Contribution of bearing capacity of land based on engineering geology in regional spatial policy (A study in Semarang City)

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Abstract. The bearing capacity of the land (BCL) is a determining factor for the bearing capacity of the environment. The BCL depends on the resources in the land space, which is called the supply capacity. The capacity of providing BCL for spatial use is determined by the stability of the landmass of the expanse of land, namely engineering geology characteristics. The BCL for the use of space has been based on the land capacity for agriculture and the physical land. There are important things that are not included in the criteria, namely the ability of the land in terms of engineering geology characteristics. Soil samples from the drill were analyzed for soil characteristics. Analysis of field and laboratory tests to get the distribution of the value of BCL, then compiled the map of the BCL of Semarang City at 2.5-5.0 m depth. The BCL value is 0.201–14.248 kg/cm², settlement value is 0–247.728 cm, duration of decline (DOD) is 0–5.147 years. The paper intended to contribute to spatial planning policy thinking, related to the BCL based on engineering geology as a determinant of land capability, an evaluation instrument of space utilization, and fundamental policy formulation.

1. Introduction
In the regulation of the State Minister of the Environment No: 17 of 2009 concerning Guidelines for Determining Environmental Supporting Capacity in Regional Spatial Planning, the stability of the bearing capacity of the land (BCL) is the capacity of the natural environment and resources that determine the bearing capacity of the environment. This is influenced by the conditions and characteristics of the resources in the expanse of land. In urban areas, the stability of BCL becomes a limiting element in fulfilling the use of space according to the ability of the land, so that there is the suitability of a stretch of land with a stable bearing capacity for certain spatial uses [1].

The BCL for spatial use so far is based on the calculation of land capability for agriculture and from the physical aspect of the land following the Ministerial Regulation mentioned above. However, the substance of the BCL as a soil mass that forms a stretch of land does not only include the ability of the land for agriculture or the physical aspects of the land, but rather the stratigraphy of the soil mass below the physical surface, namely the characteristics of engineering geology.

One of the phenomena that occur related to the characteristics of engineering geology is land subsidence which is a decrease in land area. The subsidence rate in Semarang to Demak City at the location of the mixed room allocation is 13.00 cm/year, the industrial space designation location is 7.80 cm to 9.30 cm/year [2]. Land subsidence is a process that occurs in soils that experience stress due to loads and strain in the soil framework. The integration of strain or deformation per unit length along the depth of stress effect is the settlement which is the magnitude of land subsidence. The amount of
subsidence is influenced by three variables, namely the coefficient of compressibility of the soil volume, changes in stress, and the depth of the soil that has the potential for subsidence. Subsidence continues when the stress changes continue to increase due to land loading.

Rimba et al [3] confirmed that land subsidence is one of the physical variables that influence the estimated level of coastline vulnerability, in addition to changes in relative sea level, coastal geomorphology, coastal slope, shoreline changes, average tidal range, and significant wave height. Suroso and Firman [4] put forward the concept that spatial planning is expected to facilitate climate change adaptation by directing future spatial and infrastructure development away from zones affected by climate-related hazards or sea-level rise or inundation of coastal plains. The study shows that the current provincial spatial plan directs land-use conversion along the northern coast of Java to continue in the future. The analysis shows that the total area of land prone to inundation is planned to be converted to industrial and residential, which means this area is also vulnerable to inundation in the future. Spatial plans issued by national and provincial governments to regulate future land use on the north coast of Java have not yet integrated measures against hazards associated with global sea-level rise. While many existing developments have been affected by coastal inundation. The case studies show that spatial planning can increase the risk of climate-related hazards or coastal inundation, rather than reduce the impact of coastal flooding. It provides a different perspective on the role of spatial planning for adaptation to climate change [4].

Semarang city dynamically requires areas to build city facilities and infrastructure. Such a tendency has led to continued land engineering efforts into areas that are ready to be built [5]. Dewi et al [6] stated that the availability of land within the city is fixed and not limited to meet the needs of the population, and it causes changes in land use in suburban areas. Changes in land use are influenced by large-scale housing developments, transportation infrastructure, industry, and tourism.

Land engineering and infrastructure planning are certainly strongly influenced by the properties of the local soil which are very diverse. The effectiveness will be obtained if certain soil properties are known in certain zones concerning the parameters needed in planning so that results can be optimal.

The failure of construction or infrastructure as a result of the failure of the BCL that is not in accordance with the use of space and results in the economic, social or community and environmental aspects being out of balance, the three main pillars of sustainable development cannot be realized. It is what underlies the writing of this paper, sourced from the results of research on the BCL in certain material zones, which can be used as a reference for land capabilities as the fundamental for spatial use policies.

2. Methodology

2.1. Location and methods

The research was conducted in Semarang City which is geographically located between 6°50' – 7°10' S 109°50' – 110°35' E, located in the north coastal area of the Java island with an area = 373.70 km² [7]. Field test points were carried out randomly spread over the area of Semarang City consisting of 122 deep drills, 109 shallow drills, and 205 DCP tests with a capacity of 2.50 tons.

The design was exploratory-descriptive-analytical-experimental. Drilling was performed to obtain representative native soil samples, at various depths, totalling 239 samples. As a follow-up, samples were analyzed in the soil mechanics laboratory to determine the values of geotechnical parameters, both physical properties and engineering properties, hydraulic properties and settlement parameters. Analysis of BCL, settlement, and duration of decline (DOD) were carried out using Microsoft Excel software [8].

2.2. Analysis of the bearing capacity of the land (BCL) – Settlement – Duration of decline (DOD)

The BCL was calculated using Meyerhof’s equation [9].

\[ Q_{alt} = N/F(K_d)(K_m) \]  

(1)
Equation (1) is a formula used to calculate BCL in Qall (kg/cm$^2$). Where Kd is a depth factor defined as 1 + 0.33Df/B < 1.33, Km is a safety factor that has been set at 1.5, with N/F determined using Terzaghi and Peck’s graphs (Figure 1) [10]. B is one unit contact area < 1.2 meters. Df is a contact area for vertical distance.

The settlement value was calculated with Craig’s formula in Equation (2) [10].

\[ S = M_v D_p H \]  \hspace{1cm} (2)
\[ D_p = Q_{all} - q_0 \]  \hspace{1cm} (3)

Equation (2) is a formula used to calculate settlement value S in centimeters. Where Mv is the volume compressibility coefficient of soil (cm$^2$/kg), Dp is additional stress due to load (kg/cm$^2$), and H is the thickness of the soil layer in (meters). According to Buisman De Beer’s formula [11], the increase in tension on deep compressible deposits, occurs at the depth as follows:

\[ H = D_p/0.1q_0 \]  \hspace{1cm} (4)

Furthermore, the duration of decline (DOD) was calculated using Equation (6)

\[ T_v = C_v T / (H)^2 \]  \hspace{1cm} (5)
\[ T = T_v (\frac{H}{2})^2 / C_v \]  \hspace{1cm} (6)

The formula used to calculate the duration of decline (DOD) is shown in Equation (6). Where T refers to the duration of decline (second), Tv is a time factor for 90% consolidation level that is set at 0.848, H is the thickness of the soil layer with the potential to sink in (meter), and Cv is coefficient of consolidation (cm$^2$/sec).

The physical properties of the soil were obtained by field and laboratory research data. Furthermore, it was used to obtain the potential for land subsidence, in terms of its ability to withstand the load, while determining the decline in duration. Distribution and zonation of soil types in Semarang city were mapped using ArcGIS 10.3 with the geostatistical methods [12].

The research points are plotted according to their coordinates on the Semarang city map. The zonation of depth is determined at 2 depth levels namely 2.5m and 5.0m; and material zones are plotted based on field data i.e. drill and DCP profiles. Interpolation in the transition zone between two different
3. Result and discussion

3.1. BCL in Semarang city spatial planning

The definition of land according to the regulation of the state minister of the environment number 17 of 2009 concerning guidelines for determining the bearing capacity of the environment in regional spatial planning is a land area whose characteristics include all signs regarding the biosphere, atmosphere, soil, geology, relief, hydrology, population of plants and animals, as well as the results of past and present human activities that are steady or cyclical [13].

Land is a structural form in the planned use of space, which includes location patterns, distribution of settlements, workplaces for trade and offices, industry, recreation areas, and land use patterns. The land arrangement is one of the sides that becomes the unity of three sides of spatial planning, namely land space, ocean space and air space. The preparation of spatial plans must always be based on perspective thinking towards the desired future state, starting from data, information on science and technology that can be used, and taking into account the diversity of perspectives on activities of each sector.

According to the Law of the Republic of Indonesia Number 26 of 2007 concerning Spatial Planning and according to Government Regulation Number 15 of 2010 concerning the Implementation of Spatial Planning, Provincial Governments – Regency or city government must prepare a regional spatial plan according to the level by taking into account the bearing capacity of the environment [14, 15]. Determination of the bearing capacity of the environment is measured by knowing the capacity of the natural environment and resources to support human life in that space for their existence. The size of the capacity is influenced by the condition and characteristics of the resources in the existing expanse of space, including: a) the ability of the land to allocate space use, b) the comparison between the availability and the need for land, c) the comparison between the availability and the need for water; so that the use of space in the area is in accordance with the capacity of the environment and resources, it must pay attention to land capabilities. Land capability becomes very important in determining the bearing capacity of the environment, because 2 other factors, namely the comparison between the availability and demand for land and water will never be realized if the BCL is unstable.

The current BCL is based on land capability for agriculture and is reviewed based on categories: a) land capability classification, b) land capability at the class level, c) land capability at the sub-class level, d) soil capability at the management unit level [13]. The BCL is not only measured from the 4 aspects above, but there are main factors of land capability, namely, aspects of the engineering geology characteristics of the soil mass forming the stretch of land. From the analysis of the calculation of the BCL against the load, subsidence and the length of time for subsidence mapped in the view of a depth of −2.50 m from the ground and a depth of -5.00 m from the ground. The review at these depths is based on consideration of the area of land use in the part of the city area (PCA), the need for information on the BCL for engineering, and alternative engineering of the geometry of the building substructure.

In accordance with the Regional Regulation of Semarang City No. 14 of 2011 concerning Regional Spatial Planning for 2011–2031, in PCA I, II, III covering an area of 7,063 ha equal 18.90% of Semarang City area, it is designated as a city service center, as a government service center and a trade center and services [16]. The other 7 PCAs are designated as sub-centers for urban services and environmental centers covering an area of 30,294 ha equal 81.10% of the area of Semarang City. Development in areas outside the city service center about 81.10% building growth tends to be classified as low-rise buildings 1 to 4 floors is more dominant, the effect of load on land is relatively small, sufficient with shallow foundation types, less than 8 m depth. The service center area covers an area of 18.90% according to the
real designation required for a high-rise building classification building, the number of floors is more than 8 floors [17]. For the classification of high-rise buildings, substructure engineering is required for deep foundation types i.e. pillar foundations with a depth of more than 8 m with different analysis with a depth of less than 8 m. For a depth of more than 8.00 m, the design is more economical using the geometry of the deep pile foundation substructure. The BCL against settlement and The DOD is calculated based on the amount of environmental BCL that is allowed to burden the land.

Table 1. Distribution of BCL – settlement – DOD at 2.50 m depth

| District / PCA | Material Type     | BCL (Q) (kg/cm²) | Settlement (S) (cm) | DOD (T) (years) |
|---------------|-------------------|------------------|--------------------|----------------|
| Semarang Tengah (01) PCA | Very soft clay  | 0.201 – 0.608 | 0.929 – 63.953 | 0.413 – 5.147 |
| I             | Rather soft clay  | 1.218 – 1.320 | 114.783 – 172.078 | 1.320 – 3.392 |
|               | Rather loose sand | 0.404 – 1.829 | 0.000 – 63.290 | 0.000 – 0.389 |
| Semarang Utara (02) PCA III | Very soft clay | 0.201 – 0.608 | 0.929 – 63.953 | 0.413 – 5.147 |
| Semarang Timur (03) PCA I | Very soft clay | 0.201 – 0.608 | 0.929 – 63.953 | 0.413 – 5.147 |
| Gayamsari (04) PCA V | Very soft clay | 0.201 – 0.608 | 0.929 – 63.953 | 0.413 – 5.147 |
| Genuk (05) PCA IV | Very soft clay | 0.201 – 0.608 | 0.929 – 63.953 | 0.413 – 5.147 |
| Pedurungan (06) PCA V | Very soft clay | 0.201 – 0.608 | 0.929 – 63.953 | 0.413 – 5.147 |
| Semarang Selatan (07) PCA I | Very soft clay | 0.201 – 0.608 | 0.929 – 63.953 | 0.413 – 5.147 |
|               | Rather soft clay  | 1.218 – 1.320 | 114.783 – 172.078 | 1.320 – 3.392 |
|               | Rather loose sand | 0.404 – 1.829 | 0.000 – 63.290 | 0.000 – 0.389 |
| Candidari (08) PCA II | Very soft clay | 0.201 – 0.608 | 0.929 – 63.953 | 0.413 – 5.147 |
| Pedurungan (06) PCA V | Very soft clay | 0.201 – 0.608 | 0.929 – 63.953 | 0.413 – 5.147 |
| Gajahmungkur (09) PCA II | Very soft clay | 0.201 – 0.608 | 0.929 – 63.953 | 0.413 – 5.147 |
| Semarang Barat (13) PCA III | Very soft clay | 0.201 – 0.608 | 0.929 – 63.953 | 0.413 – 5.147 |
| Mijen (14) PCA IX | Very soft clay | 0.201 – 0.608 | 0.929 – 63.953 | 0.413 – 5.147 |
| Ngaliyan (15) PCA X | Very soft clay | 0.201 – 0.608 | 0.929 – 63.953 | 0.413 – 5.147 |

The results of the analysis of material zonation and geological characteristics of the subsurface soil of Semarang City as well as the calculation of the BCL, settlement and DOD are mapped in the map of the distribution of BCL of the Semarang city, at each depth of -2.50 m from the ground and depth - 5.00 m from the ground. (See Figure 2, Table 1, Table 2).
**Table 2. Distribution of BCL at 5.00 m depth**

| District / PCA          | Material Type        | BCL (Q) (kg/cm²) | Settlement (S) (cm) | DOD (T) (years) |
|-------------------------|----------------------|------------------|--------------------|-----------------|
| Semarang Tengah (01) PCA I | Very soft clay       | 0.201 - 0.404    | 1.031 - 37.254     | 2.161 - 3.781   |
|                         | Rather loose sand    | 2.338 - 5.085    | 0.000              | 0.000           |
| Semarang Utara (02) PCA III | Very soft clay       | 0.201 - 0.404    | 1.031 - 37.254     | 2.161 - 3.781   |
|                         | Rather loose sand    | 0.404 - 2.439    | 80.495 - 147.733   | 0.211 - 2.521   |
| Semarang Timur (03) PCA I | Very soft clay       | 0.201 - 0.404    | 1.031 - 37.254     | 2.161 - 3.781   |
| Gayamsari (04) PCA V    | Very soft clay       | 0.201 - 0.404    | 1.031 - 37.254     | 2.161 - 3.781   |
| Genuk (05) PCA IV       | Very soft clay       | 0.201 - 0.404    | 1.031 - 37.254     | 2.161 - 3.781   |
| Pedurungan (06) PCA V   | Soft clay            | 0.710 - 0.811    | 7.076 - 77.831     | 2.224 - 2.608   |
| Semarang Selatan (07) PCA I | Very soft clay       | 0.201 - 0.404    | 1.031 - 37.254     | 2.161 - 3.781   |
|                         | Rather hard clay     | 1.931 - 4.678    | 103.520 - 247.728  | 0.061 - 0.970   |
|                         | Rather loose sand    | 2.338 - 5.085    | 0.000              | 0.000           |
|                         | Dense sand           | 6.916 - 12.408   | 0.000              | 0.000           |
| Candisari (08) PCA II   | Very dense sand      | 13.731 - 14.036  | 0.000              | 0.000           |
|                         | Rather loose sand    | 2.338 - 5.085    | 0.000              | 0.000           |
|                         | Dense sand           | 6.916 - 12.408   | 0.000              | 0.000           |
|                         | Very dense sand      | 13.731 - 14.036  | 0.000              | 0.000           |
| Gajahmangkur (09) PCA II | Rather hard clay     | 1.931 - 4.678    | 103.520 - 247.728  | 0.061 - 0.970   |
|                         | Hard clay            | 4.373 - 10.577   | 0.000 - 81.877     | 0.000 - 0.083   |
|                         | Rather loose sand    | 2.338 - 5.085    | 0.000              | 0.000           |
|                         | Dense sand           | 6.916 - 12.408   | 0.000              | 0.000           |
|                         | Very dense sand      | 13.731 - 14.036  | 0.000              | 0.000           |
| Tembalang (10) PCA VI   | Very soft clay       | 0.201 - 0.404    | 1.031 - 37.254     | 2.161 - 3.781   |
|                         | Soft clay            | 0.710 - 0.811    | 7.076 - 77.831     | 2.224 - 2.608   |
|                         | Rather soft clay     | 0.506 - 0.811    | 54.180 - 107.735   | 2.492 - 2.581   |
|                         | Hard clay            | 4.373 - 10.577   | 0.000 - 81.877     | 0.000 - 0.083   |
|                         | Dense sand           | 6.916 - 12.408   | 0.000              | 0.000           |
|                         | Very dense sand      | 13.731 - 14.036  | 0.000              | 0.000           |
| Banyumanik (11) PCA VII | Dense sand           | 6.916 - 12.408   | 0.000              | 0.000           |
| Gunungpati (12) PCA VIII | Rather hard clay     | 1.931 - 4.678    | 103.520 - 247.728  | 0.061 - 0.970   |
|                         | Rather soft silt     | 0.710 - 0.913    | 40.100 - 82.757    | 0.700 - 2.521   |
|                         | Dense sand           | 6.916 - 12.408   | 0.000              | 0.000           |
|                         | Very dense sand      | 13.731 - 14.036  | 0.000              | 0.000           |
| Semarang Barat (13) PCA III | Very soft clay       | 0.201 - 0.404    | 1.031 - 37.254     | 2.161 - 3.781   |
|                         | Rather hard clay     | 1.931 - 4.678    | 103.520 - 247.728  | 0.061 - 0.970   |
|                         | Soft silt            | 0.313 - 0.710    | 1.350 - 40.100     | 0.007 - 0.700   |
|                         | Rather loose sand    | 0.404 - 2.439    | 80.495 - 147.733   | 0.211 - 2.521   |
|                         | Dense sand           | 6.916 - 12.408   | 0.000              | 0.000           |
|                         | Very dense sand      | 13.731 - 14.036  | 0.000              | 0.000           |
| Mijen (14) PCA IX       | Rather hard clay     | 1.931 - 4.678    | 103.520 - 247.728  | 0.061 - 0.970   |
|                         | Rather loose sand    | 2.338 - 5.085    | 0.000              | 0.000           |
|                         | Dense sand           | 6.916 - 12.408   | 0.000              | 0.000           |
|                         | Very dense sand      | 13.731 - 14.036  | 0.000              | 0.000           |
| Ngaliyan (15) PCA X     | Very soft clay       | 0.201 - 0.404    | 1.031 - 37.254     | 2.161 - 3.781   |
|                         | Rather hard clay     | 1.931 - 4.678    | 103.520 - 247.728  | 0.061 - 0.970   |
|                         | Soft silt            | 0.313 - 0.710    | 1.350 - 40.100     | 0.007 - 0.700   |
|                         | Dense sand           | 6.916 - 12.408   | 0.000              | 0.000           |
|                         | Very dense sand      | 13.731 - 14.036  | 0.000              | 0.000           |
| Tugu (16) PCA X         | Very soft clay       | 0.201 - 0.404    | 1.031 - 37.254     | 2.161 - 3.781   |
|                         | Soft silt            | 0.313 - 0.710    | 1.350 - 40.100     | 0.007 - 0.700   |
|                         | Dense sand           | 13.731 - 14.036  | 0.000              | 0.000           |
3.2. Contribution to spatial policy

Land subsidence is a critical problem that must be addressed by big cities in coastal areas, such as Semarang. Monitoring of subsidence is very important to predict and mitigate disasters that can cause such land subsidence. An economical and effective monitoring method, which can continuously provide accurate measurements over a large area, is urgently needed. Differential Interferometry Synthetic Aperture Radar (DInSAR) has the potential to be a powerful technique that can meet this need. It was found that the subsidence transition differs depending on the location, and that the rate of subsidence is still increasing in the northern and northeastern parts of the coastal area [18].

Considering the previous research that reported the transition of land subsidence differs depending on the location, and that the rate of land subsidence is still increasing in the northern and northeastern parts of the coastal area, there is a complementary correlation with the results of this study, especially with the mapping of BCL and potential settlement and the DOD in the Semarang city for the benefit of land engineering in spatial planning.

Buchori et al. [19] report that rising sea levels in northern Java, Indonesia, have impacted coastal cities that are prone to flooding and inundation. This study reports the extent to which spatial planning, mandated by the Republic of Indonesia Law no 26 of 2007 on Spatial Planning, to minimize people’s risks and increase their resilience, has taken into account the hydro-meteorological hazards of Semarang City in northern Java. Geographical Information System (GIS) based spatial analysis is used to predict the anticipated vulnerability based on the combined effect of two processes, namely the tendency of land subsidence and sea level rise. Furthermore, by presenting current and projected vulnerability maps to 2031 with urban land use plans in the same time frame, the results show that most of the areas with anticipated flooding and inundation are residential, industrial, and commercial areas, indicating that currently this land use plan has not taken into account hazards adequately. Regarding the conclusions of the study, the study in this paper can further refine the variables in future land use planning, especially the link between land use suitability and BCL and its implications for subsidence.

The Regional Regulation on Spatial Planning for the City of Semarang in 2011 – 2031, stipulates that the Semarang City area is divided into ten PCA as shown in Figure 3. Map of the distribution of BCL of Semarang City, can be used to control land use to match the bearing capacity of the existing land, so that the failure of infrastructure structures, especially in very soft to soft zones because subsidence does not occur, considering that it has been anticipated since the design. It can also be used as a reference in formulating practical spatial planning policies, as a frame of reference for the development planning process in the Semarang city.

On the map of the distribution of BCL of Semarang City, at a depth of ~5.00 m from the ground, it was found that the zone of very soft clay with BCL value 0.201 kg/cm² lay in Tugu District, West Semarang, North Semarang, East Semarang, Gayamsari, and Genuk which are included in the Service
Center System Development area in PCA X, III and IV. PCA III is intended for air and sea transportation, trade and services, offices [16]. PCA X and IV for industry. Meanwhile, the soft clay zoning with BCL value 0.406–0.712 kg/cm² is also spread in the Districts of West Semarang, North Semarang, Central Semarang, East Semarang, Gayamsari, and Genuk, as well as a little South Semarang. This soft clay zoning is included in PCA III, I, V, IV with the designation of air transportation, trade offices and services. For the classification of BCL which is equivalent to BCL value 0.406–0.712 kg/cm², soft silt, spreads in a small part of Ngaliyan District, West Semarang, and a few areas of South Semarang and Central Semarang. The soft silt zone is included in PCA X, III, I, designated for industry, offices, trade and services, air transportation. If viewed geomorphologically or the shape of the earth's surface, the clay zone is very soft and part of the soft silt zone is a plain area, a low relief area with shallow valleys or in the form of a plateau of approximately +6.25 MAL, or it is said to be the lower part of Semarang.

Figure 3. The PCA of Semarang city

In the hills area of Semarang city are slightly wavy with a height difference of 5–75 m [20] the material and mass properties in the field at a depth of -5.00 m from the ground surface, have started to differ, dominated by loose silt-sand, slightly hard clay, slightly dense sandy sand, BCL value 0.404-12.408 kg/cm², spread out in half of Ngalian District, hilly West Semarang, South Semarang, Gajah Mungkur, half of Candasari and Tembalang, half of Pedurungan. This area is included in PCA X, III, I, II, and VI with the designation of industry, offices, trade and services, education, police and sports.

In the area of Semarang, the steep hills with a height difference of 75-400 m [20] the material and mass properties in the field at a depth of -5.00 m from the ground, are dense sand and very dense sand, slightly hard clay and very hard clay, rather dense silt-sand, hard rock, BCL value 2.648-14.240 kg/cm², spread out in Mijen District, half of Ngalian, Gunungpati, half of Gajahmungkur, Banyumanik, half of Tembalang. This area is included in PCA IX, X, VIII, II, VII, VI, with allotment for public service offices, industry, education, offices, trade and services, military offices.

4. Conclusion

The contribution of BCL based on engineering geology in the spatial policy of Semarang city is: (1) obtained indicators of the amount of BCL for the criteria for determining environmental BCL in regional spatial planning, which so far have only been based on indicators of land capability for agriculture. (2) as a source of information to understand the geotechnical conditions of Semarang city's land zonation,
as well as a guide in the field of engineering, related to the standard value of safe BCL is 0.201 – 14.248 kg/cm², settlement is 0 – 247.728 cm, and the DOD is 0 – 5.147 years. (3) as initial information about the characteristics of engineering geology regarding the properties of subsurface soils needed in spatial planning. (4) improve the performance and control of spatial planning in anticipating the failure of the BCL, especially subsidence.

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