On the Height Datum of Taiwan

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Outline

- Introduction
- The reference tidal station and height origin
- First order levelling network
- Gravity and local geoid model
- The current progress
- Concluding remarks

Introduction

- The vertical dimension of a geodetic system is just as important as the horizontal, and even more complex.
- Height systems:
  - dynamic height,
  - orthometric height,
  - normal height, and
  - geometric height

Introduction -2

- The Department of Land Administration, under Ministry of the Interior, is fully responsible for the definition and maintenance of national surveying datum in Taiwan.
- "Implementation Regulations of Fundamental Surveying" (基本測量實施規則, http://law.moj.gov.tw/LawClass/LawAll.aspx?PCode=D0060096) published on November 15, 2007,

Introduction -3

- In article 7, the vertical geodetic datum applied in Taiwan is officially defined as **TWVD 2001**.
- article 8 regulates the gravity survey
- article 9 regulates the depth datum
- National Land Surveying and Mapping Center (NLSC): regular maintenance of the national fundamental surveying infrastructure, including both horizontal and vertical, physical and geometric.

The reference tidal station and height origin

MOI (2011a):

"The height of Benchmarks in Taiwan adopted orthometric system. And, the height is referenced to the tide dated to **January 1, 1990**, under standard atmospheric condition. This tidal reference value is derived from the tidal observations collected from **1957 to 1991**. This height datum is named Taiwan Vertical Datum 2001, TWVD2001 in abbreviation."

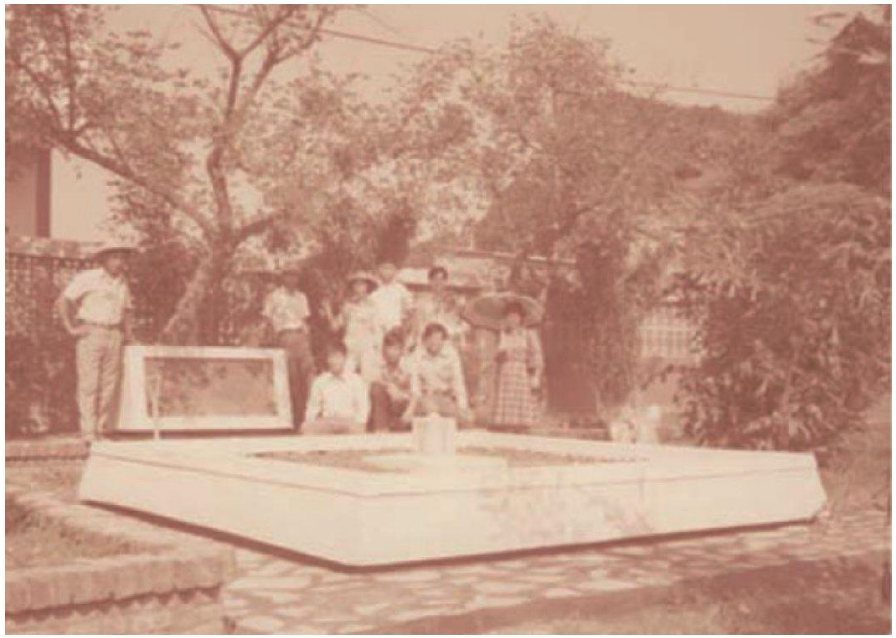
Levelling History

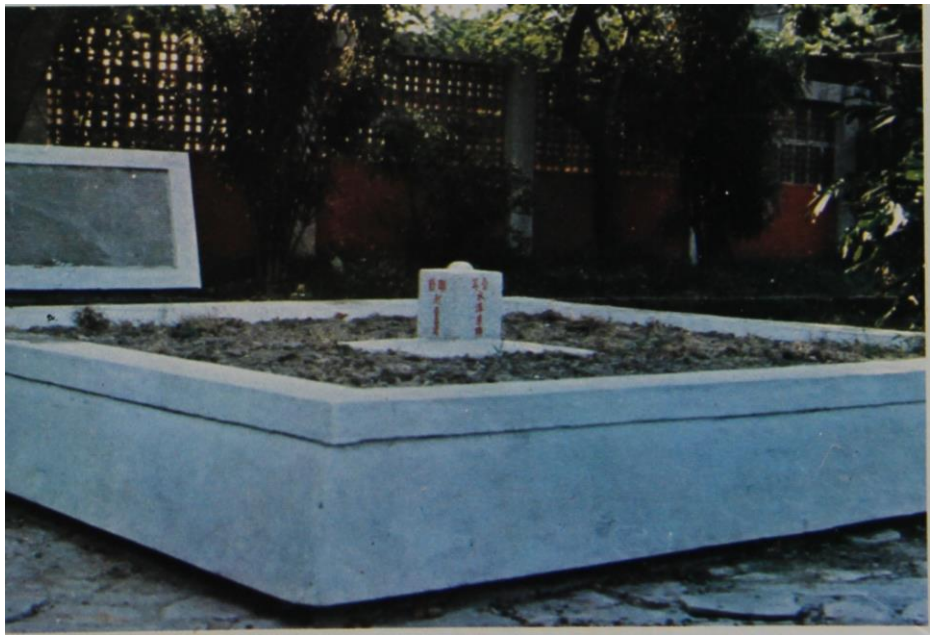
- 1902-1914: Japanese occupation era
- 1975
- 1984
- 2001-2003

1902

臨時臺灣總督府工事部基隆出張所社寮島驗潮所

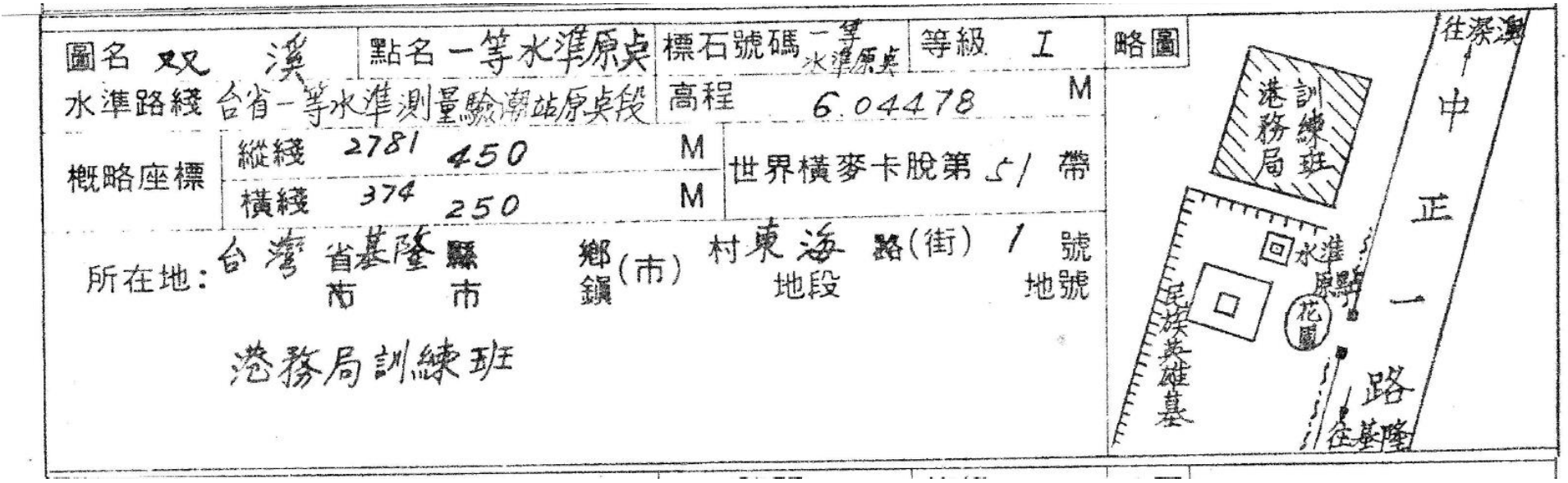
(Photo archived in the library of National Taiwan University, digital image provided by MOI)





1977

The Keelung First Order Levelling Origin, 1977
(Provided by MOI)

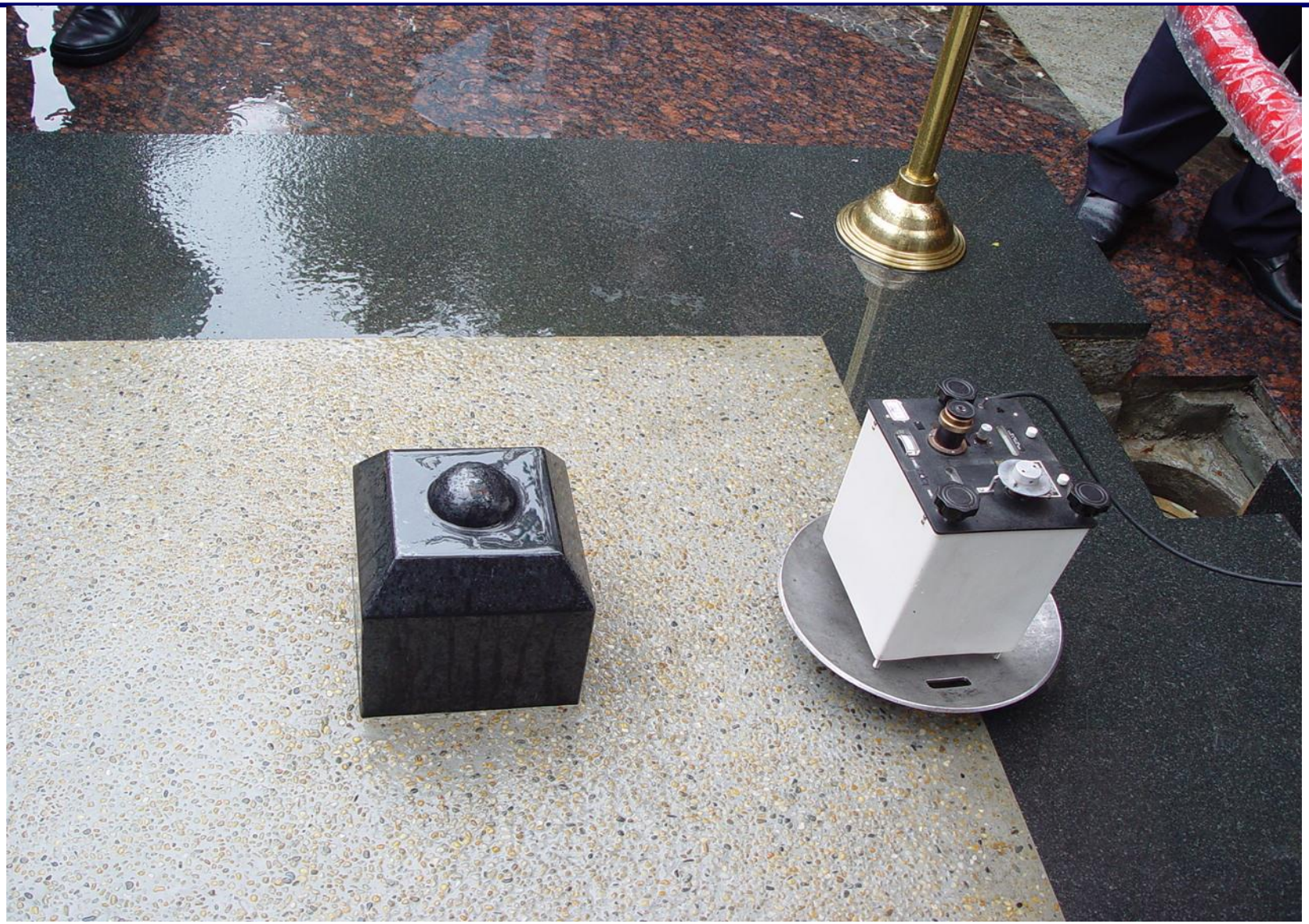


Height published in 1979 in the amendment of 1977 National Levelling Report

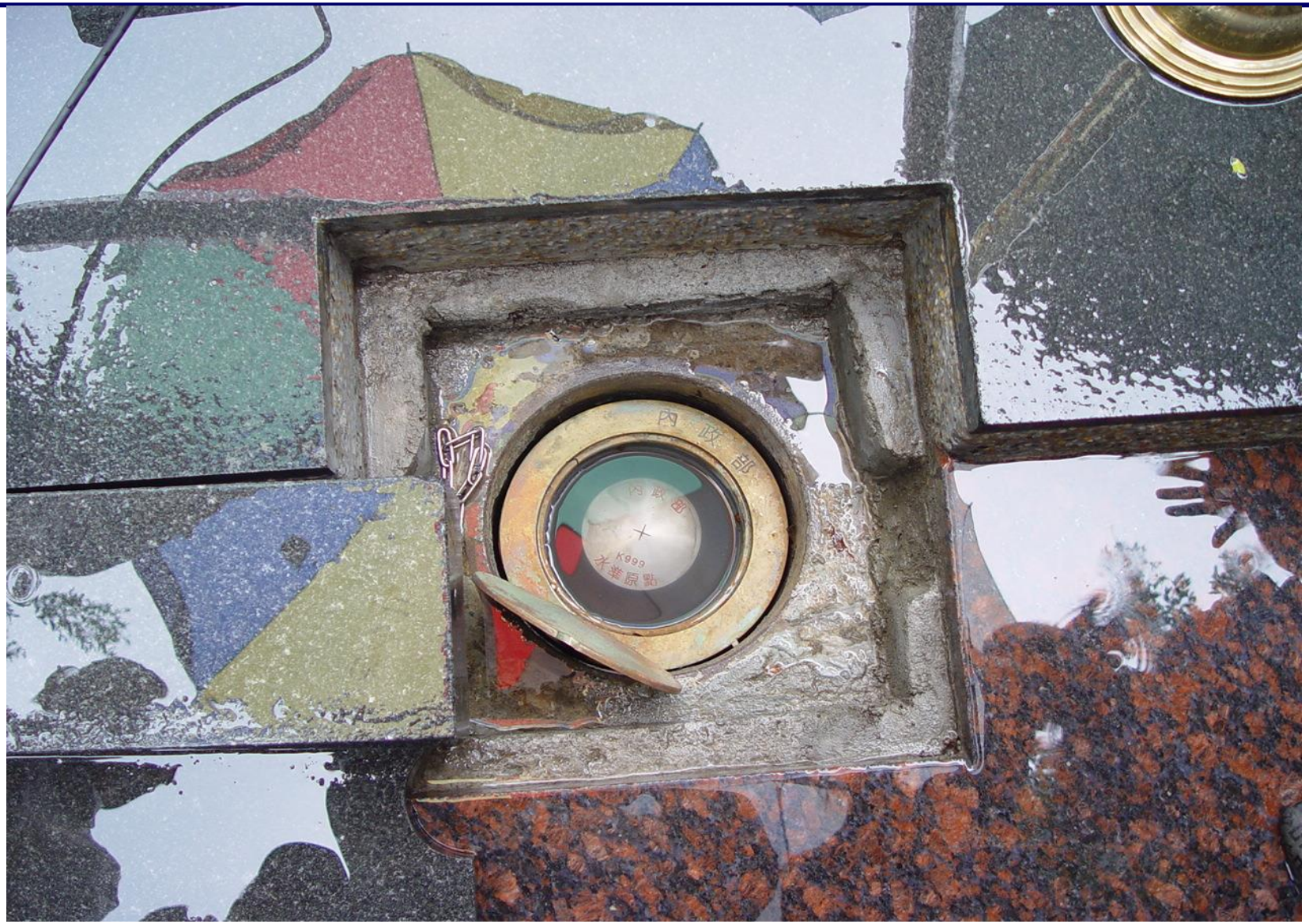
2002


臺灣水準原點
內政部
中華民國九十一年七月


臺灣水準原點誌
水準原點爲各地水準測量之基點，乃建立國家高程（俗稱海拔高）測量控制系統及各項工程建設之依據。
臺灣高程測量控制系統，始於西元一九一四年之環島水準測量。臺灣光復後，內政部曾於一九七五年及一九八四年辦理全臺灣之水準測量，均以基隆港平均海水面爲高程基準面，並於一九七九年在基隆海門公園內設置水準原點，此爲臺灣首創之水準原點。後因標石毀損，現已不復存在。內政部鑑於水準原點之重要性，乃決定重新建置，爲期美觀及永久保存，特別採雙水準原點設計，一爲主點（點號：K999）以不銹鋼棒接續方式植入地下17.5公尺；另一爲副點（點號：K998）以花崗石製作，埋設於地面，便利各界引測。
水準原點之高程仍以基隆港平均海水面爲高程基準面，主點高程值爲5.61560公尺，副點高程值爲 公尺，據此訂定二〇〇一年臺灣高程基準（TWVD2001），並辦理一等水準測量工作，建立臺灣高程測量控制系統。爲資紀念，特立此碑，以昭週知，並期各界共同維護。
內政部
中華民國九十一年七月




內政部


內政部
內政部
K999
水準原點


內政部
內政部
K999
水準原點

2013

新站位置


福長宮
八斗街
海科館主題館區
安檢所
平浪橋
長潭里漁港
海洋劇場
碧水巷站(海科館)
臺灣水準原點
北
斗子站
大客車


臺灣水準原


臺灣水準原點
內政部
中華民國九十一年七月立
一〇二年十二月遷建


臺灣水準原點
內政部
中華民國九十一年七月立
一〇二年十二月遷建


水準原點 誌
水準原點，迺全國測量地表高程（俗稱海拔高）之起算點位，亦是訂定國家高程系統之法定依據。臺灣全面實施水準測量始於民國三年（西元一九一四年）；光復後，內政部參酌基隆港長期平均海水面高度，於海門公園內設置水準原點，允為各項公共建設之共同基礎。嗣因環境變遷，為兼顧地方永續繁榮發展，爰遷建於此；啟用伊始，謹以為記。
內政部
中華民國一〇二年十二月
Datum Benchmark
Datum Benchmark is the legally defined national vertical reference to serve as the geodetic datum The earliest geodetic vertical system associated with island-wide leveling network in Taiwan was established in 1914. After the regime change in 1945, the Ministry of the Interior set up the datum benchmark in the Haimen Park which pertains to the mean sea level observed by Keelung tide gauge. In compliance with the development of local community, the datum benchmark is re-located here to continue the service henceforth.
Ministry of the Interior
December, 2013


BM997
內 政 部
99年8月
K997
水 準 原 點


水準原點
水準原點　係國土測繪法規定地表高程（俗稱海拔高）之起算點位。本水準原點副點K996，迺依循古法採石椿埋設，復融合測量方位與高程意象進行美化設置；鄰近另設有水準原點主點K997採不銹鋼棒植入深達14公尺之岩盤，以力求穩固，用昭來茲。
Datum Benchmark
Datum Benchmark is the legally defined national vertical reference to serve as the geodetic datum. This associa tum benchmark K996 is designed and built in the form of a traditional stone carving pillar with its artistic images to symbolize the concept of geodetic orientation and elevation. The pri ary datum be mark K997 located nearby is exclusively set on a stainless steel rod bored in deep to ensure the mark is as sturdy as possible.


BM 996
Datum Benchmark

First order levelling network

- Dated to the end of 2015, there are 2140 first order benchmarks distributed in Taiwan. Considering the total land area of Taiwan, 36,193 km^2, the density is quite high. These benchmarks are all linked into a network.
- The major part of the survey was conducted in 2001-2003, and maintained by NLSC annually.

First order levelling network -2

- In the specification documented in the appendix number 5 of "Implementation Regulations of Fundamental Surveying", the accuracy of the levelling is $\pm 2.5\text{mm}\sqrt{k}$, where k is the number of levelling route length in km..

First order levelling network -3

- The first order levelling network is not limited to Taiwan island only, but also on other surrounding islands, including Kinmen, Hsiao Kinmen, Penghu, Qimei, WangAn, Luedao (Green island), Lanyu, Xiaoliuqiu, Nangan, Peigan, Dongsha, and others.
- The zero height reference is all referred to the MSL of local tidal stations.

Gravity and local geoid model

- Ministry of the Interior announced a version of digital geoid undulation model in 2002.
- The current model is TWHYGEO2014.
- The coverage is between latitude north 21 to 26 degree, longitude east 119 to 123 degree. The spatial resolution of TWHYGEO2014 is **30x30** arc second and is a hybrid model derived with merging gravity datasets referenced on the global gravity model EGM2008

The current progress

- **Height modernization**
- **Depth datum**
- **Dynamic vertical datum**

Height modernization

- Could the first order benchmark be maintained with GNSS?
- How reliable would it be?
- How well would the CORS (Continuously Operated Reference Stations) be able to serve as a height frame?

Depth datum

- The nature of depth datum is that it is completely linked to the tide at that site.
- The geoid is the shape that the surface of the oceans would take under the influence of Earth's gravity and rotation alone, in the absence of other influences such as winds and tides” (Wikipedia, 2017)

Depth datum -2

- The geoid deviates from the MSL (Mean Sea Level). And, the offset between LAT (Lowest Astronomic Tide) and MSL varies from location to location. LAT is the reference surface for depth datum recommended by IHO (IHO, 2012).

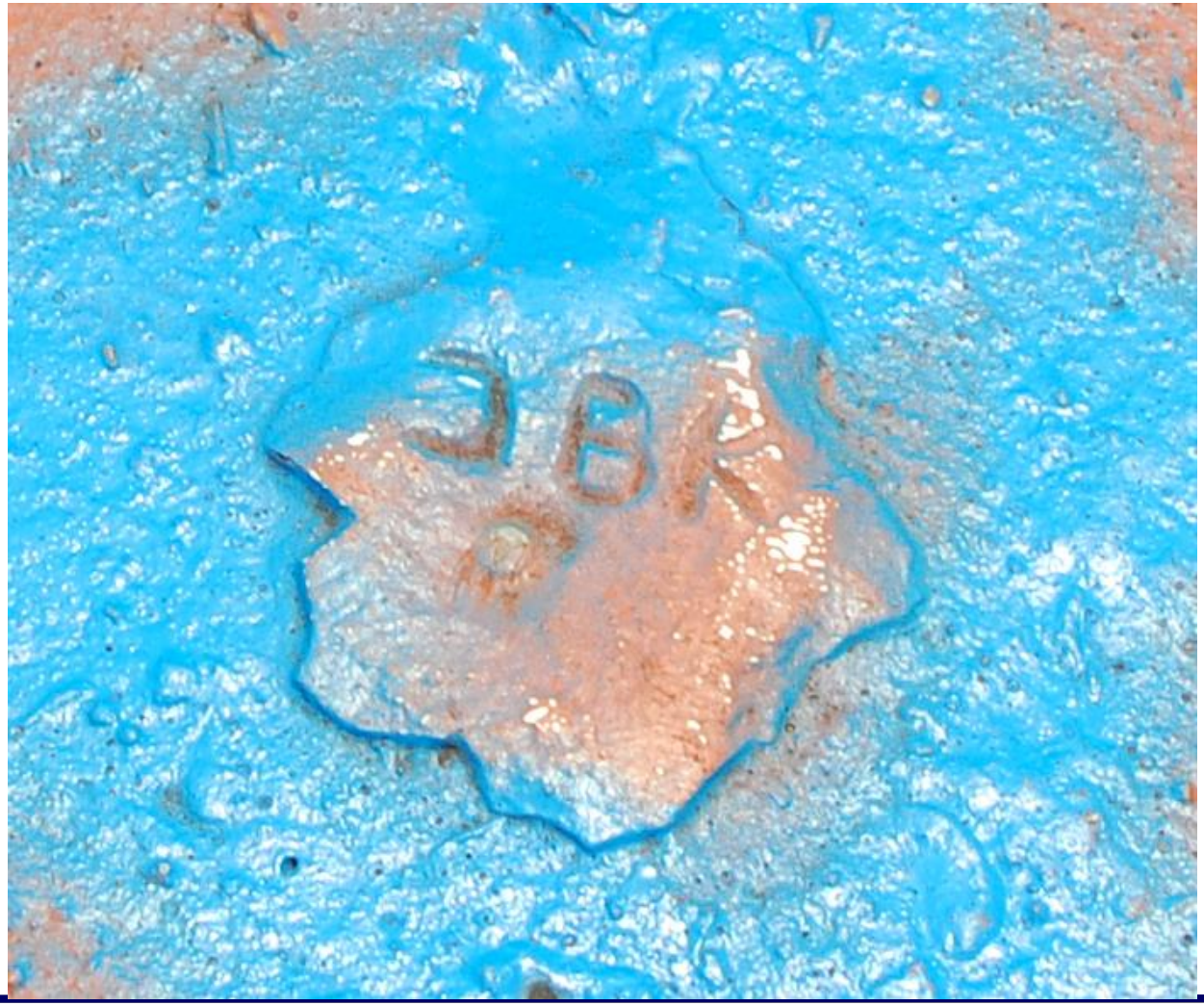
Dynamic vertical datum

- Earthquakes, typhoon and intensive rainfalls, volcano activities, ground water consumption, etc.
- All these factors together mean that a dynamic model for the vertical dimension would be ideal.

GDBD2009

- A new geocentric datum for Brunei Darussalam 2009 (GDBD2009) was established using GPS space geodetic technology based on the ITRF2005 reference frame.
- The GDBD2009 is related to ITRF2005 through the inclusion of the 8 GPS stations of the Brunei Darussalam Zero Order Network and have been processed together with more than fifty IGS stations around the world.

Surveying Marks in Brunei Darussalam



Jambatan Pehin dato Haji Awang Mohd Noor

Welcome to Taiwan

- ASEAN- Taiwan Forum on Land Surveying and Geomatics on 10 July 2017

Welcome to Taiwan

- Taiwan is also looking forward to hosting ASEAN-FLAG meetings and conferences such as SEASC in the future.

Thank you for your attention ！