Confirmation of the relative gravity measurement by the absolute gravimeter at NIMT

N Woradet* and T Priruenrom
Pressure Laboratory, Mechanical Department, National Institute of Metrology (Thailand), Pathumthani, 12120 Thailand

*E-mail: Nattanan@nimt.or.th

Abstract. The local gravity measurement using relative gravimeter was confirmed to the reference absolute gravity station by National Institute of Metrology (Thailand); NIMT. Five known absolute gravity value stations were used in this confirmation. By applying the A-B-A measurement pattern, the time dependent of the relative gravity value at the reference station was calculated. Then the short term drift correction was introduce to the relative gravity reading of the loop. The relative gravity difference ($\Delta g_{rel}$) was compared to the absolute gravity difference ($\Delta g_{abs}$) between A-B stations. Five measurement loops were given the maximum difference between $\Delta g_{rel}$ and $\Delta g_{abs}$ of 0.012 mGal which is less than the absolute gravity uncertainty value of the station in that measurement loop. Therefore, the relative gravimeter is confirmed to report the local gravity value rely on the reference absolute gravity station using daily measurement loop with A-B-A pattern.

1. Introduction
The local gravity is one major variable of pressure measurement using the pressure balance apparatus. By force over area principal, the gravity value from IAG equation leads to 50 ppm source of uncertainty. To reduce this value for more accurate pressure calibration, the gravity should be evaluated with less uncertainty. National Institute of Metrology (Thailand); NIMT, which have the gravimeter was decided to transfer the local gravity from NIMT reference station to whom that would like to reduce the uncertainty of pressure measurement.

The absolute gravimeter FG5-X is the most accurate instrument nowadays. But the FG5-X is not the field survey equipment type; therefore the relative gravity survey type equipment was introduced. The relative gravimeter could be used to determine the gravity value of station with a quite more uncertainty; however it is less enough to reduce uncertainty of pressure measurement. The gravity measurement is almost effect by many environmental parameters that are time variable. This paper is to study the consistency of relative gravity and absolute gravity among 5 stations. The relative gravimeter model CG-5 by Scintrex Ltd. and absolute gravimeter model FG5-X by Micro-g Lacoste Inc. were used.

2. The Scintrex Autograv CG-5 Gravimeter
The Scintrex autograv CG-5 gravimeter is the non-magnetic fuse quartz spring gravimeter manufactured by Scintrex Ltd. It is the widely used instrument for measuring the relative gravity with highly accuracy (~10 $\mu$Gal standard deviation) with measurement range covered the gravity difference
of 8000 mGal. There is a sensor controlled temperature chamber for stabilizing quartz sensor so the instrument can be operated in wide range temperature, -40 to 45 °C. The relative gravimeter; Scintrex autograv CG-5 (serial no. 140241177) was used to measure the gravity difference between stations. The gravimeter obtained a reading by continuously averaging a series of 6 Hz sample with automatic software correction included tide, instrument tilt, temperature, noise rejection, seismic noise filter, terrain corrections and long term drift. The gravity reading is retrieved in text file format for data processing.

3. Relative Gravity Confirmation

3.1. Gravity measurement method

To confirmation the relative gravity transfer from absolute gravity value, 5 known absolute gravity station, as in Figure 1, were used to take the measurement.

![Figure 1. The pictures of 5 measurement stations](image)

Before starting each measurement project/loop, the instrument was calibrated the long term drift of the reading at least 12 hours. For absolute gravity determination, the relative gravity measurement loop was started from the reference station to the unknown gravity station in A-B-A pattern. Then the absolute gravity from the reference station was corrected and transferred to the unknown station by the measured relative gravity difference. If applicable, the measurement loop should be completed within 24 hours (1 day).

At each measurement station before taking gravity data, the instrument was activated and stabilized for at least 10 minutes. In general, the instrument reading is 6 Hz sampling rate, it means that the instrument take 6 readings every second. The main parameter setup of measurement in each station for 1 set is shown in Figure 2

![Figure 2. Set up parameter for measurement set](image)

For 5 reading data of 1 set, the instrument software was calculated from total 1800 raw reading data. In this project, the relative gravity was measured for 2 sets with time deviated 10 minutes at each station. The main parameters used in retrieved data were; gravity data, standard deviation and time.


### 3.2. Short term drift correction of data

The text file data which is contained gravity reading and other parameters is retrieved for the short term drift manual correction and the gravity deviation for each station. By measuring in A-B-A pattern, the short term drift can be calculated by the reading difference of station A between start and end loop with operating loop times. To eliminate the drift over time within measurement loop, the calculated short term drift given in Table 1 was added to correct the gravity reading of each station.

#### Table 1. Short term drift for measurement loop

| Loop            | Short term drift \(\times 10^{-5}\) (mGal/minute) | Short term drift mGal/12 hours |
|-----------------|-----------------------------------------------|--------------------------------|
| Mark no.8-Mark no.1 | 7.20                                         | 0.052                          |
| Mark no.8-Mass Lab. | 2.69                                         | 0.019                          |
| Mark no.8-Force Lab. | 1.03                                         | 0.007                          |
| Mark no.8-Mark no.2 | 2.22                                         | 0.016                          |
| Force Lab.-Mass Lab. | 4.65                                         | 0.033                          |

\(\text{mGal} = 10^{-5}\text{m}\cdot\text{s}^{-2}\)

### 3.3. Gravity confirmation Result

After short term drift correction process, the average of all reading data was used as the representative value for each station. The deviation value between the relative gravity value and the absolute gravity value for each loop are shown in Table 2.

#### Table 2. The gravity deviation value between relative gravity difference and absolute gravity for each measurement loop

| Loop             | \(\Delta g_{rel}\) mGal | \(\Delta g_{abs}\) mGal | Deviation mGal |
|------------------|-------------------------|-------------------------|----------------|
| Mark no.8-Mark no.1 | 15.447                   | 15.435                  | 0.012          |
| Mark no.8-Mass Lab. | 0.033                    | 0.029                   | 0.004          |
| Mark no.8-Force Lab. | -0.031                   | -0.032                  | 0.001          |
| Mark no.8-Mark no.2 | 0.065                    | 0.061                   | 0.004          |
| Force Lab.-Mass Lab. | -0.134                   | -0.125                  | 0.009          |

Maximum 0.012
Table 3. Absolute gravity values of the stations measured by FG5-X absolute gravimeter

| Station       | Absolute g | U(k=2) |
|---------------|------------|--------|
| Mark no.8     | 978312.4410| 0.018  |
| Mark no.1     | 978297.0061| 0.037  |
| Mass Lab.     | 978312.4120| 0.018  |
| Force Lab.    | 978312.4730| 0.018  |
| Mark no.2     | 978312.5662| 0.021  |

The relative gravity differences between 2 stations as shown in Table 2 express the deviation from absolute gravity difference for all loops with 0.012 mGal maximum. The difference for each loop is fluctuates within the uncertainty report of the absolute gravity station. Then the possible of relative gravity difference could be up to the uncertainty of station because the major influent of field survey is environmental condition.

The local gravity can be transferred gravity from the absolute gravity value at known station using the equation below;

\[ g_{local} = g_{abs} + \Delta g_{rel} \]

The uncertainty evaluation of the local gravity should take the short term drift and the standard error of the reading as source of uncertainty.

4. Conclusion
Therefore, the relative gravimeter with A-B-A measurement pattern can be used to determine the local gravity of the interesting station. The local gravity determined by using the relative gravimeter is consistent with the absolute gravity determination method. The maximum difference found in this work is 0.012 mGal that it is not significant when compared to the uncertainty of absolute gravity which is reported along with absolute gravity value measuring using absolute gravimeter model FG5-X. In addition, nearly all works can accept to use the local gravity value determined by the relative gravimeter with larger uncertainty instead of absolute gravimeter.

References
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