Urban Gravity Measurements for the Subsurface Mapping; Case Study Kaliawi

Rizka1*, Lea Kristi Agustina2 and Hot Mazmuloh2

1 Geophysical Engineering Program, Institut Teknologi Sumatera, Lampung Selatan, Indonesia
2 Geomatics Engineering Program, Institut Teknologi Sumatera, Lampung Selatan, Indonesia
* E-mail: rizka@tg.itera.ac.id

Abstract. Gravity method is a passive geophysical method that can measure and obtain subsurface models based on rock density. Gravity method can be done in urban areas to obtain information about subsurface model as a reference in making urban policies related to disaster mitigation and urban development based on earth potential. Gravity research was conducted in Kaliawi, Bandar Lampung. Kaliawi has many problems including dense settlements and slums, areas prone to floods and landslides and has limited availability of fresh water. Based on the Complete Bouguer Anomaly results, the western area of Kaliawi has a low anomaly (36.8 – 38.2 mGal) with lithology of sandy-clay sedimentary rocks. Whereas the eastern area of Kaliawi has a high anomaly (38.4 – 40.8 mGal) with tuff lithology and can be bedrock. Based on the gravity anomaly and lithology, the western area of Kaliawi is a landslide area and recharge area while the eastern area of Kaliawi is good for settlement because it has bedrock.

1. Introduction
Geophysics can be applied to the regulation of urbanization. The application is conducive to understanding changes and impacts on the physical environment and having a role in developing a sustainable urban infrastructure system. This study is called urban geophysics. According to [1] the application of geophysics as 'Urban Geophysics' is not only the application of geophysical exploration in cities, but also brings changes to the field of urban geophysics. One geophysical method that can be applied in urban areas is the gravity method.

The gravity method is a geophysical method that utilizes the earth's gravitational field to describe subsurface rocks based on diversity in density. Gravity methods can be applied in urban areas to identify groundwater levels and expand urban areas that are related to the physical infrastructure needed in development. The gravity research that has ever been done in urban areas such as [2], [3], [4], [5], [6], [7].

In this study, research was conducted at Kaliawi, Bandar Lampung, Lampung. This area is located in the center of Bandar Lampung city which is the center of trade and shopping. Kaliawi has a high population density with many problems. The problem is the irregular condition of the building layout, limited availability of fresh water, landslide-prone areas. A study was carried out on the application of the Kaliawi regional gravity method to map land-based spatial planning by identifying areas prone to geological hazards (landslides) and analyzing aquifer areas.

2. Regional Geology
This study was conducted in the Kaliawi area, Bandar Lampung, Lampung. According to [8] Kaliawi is in Young Volcanic Deposits (Qhv) which is dominated by one unit of rock, namely Andesitic-basalt...
lava, breccia and tuff Eruption from Betung Mount. Young Volcanic Deposits (Qhv) are quarter-old (Holocene) volcanic rocks. Quarter-old rocks can be categorized as young rocks.

3. Gravity method

The gravity method is a geophysical method that utilizes the earth's gravitational field to describe subsurface rocks based on diversity in density [9]. Measurement of field gravity contains many values that are not derived from subsurface reflections. Before further interpretation is needed a process of reduction in the form of corrections to the gravity value of the field measurements. These corrections consist of tide correction, drift correction, spheroid reference and geoid correction, free air correction, Bouguer correction and terrain correction.

After being reduced, a Bouguer Anomaly (CBA) anomaly will be produced. Basically, the Bouguer anomaly is the difference between the measured gravity value which has been reduced to the size reference field and the theoretical gravity value at the specific reference field at a point. Complete Bouguer Anomaly is calculated using equations [10]:

$$CBA = G_{obs} - G(\phi) + FAC - BC + TC$$

CBA: Complete Bouguer anomaly (CBA), gobs: g observation value, FAC: air-free correction, BC: Bouguer correction, TC: terrain correction, gϕ: spheroid and geoid correction.

This study measured gravity using a Scintrex CG-5 instrument and topography using GPS Geodetic in Kaliawi. Measurement of gravity and GPS Geodetic is done as many as 24 measurement points. The distribution of gravity and topography measurement points in Kaliawi can be seen in Figure 1.

Figure 1. Map of the distribution of Kaliawi's gravity and topography measurements.
4. Results and Discussion

Urban gravity studies were carried out in Kaliawi, Bandar Lampung, lampung. Before measuring gravity in Kaliawi, researchers reduced the value of absolute gravity at the Bench Mark (IT-2) ITERA campus tied to the Gravity Base Point at the Branti Meteorological Station. Based on the calculation, the gravity value at ITERA is 978099.13 mGal (Table 1).

| Stasiun   | Latitude | Longitude | Gravity Value (mGal) |
|-----------|----------|-----------|----------------------|
| BMG.1.0322 | -5.24389 | 105.18139 | 978115.11             |
| IT-2      | -5.35674 | 105.31561 | 978099.13             |
| BMG.1.0322 | -5.24389 | 105.18139 | 978115.11             |

After obtaining the gravity value at ITERA, gravity and GPS Geodetic measurements were taken at Kaliawi. The results of Kaliawi's Complete Bouguer Anomaly (CBA) data processing can be seen in Figure 2.

Based on the Complete Bouguer Anomaly (CBA) map, Kaliawi can be analyzed that the western region has a low anomaly that is suspected to be sedimentary rock. Sedimentary rocks are also strengthened by the discovery of hills that have lumps of fine grain sized sedimentary rocks. This rock is thought to be a mixture of sand and clay which is fragile and prone to weathering and prone to landslides. This can be a cause of landslides in residential residents. In addition, there is an overload due to population settlements on the hillside and vehicles passing on the hillside.

Based on the map of Complete Bouguer Anomaly (CBA) Kaliawi can be analyzed that the eastern region has a high anomaly that can become bedrock. This area is suitable for residential areas because it has hard rock that can support a solid foundation.

Based on this study, the author recommends that the western area of Kaliawi be used for conservation land and recharge areas. The western region of Kaliawi is also unsuitable for dense settlements because it is prone to landslides. Whereas for densely populated settlements should be arranged in the eastern area of Kaliawi. According to Complete Bouguer Anomaly (CBA) data in the east, it is suspected that it has thick bedrock making it suitable for the construction of solid foundations.
5. Conclusion
Based on this study, gravity methods can be used in urban areas for land use. Based on gravity data, the western part of Kaliawi can be used for conservation land and recharge areas. The western area of Kaliawi is also not suitable for dense settlements because it is prone to landslides. It is recommended that the arrangement of densely populated settlements be located in the eastern area of Kaliawi. According to Complete Bouger Anomaly (CBA) data in the east, it is suspected that it has thick bedrock making it suitable for the construction of solid foundations.

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