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Specifications for construction of Co-located GNSS continuously operating reference stations and tide gauge stations

全球导航卫星系统（GNSS）连续运行基准站与验潮站并置建设规范

(*English Translation*)

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Contents

Foreword

SAC/TC 283 is in charge of this English translation. In case of any doubt about the contents of English translation, the Chinese original shall be considered authoritative.

This standard is drafted in accordance with the rules given in the GB/T 1.1-2009 *Directives for standardization-Part 1: Structure and drafting of standards*.

This standard was proposed by Ministry of Nature Resources of the People's Republic of China.

This standard was prepared by National Technical Committee 283 on Ocean of Standardization Administration of China, Sub Committee 5 on Marine Engineering Investigation and Geomatics （SAC/TC283/SC5）.

Specifications for construction of Co-located GNSS continuously operating reference stations and tide gauge stations

1 Scope

This standard specifies general requirements, design, site selection, infrastructure, equipment and installation, and facility maintenance of construction of co-located GNSS continuously operating reference stations and tide gauge stations.

This standard is applicable to the construction of co-located GNSS continuously operating reference stations and tide gauge stations.

2 Normative Reference Documents

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

—GB50057-2010 *Design code for protection of Structures against lighting*

—GB12897-2006 *Specifications for the first and second order leveling*

—GB/T14914-2018 *The Specification for offshore observation*

—GB/T28588-2012 *Specifications for the continuously operating reference station using global navigation satellite system*

—CH/T2011-2012 *Specifications for the operation and maintenance of continuously operating reference stations using global navigation satellite system*

3 Terms, Definitions and Abbreviations

3.1 Terms and Definitions

For the purposes of this document, the following terms and definitions apply.

3.1.1 Global Navigation Satellite System (GNSS)

space-based radio positioning system adopted artificial satellites for determination of positions and times of observing sites

Note: mainly including GPS, GLONASS, GALILEO, BDS

3.1.2 GNSS receiver

the device that receives GNSS satellite signals

3.1.3 GNSS continuously operating reference station (CORS)

the station that receives GNSS satellite signals for continuous observation

3.1.4 leveling network for tidal observation

local leveling network used for detecting the change of tidal datum and maintaining vertical datum of the tidal observation shall be leveled in conjunction with the national first or second order leveling network not lower than the second order leveling accuracy.

3.1.5 island-style tide gauge well

island-style tide gauge well built with tidal observation equipment, fixed by brackets and placed in the sea to observe tidal variation.

Note: The tide gauge well may be installed in two ways: to be put on the seafloor or suspended in the water according to water depth.

3.1.6 shore-side tide gauge well

shore-side tide gauge well built on the shore, connected to the sea through water delivery pipelines and used for tidal observation.

3.1.7 height datum

the elevation of leveling origin and its starting reference surface ,determined by tide gauge data.

3.1.8 co-located station

GNSS CORS and tidal gauge station that operates associatedly and synchronously.

3.2 Abbreviations

For the purposes of this document, the following abbreviations apply.

BeiDou Navigation Satellite System (BDS)

China Geodetic Coordinate System 2000 (CGCS2000)

Galileo Navigation Satellite System (GALILEO)

Global Navigation Satellite System (GLONASS)

Global Positioning System (GPS)

Coordinated Universal Time (UTC)

4 General Requirements

4.1 Required functions

4.1.1 functions of GNSS and tidal observation.

4.1.2 connection measurement of leveling network, including check benchmarks among GNSS CORS, tide gauge, and higher order benchmark in the network.

4.1.3 observation of the vertical movement of the crust in a global geodetic reference frame and observation of sea level relative to the sea level under geodetic datum.

4.1.3 observation of meteorological parameters such as atmospheric pressure, temperature and humidity.

4.2 Site selection requirements

4.2.1 GNSS CORS and tide gauge stations shall be built next to each other within a distance less than 1 km and located in the same geological block body.

4.2.2 Connection leveling of no less than the second order leveling accuracy between GNSS CORS and tide gauge station. The benchmarks shall be conveniently accessible.

4.3 Observation elements

4.3.1 Elements observed at CORS station: GNSS signals (including time, carrier phase, pseudorange, Doppler shift, signal-to-noise ratio, broadcast ephemeris), atmospheric pressure, temperature, humidity and so on. The format of data recording and storage shall be in accordance with the requirements of GB/T 28588-2012, 7.5.4.

4.3.2 Elements observed at tide gauge station: Observing tidal height and its corresponding time. The format of data recording and storage should be referred to Annex C to GB/T14914-2018.

4.4 Coordinate system and time system

4.4.1 Co-located stations adopt national Geodetic Coordinate System and National Elevation Datum.

Both the local tidal height datum and the National Elevation Datum are adopted for tidal observation equipment.

4.4.2 UTC shall be adopted for co-located stations.

4.5 Technical indexes

4.5.1 The tide gauge station shall use automatic tide gauges to make continuous observation. The water level data shall be sampled every 3s. The mean value of sample data shall be calculated every 1 min. The 1 min mean value before each hour represents the tide height of the hour. The maximum permissible error of tide level measurement is ± 1 cm, and the maximum permissible error of tide time measurement is ± 1 min.

4.5.2 The GNSS receiver shall receive all in view, multi-mode, multi-frequency and multi-code satellite signals. Choke ring antenna shall be used. The data sampling interval is 15s. The satellite elevation cut-off angle is ≥10°. The annual average accuracy of each component of station coordinates is ≤ 0.5 mm. The accuracy of the coordinate velocity field is ≤ 2 mm/ year (horizontal), and 5 mm/ year (vertical).

4.5.3 The accuracy of atmospheric pressure measurement should be ≤0.1hPa; the accuracy of temperature measurement should be ≤0.5 ℃; and the accuracy of humidity measurement should be ≤1%.

4.5.4 The accuracy of leveling should be higher than that of second order leveling specified in GB/T 12897-2006.

5 Design and site selection

5.1 Design

5.1.1 Review topographic maps, geological structure maps, sea charts, historical tidal data, traffic maps, and other information to gain a detailed understanding of the geological structure, hydrology, meteorology, sea ice, transportation, material supply, power supply, and communication conditions. Preliminarily data shall be collected for the determination of the location of co-located stations.

5.1.2 Select the type of tide gauge well and design its structure according to the shoreline, geological structure, hydrology, and other conditions of the site.

5.1.3 Provide the construction plan for an observation room; design the observation room structure and equipment layout; draw up the structure and layout map.

5.1.4 Select the type of GNSS observation pier and its location in light of the observation room construction plan.

5.1.5 Design the leveling network structure and initial position of the benchmarks.

5.1.6 Draw up the design draft of observation facilities and prepare the design report.

5.2 Site selection

5.2.1 Site selection of tidal gauge station

The location of the tide gauge station shall comply with the following requirements:

a) The sea regions connecting unimpededly with the open sea, having smooth flow and not being easily affected by siltation and waves shall be selected.

b) Coasts that are severely washed, susceptible to collapse, or into which a large river or drainage system flow shall be avoided.

c) Any plan for engineering project nearby should be carefully investigated to see if the project

affect the operation of the tide gauge.

d) The water depth is ≥ 1 m at the lowest tide.

e) Marine structures including breakwaters, wharves, trestles should be fully considered in site selection.

5.2.2 Site selection of GNSS CORS

The locations of the GNSS CORS shall comply with the following requirements:

a) No obstacle above 10° of elevation of the GNSS CORS. In special cases, the obstacles below 30° of elevation of the station may be allowed. The sum of horizontal view angle of the station shall be ≥ 270°.

b) The GNSS CORS shall not be located in the pass of a directional microwave communication channel. In addition, the distances between GNSS CORS and microwave stations, radio transmitting stations, high voltage lines or other electromagnetic interference areas shall be ≥ 200 m.

c) A test of GNSS observation shall be carried out continuously for more than 72 hours. The test indicators shall comply with the requirements given in 7.2.1 of GB/T28588-2012.

5.2.3 Co-location Requirements

The site of the co-located station shall comply with the requirements given in 5.2.1 and 5.2.2. In case that the requirements given in 5.2.1 and 5.2.2 cannot be met at the same time, the GNSS CORS and the tide gauge station shall be built separately according to the requirements given in 5.2.1, 5.2.2 and 4.2.

6 Infrastructure

6.1 Tide gauge well

6.1.1 The wellbore of each tide gauge well may be built with reinforced concrete, or with steel or high strength plastic materials. The materials shall be corrosion resistant, sturdy, and durable. The shape of each wellbore is generally round with an inner diameter not smaller than 0.4 m. An inlet opening should be designed for water pipes.

6.1.2 The placement of each tide gauge well shall comply with the following requirements: the wellhead shall be 2 to 3 m higher than the local theoretical highest tidal level, the bottom of well shall be 1 to 1.5 m lower than the theoretical lowest tidal level, and the inlet opening shall be at 0.5 to 1 m below the theoretical lowest tide level.

6.1.3 Any tide gauge well obviously affected by the waves shall be installed with a wave absorber. For any wellbore placed on the seafloor, the wave absorber shall be at 0.5 m above the inlet opening. For any wellbore suspended in the sea, a wave absorber shall be installed on the bottom of the wellbore.

6.1.4 The minimum scale of the staff gauge outside the well shall be 1 cm; accumulative error shall be ≤0.5 cm. The minimum scale of staff gauge inside the well shall be 0.1 cm; accumulative error shall be ≤0.5 cm.

6.2 Observation room

Observation rooms shall be built above each tide gauge well. Tidal observations, leveling, and GNSS observations shall be taken into account in the structural and functional design. The floor area should be no less than 15 m^2, and the interior space height shall be greater than 3.1 m. When tidal observations and GNSS observations cannot comply with the requirements of co-location, the tide and GNSS observation rooms may be built separately according to the requirements given in Annex D of the GB/T14914-2018 for tide gauge and the requirements given in 7.3.3 of GB/T28588-2012 for CORS station.

6.3 GNSS observation pillar

The construction of each GNSS observation pillar shall comply with the requirements given in 7.3.1 of GB/T28588-2012.

6.4 Benchmarks

6.4.1 There shall be at least one fundamental benchmark, one GNSS check benchmark and one tide check benchmark. The fundamental benchmark shall be located on an area with a stable foundation near the co-located station; The GNSS check benchmark shall be set up at the GNSS pillar; The tide check benchmark shall be set up near the tide gauge well.

6.4.2 The site selection and burying of the fundamental benchmark, tide check benchmark, and GNSS check benchmark shall be in accordance with requirements given in 5.2.4 of GB12897-2006.

6.4.3 The fundamental benchmark shall be linked to the national level height system in accordance with the accuracy of national second order leveling as specified in GB/T 12897-2006.

7 Equipment and Installation

7.1 Equipment of co-located station

Each co-located station is mainly provided with tide gauge, GNSS, meteorological, power supply, communication, and lightning protection equipment, as well as computers and cabinets, etc.

7.2 Installation and testing

7.2.1 Instrument testing shall be carried out before the installation of each tide gauge, GNSS equipment, meteorological equipment, and so on. Accordingly, qualification certificates shall be obtained from relevant professional testing institutions.

7.2.2 The installation of each water level gauge, wave absorber, and staff gauge shall be in accordance with the requirements given in Annex E of GB/T14914-2018. The installation of lightning protection equipment shall be in accordance with the requirements given in 4 of GB50057-2010. Other equipment shall be installed according to the instructions or manuals provided by equipment manufacturers, and the related equipment registration forms shall be filled out in detail after the installation.

8 Facility Maintenance

8.1 Maintenance of observation facilities

8.1.1 The maintenance of tidal facilities should include at least the following items: regular inspection of the water level gauge, regular cleaning of the tide gauge well, float system cleaning, inspection of water gauges inside and outside each well and data records. The maintenance shall be carried out with the requirements given in Annex E of GB/T14914-2018.

8.1.2 The maintenance of GNSS observation equipment includes regular inspection of the GNSS receiver and antenna, hardware updates of the GNSS CORS, and inspection of the power supply equipment. The maintenance shall be carried out with the requirements given in 7.1 of CH/T 2011-2012.

8.1.3 The meteorological equipment inspections include the working condition of meteorological equipment, the wearness of cables, and the recording of meteorological data.

8.2 Maintenance of power supply equipment

The maintenance of power supply equipment includes oxidation of terminals, battery leakage, discharge time and battery capacity.

8.3 Maintenance of communication equipment

Communication equipment maintenance includes at least the working condition of each network device, delay time, packet loss checking and network security.

8.4 Lightning protection equipment

The inspection of lightning protection equipment includes the working condition of any lightning protection equipment, loosening and rustiness of grounding connection line, and resistance change of grounding cables.

8.5 Maintenance of elevation datum

The fundamental benchmark, tide check benchmark, and GNSS check benchmark shall be re-measured once a year. If elevations of these points have not changed after two years, the fundamental benchmark shall be re-measured every four years, and the check benchmarks shall be re-measured every two years. The re-measurement of these points shall comply with the requirements given in 7 of GB12897-2006.

9 Archiving

9.1 Paper materials

Paper files shall include:
—Site selection reports;
—Civil engineering contract of site;
—Site design proposal and construction completion report;
—Description of site points;
—Civil engineering design drawings, construction drawings, completion drawings
—Leveling branch, line map, and description of points
—Site construction summary and technical report;
—Equipment registration form;
—Equipment installation and acceptance report.

9.2 Data

Data shall include:
—Raw data from field testing;
—Photographs and videos of site selection, construction process and completion;
—Digital documents including description of points, roadmaps of leveling, technical designs, technical reports;
—GNSS observation data, tide data, leveling data and meteorological data during the testing.