays, while surveying and mapping technology, surveying and mapping equipment were continuously developing, the main contents of the marine based on surveying and mapping were also continuously enriched and improved. At the current stage, the main contents of the marine base surveying and mapping includes: Control survey, coast topographic survey, bathymetric survey, submarine topography survey, submarine surface substrate survey, tidal observation, marine gravity measurement, marine magnetic survey, various types of marine charts and atlas compilation, compilation of navigational data, compilation and distribution of notice to mariners, publication and supply of navigational books, etc.

Throughout 60 years of the development of marine surveying and mapping, its operating mode had made a leap from manual to automatic operation. Bathymetric survey was mainly carried out by from using sounding lead manually to the mechanization job using echo depth sounder, and to the mechanization job of bathymetric survey realized by utilizing automatic hydrographic survey system. Coast topographic survey had also realized the survey mode of the combination of aerial photogrammetry, electronic tablet and GPS-RTK.

The advent of GPS measurement technology created a new high-tech method for marine surveying. Since the emergence of GPS technology, the measurement mode realized the leap from points and lines measurements to surface measurements. Bathymetry developed from point by point to line by line, with the emergence of multibeam bathymetric system, then to be face by face, which improved the working efficiency and the density of bathymetry significantly. At the same time, the data acquisition has realized the leap from the simulation to the digit. The information acquisition trends to real-time datum and Standardization, the information acquisition platform trends multiplication, the information management and the use trend standardization, the digit information product trend diversification. GPS technology has made rapid development; D-GPS technology, WAD-GPS technology, Precise Point Positioning, satellite difference GPS technology, Real-Time Kinematic (SRTK) technology and CORS technology are widely used in control survey and marine localization.

This article discussed the application of GPS technology positioning in mattresses lying under the water of marine navigational matters project and hull dolosse installment localization and the seabed, the island wall monitoring. This researching content belongs to the domain of marine survey.

I. SURVEY OF THE PROJECT

Yangkou Port artificial island project in Nantong Port is located in the west sun sandbar of Rudong beach shoal, Nantong City, Jiangsu Province, which lies to 32 kilometers west from Xiaoyangkou Port, 50 kilometers southeast from Lvsi Port, and the geographic location of which lies to 32°32′50″north latitude, 121°25′35″east longitude, and 13 kilometers away from the nearest land coastline. Artificial island project is the most important component of Nantong Port Yangkou Port system

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projects which includes Area Waterways, Pierhead Trestle, Artificial Island, and Continental Island Channel. Artificial island is located in the beach of the west sun sandbar with the elevation of -2.5 ~ +4.0 meters, the coastal sedimentary environments is greatly influenced by tides, sandy soil and cohesive soil alternated with the depositions metrically, of which the northeast wind has the most influence on the project . Design water level is +6.89 meters, low water level is +0.81 meters, the extreme high water level is +9.00 meters, and the extreme low water level is -0.25 meters.

This project needed total length of 4688.458 meters mileage to protect the bottom, of which needs length of 2458.717 meters to let the large-scale ships carry out submarine laying, the width of soft-body mattresses used to protect the bottom ranges between 75 and 125 meters with the change of underwater topography elevation. The armor stone amounts to 81847, including 6t dolosses 43875, 4t dolosses 7053, 4t Wang dolosses 6084 and 3t Wang dolosses 24835. And 9 monitor cross sections had been built to this project artificial seabed, each section length was 150m; Section monitoring was set on the island wall at intervals of 50m after the project formation.

II. SOFT-BODY MATTRESSES LAYING UNDER THE MARINE WATER

A. Preparations for construction

Configuration of measuring equipments:

Two Hi-Target HD-5GPS dual frequency receivers, two UHF cables, each of which is 20 meters, and each GPS cable is 30 meters.

One desktop computer, one 500w UPS, one D.C. regulated power supply (12V-13V), one Hi-Target construction localization software package.

GPS-RTK positioning accuracy: Plane ± (10mm+1ppm), elevation ± (20mm+1ppm).

Setting of ship –type Parameters:

After the GPS antenna arrangement finishes, ship –type parameters of layout-ship needs to be measured. First a hull coordinate system needs to be established, as shown in Fig.3-10, The plane datum's x axis of the hull coordinate system points to the bow, origin is located in the rear of the hull, y axis points to ship port. the total station is used to measure the main operating point, the auxiliary operating point and the coordinate of GPS1, GPS2 antenna position under the hull coordinate system's coordinate (main, auxiliary operating point are the characteristic points that we defines to control construction), their coordinate are as follows (unit m):

GPS1 (X=13.440m, Y=-7.592m)

GPS2 (X=13.515m, Y=8.492m)

The main operating point: X=18.830m, Y=-17.277m;

The auxiliary operating point: X=59.445m, Y=-17.277m

Of which, the hull independent coordinate system as shown in Figure 1:

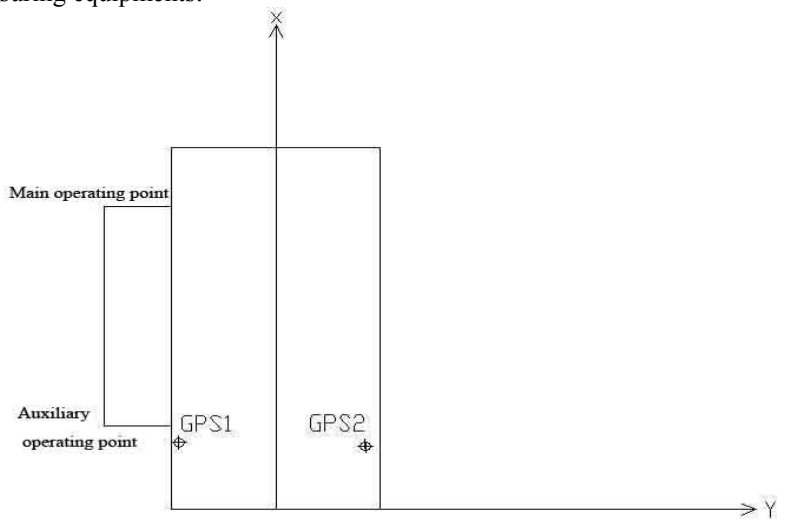

Figure 1. The independent coordinate system of Geotextiles-laying boats

What needs to be paid attention to: The main operating point, the auxiliary operating point's coordinate is surveyed when the slide is horizontal, while under construction, for the convenience of mattress sliding, there is an angle between the slide and the deck plane (generally about 40 degrees). Therefore, when ship–type parameters is set, the main operating point, the auxiliary operating point's coordinates needs to calculate according to the slide's actual angle when construction was on.

Parameters setting of survey construction software:

While using Hi-Target construction localization software, various parameters must be set correctly before the work, so that the software can function correctly. The concrete setting method is as follows:

(1) Control parameters

1) Setting of horizontal coordinates: Choose "Xi'an Geodetic Coordinate System 1980"

2) Setting of central meridian longitude: 121°22 ' 00"

3) Setting of transformation parameter: Input calculated 7 parameters

(2) Project parameters

1) Axis file: There are two methods used to set axis

file, one is to input by the coordinate of characteristic points, the other is to draw with CAD, then, import them to the software. The latter method is often used when construction carries out.

2) Mattress file: to import each parameter of mattress to the software.

(3) Setting of ship –type Parameters: to import the measured ship-type parameters to the software.

(4) Other setting

1) setting of GPS receiver: GPS receiver's serial number and baud rate needs to be set.

2) record setting: to set the recording mode in course of mattresses laying, this project records one time each 5 meters.

3) setting of the record limitation: RTK fixed solution.

B. The main steps of implementing the measurement

(1) The installment of GPS antenna

The arrangement of GPS antenna and the UHF antenna is an important work, the position that it arranges immediately influences working state and working quality of GPS.

The principle of antenna arrangement is: The GPS antenna should avoid the obstacle as far as possible, no object will influence it in range of 15 degree elevation angle. The antenna's position needs to reach a certain altitude, so that it can reduce the influence of multipath effect and the construction.

For the purpose of making certain of positioning accuracy, the farther intervals of two GPS antennas are, the better they will be, but because of the influence of factors, which includes construction, the antenna height, the obstacle, the cable length, the differential signal receiving and so on, the GPS antenna's installment position gets a certain limit .The GPS antennas will be installed on both sides of stern after choosing carefully and an overall consideration.

(2) The matching of GPS

After completing all settings, before carrying out the construction, the construction localization software needs to be matched. This is an integration test about the setting of ship-type parameters and seven parameters, and it is a quite important step. Its method is as follows:

Using knapsack GPS to survey the coordinate of main, auxiliary is operating points, at the same time, using the construction localization software to survey the coordinate of main, auxiliary operating points. Making sure that double measurements go hand in hand with it, otherwise, it will have a bigger error. As long as controlling the planimetric position of soft-body mattresses when geotextiles laying is on, so it does not need to match the elevation.

Calculating the difference value of the double measurements, the construction localization can be carried out when the differential value is shorter than 15cm (The criterion prescribes that the allowance error of geotextiles laying is 50cm).

The record of matching needs inspection application. In order to guarantee the accuracy of geotextiles laying, knapsack GPS should be used to match when just starts to pave the first mattress.

(3) The methods and steps of implementing the measurement

Using the function of GPS-RTK, real-time gathering a group of GPS coordinate through software each 1s, according to the mutual position relations between two GPS points and main, auxiliary operating points, real-time figuring out main, auxiliary operating points coordinate, mileage, deflection distance, etc. By comparing with the theoretical value, real-time displaying its differential value on the computer interface, the captain directs geotextiles-laying boats to take place according to deviation value displayed on the software, so that mattresses can be laid correctly in the designed position.

1) Running the software, building the connection with GPS. On the computer screen will it demonstrate the axes position plan of the entire region which needs to be geotextiles laid as shown in Figure 2.

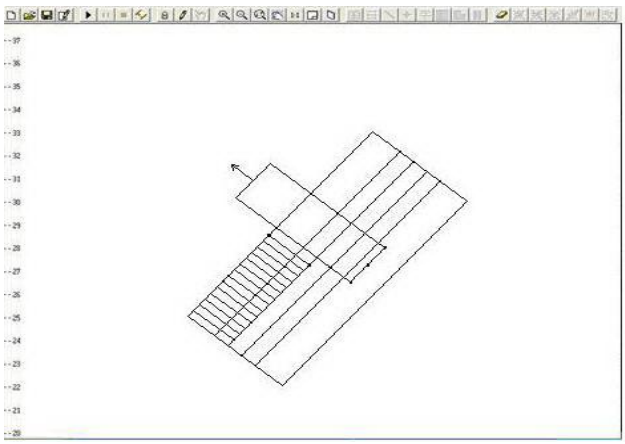

Figure 2. The interface chart of software layout software

2) Using " Ctrl+ mouse" to choose the axes which needs to be geotextiles laid, starting the project, inputting each parameter of mattress. Then software real-time displays the information of differential value between

various datum of the current mattress position and academic mattress datum on the screen of computer and so on. The captain makes the centre line of slide coincide with the centre line of academic mattress ,by using stranded cable to adjust hull position ,according to the information real-time displayed.

3) After everything is ready, geotextiles laying can be carried out when the condition of GPS achieves "the fixed narrow distance solution".

4) In the process of construction, GPS stays turned on all the time, which real-time monitor position of mattresses, if situations like deviation and so on is discovered, stranded cable adjustment should be carried out in time, thus guarantees that mattresses are laid according to the design requirements.

5) After mattresses finishes being laid, data recording will be stopped. Detecting the laid mattresses with knapsack GPS, and through stranded cable to move the ship. Detecting the real position of the four corners of mattress , both sides of the centre line of embankment mattress, the interlocking block mattress and the gravel helping mattresswhen geotextiles laying is on, if the detection is qualified, namely single sheet of mattress finish being laid.

6) Confirming academic build press width and figuring out academic number of center stake of next sheet of mattress according to real position (the most disadvantageous position)of this sheet of laid mattress and transverse shrinkage range of shelter. Importing them into construction localization software to produce the region which needs to be geotextiles laid. Its flowchart of operating process is roughly shown in Figure 3.

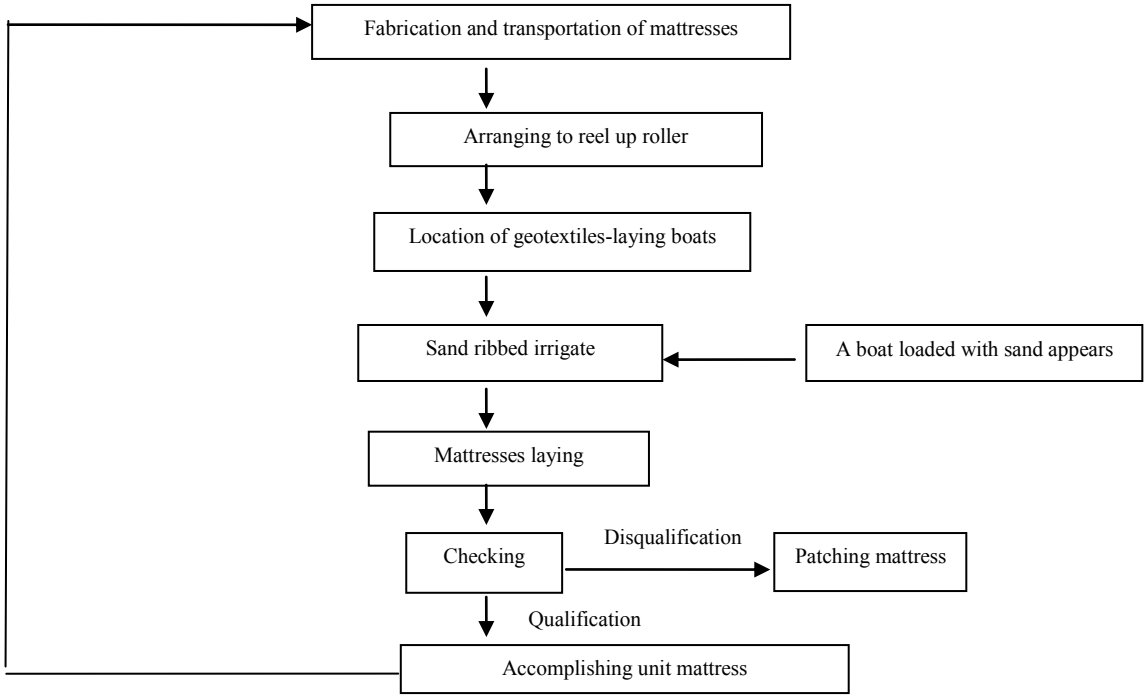

Figure 3. Flowchart of operating process of mattresses

Soft-body mattresses laying under the marine water of this project starts on March 13, 2009, ends completely on June 13, 2009, using non-tidal survey method and the sounding survey method to detect mattress, discovering that the situation of the mattress is good, which meets the requirement specifications, showing that this construction control method is successful.

III. DOLOOSE INSTALLMENT LOCALIZATION

A. The configuration of Measurement equipment

A Hi-Target HD-5 GPS dual-frequency receiver;

A UHF electric cable and a 50-meter-long GPS electric cable;

A desktop computer;

A set of Hi-Target marine surveying software;

With, GPS-RTK positioning accuracy: Plane: ± (10mm +1 ppm), elevation: ± (20mm +1 ppm).

B. Preparation of construction

The project armor stones installed by the dike body thickness and process requirements, would be placed in 3-layer. First layer for design bottom elevation ~ + 4.0 m, second was + 4.0 m ~ + 9.0 m, third was + 9.0 m ~ design top elevation of surface (above water surface part). After each breaker strip slope qualified, carry on the armor stone installment promptly.

The armor stones were placed in district according to the floating crane and the crane hoisting capacity. Before the placement, put blocks as much as possible in order to reduce the localization number of times and raise the imposition efficiency. It was also advantageous for the block installation management [4].

(1) Installing plan drawn

According to design requirements, the dolosses were placed by fixed rules, Wang dolosses were placed stochastically using fixed-point and the specific placement parameters were calculated as follows:

Horizontal distance Eq.1:

$$\alpha = \frac{10}{\sqrt{\frac{N}{2}}} \quad (1)$$

The slope (vertical axis) direction distance Eq.2:

$$b = \alpha \bullet \frac{m}{\sqrt{m^2 + 1}} \quad (2)$$

In Eq:

N---- The number of blocks per $100m^2$, determined by design

m---- Gradient of slope 1: m

According to the design requirements, 6t dolosse N=51, 4t to dolosse N=60.5, 4t Wang dolosse N=47, 3t Wang dolosse N=57. Besides the berm part, the slope of this project was 1:2 ratio, namely m = 2.

Substitutes the above formula computation with the N, m value to obtain the installation space:

6t dolosse α=1.980m， b=1.771m

4t dolosse α=1.818m， b=1.626m

4t Wang dolosse α=2.063m， b=1.845m

3t Wang dolosse α=1.873m， b=1.675m

Note: in the part of berm b=α

Based on the above calculated installation space, the horizontal installation plan was drown with CAD. Figure 4 was as follows:

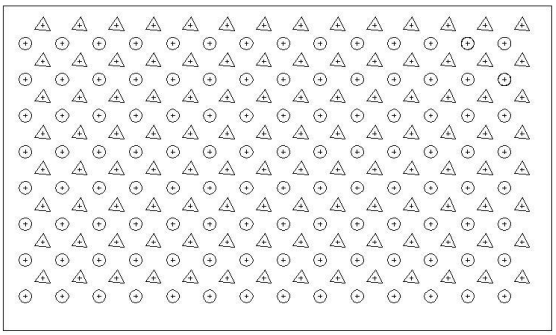

Figure 4. The interface chart of software layout software

For the easily operation, different symbols were used to stand for different layers. After the horizontal installation plan was completed, guiding the segmented into the marine surveying software installation file, save for segmented to assignments.

(2) The arrangement of GPS antenna

Installing a foundation on the top of the pole in the crane ship to make it above the crane hook, placing the GPS antenna on the foundation, so that GPS antenna and hook were at the same vertical line, putting the GPS cable wire in the crane cab to connect GPS receiver, placing the desktop in the crane cab, the display monitor was arranged in front of the crane driver, so it was advantageous for the crane driver's operation. The crane GPS installation plan was shown as Figure 5.

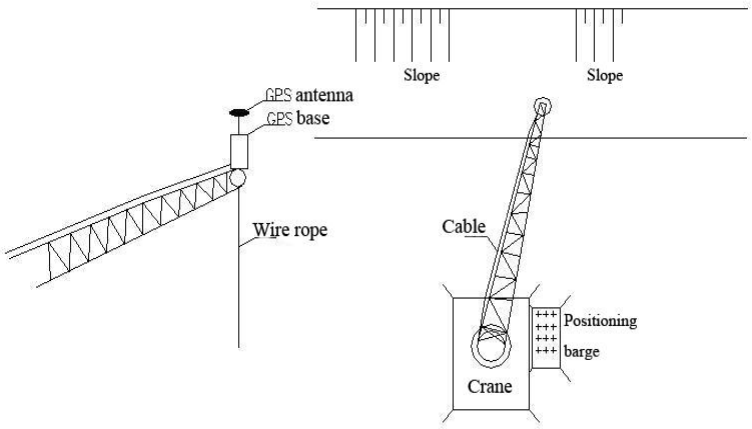

Figure 5. GPS assisting Crane Install schematic

(3) Installation location measurement

Before the construction, the marine surveying

software was modified to add the “point navigation” function by the Hi-Target company according to the custom’s requirements.

Before the operation, set each parameter correctly and check each one with the GPS backpack. After the parameters were qualified, start the work for blocks’ installation location. When work, use the software’s “point navigation” function with "Shift + mouse" to select to install the armor in the center, the software contact surface would display real-time datum that the difference and azimuth difference of the armor’s center position between actual and designed position. According to the real-time difference and azimuth difference, driver moves the pole to the design position, and then relaxes hook. At the same time surveyors record the point coordinates.

The marine surveying software has two types to record coordinate--“automatically” and “manual” two ways: the record was set to manual mode when in the armor block installation process. Just press the space bar, the installed blocks’ plane coordinates would be recorded and their symbols would be drawn. So during the next installation, blocks could be recognized easily and it helps to prevent loss or false installation.

IV. SECTION MONITORING

During the construction of the project, we should monitor the seabed and island wall when there is any influential typhoon or wind above 8 levels.

C. Seabed monitoring

Nine monitor sections were built to the artificial project seabed according to client's requirement, each section length was 150m, measure the water depth using the GPS-RTK positioning technology. After the survey finished, produce the sectional drawing with before and after the wind measured elevation data, superimpose the cross section diagram and do the erosion analysis according to Figure 6. Then writing a report and give it to supervisor with the cross section diagram.

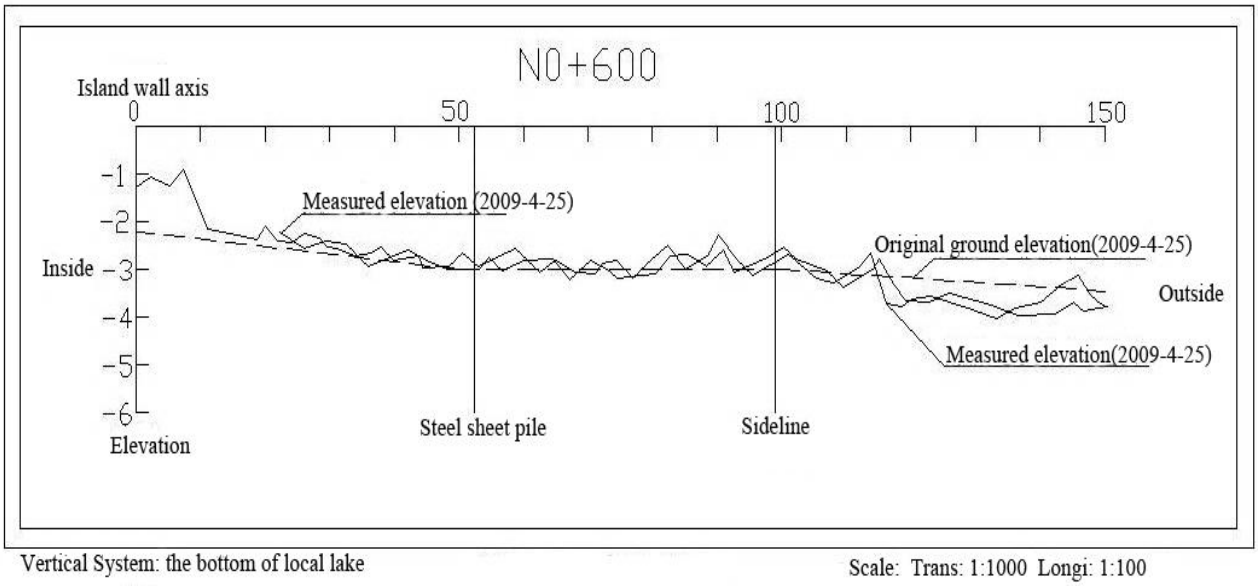

Figure 6. Seabed superposition sectional drawing

D. Island wall monitoring

In typhoon period, for project security, building an observation cross section along spool thread with an interval of 50m after island wall water leakage forming, do the monitor before and after the wind.

First the handbook was used to calculate the cross section, when ebb tide, carry on the data acquisition using GPS backpack, every other 1-2m gathers a spot. Then, with the software production section diagram, superimpose the sectional drawing, carry on the analysis according to the superimposition section diagram and use it to guide further construction. The superimposition cross section is shown in Fig.7.

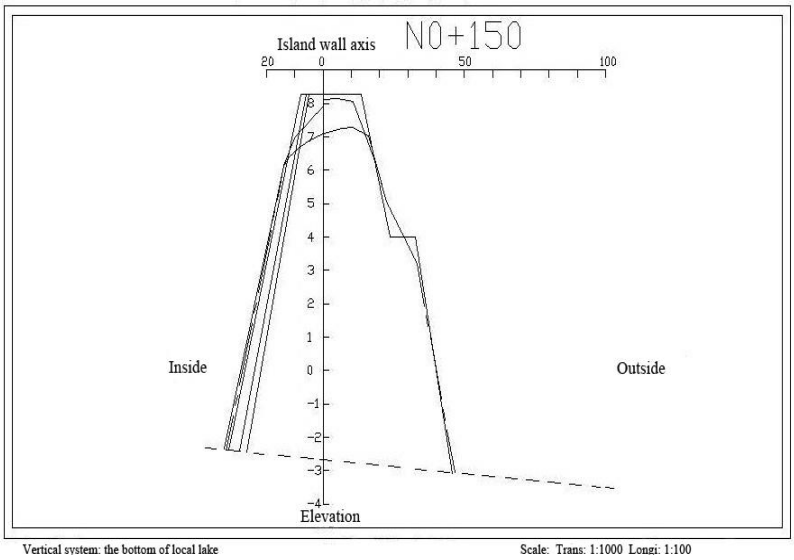

Figure 7. The sea wall superposition sectional drawing

According to the section diagram, calculate the difference value before and after the wind, as the basis for the claim.

V. SUMMARY

Through the example of the artificial island project in Nantong Yangkou, this paper analyzed and studied viability of the application of GPS technology in mattresses laying under the water of marine navigational matters project and the hull dolosse installment localization and the seabed, the island wall monitoring. According to experiment data, obtained some work experiences, concrete contents were as follows:

(1) The double check works of GPS points

In the process of this work, surveying the main, auxiliary operating point with the marine positioning software, double surveys needed to go hand in hand with each other to the utmost, otherwise, the error was bigger.

(2) The choice of GPS antenna's position

For the purpose of making certain of positioning accuracy, the farther intervals of two GPS antennas were, the better they would be, but because of the influence of factors, included construction, the antenna height, the obstacle, the cable length, the differential signal receiving and so on, the GPS antenna's installment position got a certain limit .The GPS antennas would be installed on one side of the boat after choosing carefully and an overall consideration.

(3) The inspection of soft-body layout

The inspection work was very important before each unit mattress finishes being laid, which concerns all the mattresses laying, and which will affect the entire layout of mattresses, so make sure that each unit mattress would be inspected by GPS.

(4) During the working, selecting the installation blocks' central point as far as possible, in order to reduced the error.

(5) Install blocks strictly according to the location on the horizontal plan. Pay attention to the installed symbols to avoid loss or false installation.

(6) As a result of the GPS signal attenuation's reason, the GPS ties could not surpass 50m, otherwise, the GPS signal could not be locked, so pay attention when installing the crane hook and the length of pole cannot surpass 50m.

(7) During the section monitoring, the survey achievement was good when the wave is smaller than 0.6m, and the error could definitely satisfy the specification. Therefore, start surveying in good weather.

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