Journal of Applied Geology, vol. 3(2), 2018, pp. 73–82
DOI: http://dx.doi.org/10.22146/jag.48595

The Quality and Distribution of Andesite Rock for Construction Materials in Kokap and Temon District, Kulon Progo Regency, Yogyakarta–Indonesia

Tego Lenggono*, Doni Prakasa Eka Putra, and Agung Setianto

Department of Geological Engineering, Faculty of Engineering, Gadjah Mada University, Yogyakarta, Indonesia

ABSTRACT. The construction projects that are currently being carried out in Kulon Progo Regency, Yogyakarta Special Province, Indonesia, started on 2018, are large-scale projects. The projects include the construction of airports, seaports, industrial estates, southern crossing lanes and the construction of Menoreh lanes. The large-scale projects require a very large supply of andesite rocks for material construction. In Kulon Progo Regency itself, there is a huge potential of andesite rock relate to two geological formations (Kebo Butak and Andesite Intrusion) exist in the region, which is found mostly in Kokap District and partly in Temon District. One parameter that determines the quality of andesite rock is their compressive strength. Due to weathering, not all of the andesite in both formation can be classified as good quality rocks. According to Indonesian Standard, the minimum compressive strength of natural stone for stakes and curbstone is 500 kg/cm^2, for lightweight building foundation is 800 kg/cm^2, for medium building foundations is 1000 kg/cm^2 and for heavy building foundations is 1500 kg/cm^2. Based on this background, this paper have objectives to know the quality of andesite rock exist in the research area and to determine the zonation of good quality andesite rock for building and road materials in the research area. Field observation were conducted to map the occurrence of andesite rock. Totally 68 rock samples were collected during field observation and tested by point load test method to know its compressive strength value. The distribution of good quality rock in the research area were determine based on spatial analysis procedure in geographical information system. Results show that andesite rocks found in research area have a compressive strength ranging from 167.12 kg/cm^2 to 2783.37 kg/cm^2. From 53 samples taken from igneous rock intrusion, it showed that 7.55 % had low quality, 13.21 % had medium quality, 30.19 % had good quality and 49.06 % had very good quality. From the 16 samples taken from the Kebobutak Formation, it showed that 12.50 % had low quality, 18.75 % had good quality and 67.75 % had very good quality. The final map of rock quality zonation reveals 28.92 % of research area classify as low quality, 2.52 % medium quality, 37.68 % good quality and 30.88 % very good quality. It can be concluded that almost 70 % of andesite in the Kokap and Temon District can be used for the running large scale projects.

Keywords: Andesite · Construction material · Kulon Progo · Yogyakarta · Indonesia.

1 INTRODUCTION

The construction in Kulon Progo Regency based on the 2017 investment booklet issued by the Kulon Progo Regency Investment and Integrated Services Office, consisted of 5 major projects that were being and would be implemented, namely the construction of airports, seaports, industrial zones, southern crossing roads and the construction of Menoreh lanes (Dinas Penanaman Modal dan Pelayanan Ter-

*Corresponding author: T. LENGGONO, Department of Geological Engineering, Gadjah Mada University. Jl. Grafika 2 Yogyakarta, Indonesia. E-mail: tegolenggono@email.com

padu Kabupaten Kulon Progo, 2017). Various building and road construction projects require a very large supply of material, one of which is andesite.

The landscape of Kulon Progo Regency is in the form of highlands, hills, lowlands, and coastal areas, contain various types of rocks, one of which is andesite rocks. The existing of andesite in this region relate to their geological condition. Based on the geological map of the Yogyakarta by Rahardjo *et al.* (2012), the lithology occurs in the research areas from old to young are Nanggulan Formation (Teon), Kebobutak/Andesite Old Formation (Tmok), andesite igneous intrusions (a), Jonggrangan Formation (Tmj), Sentolo Formation (Tmps) and alluvium surface deposits (Qa), see Figure 1. The Nanggulan Formation consists of sandstone lithology with lignite inserts, sand marbles, and clay stones with limonite concretion, marl inserts and limestone, sand and tuff. The Kebobutak Formation consists of andesite, tuff, tuff lapilli, agglomerates, and inserts of andesite lava. Andesite igneous intrusions have varied compositions from hypersthene andesite to hornblende-augite andesite and trachyandesite, most of which have experienced propylitization. The Jonggrangan Formation at the bottom consists of conglomerates, tuff marbles, limestone sandstone with lignite inserts. The Sentolo Formation is composed of limestone and sandstone. Alluvium surface deposits consists by sand, silt and clay along large rivers and coastal plains.

According to its geological condition, the potential of andesite in Kulon Progo Regency is very huge, reaching about 5 Billion tons (Lazuardi, 2016), which is spread in several districts including Kokap and Temon Districts (Purwasatriya, 2013, Suwarno, 2017 and Sudiyanto, *et al.*, 2017). However, until today. there is no comprehensive report on the quality of andesite rocks in both regions and also their potential location of good quality rock used for building and road materials. All of this information if their exist can be used to localize the potential mining site of andesite on this region. Regarding to this problem and objectives, study area is focused on Kokap and Temon District, Kulon Progo Regency, Yogyakarta, as both districts have the most potential andesite rock and near to the project activities (Figure 2).

2 THEORETICAL BACKGROUND

Andesite is one type of igneous rock that is widely used in the construction sector, especially infrastructure such as roads, bridges, housing, airports, and seaports. Other uses are for ornaments and wall accessories, basic materials for making sculptures, and also utilization in the medical field. The quality of andesite rocks that are used in the construction sector, especially for building and road materials, need to be examined. One parameter that determines the quality of andesite is the value of compressive strength. Igneous rock, including andesite rocks, have a hardness level with classifications ranging from medium to very strong with a range of compressive strength values from 40 MPa to 320 MPa or 408 kg/cm^2 to 3265 kg/cm^2 (Table 1).

The compressive strength of andesite used as a building foundation and road material must reach a certain value. Based on the Decree of the Minister of Public Works Number 306 / KPTS / 1989 concerning Ratification of 32 Concept Standards of the Indonesian National Standard (SK SNI) in the Field of Public Works, Standard Number 03-0394-1989 concerning the standard requirements for the quality of natural stones used for building foundations, stakes and curb stone, then andesite rocks that can be used for building materials are those with a minimum compressive strength of 500 kg/cm^2.

3 RESEARCH METHODS

This research was carried out through several stages, including field preparation, field observation, laboratory test, data inventory, data processing and data evaluation in the GIS software for the zonation of rock quality. The initial activity was field observation which aimed to observe the weathering conditions of rock outcrops and determine the location of sampling. During the field observation, the andesite rock outcrops can be classify as massive-fresh and weathered outcrops. Based on this condition, the rock samples were only taken from massive-fresh outcrop, but the information of weathered outcrops were plotted in the map to be used for the delineation of zonation of good qual-

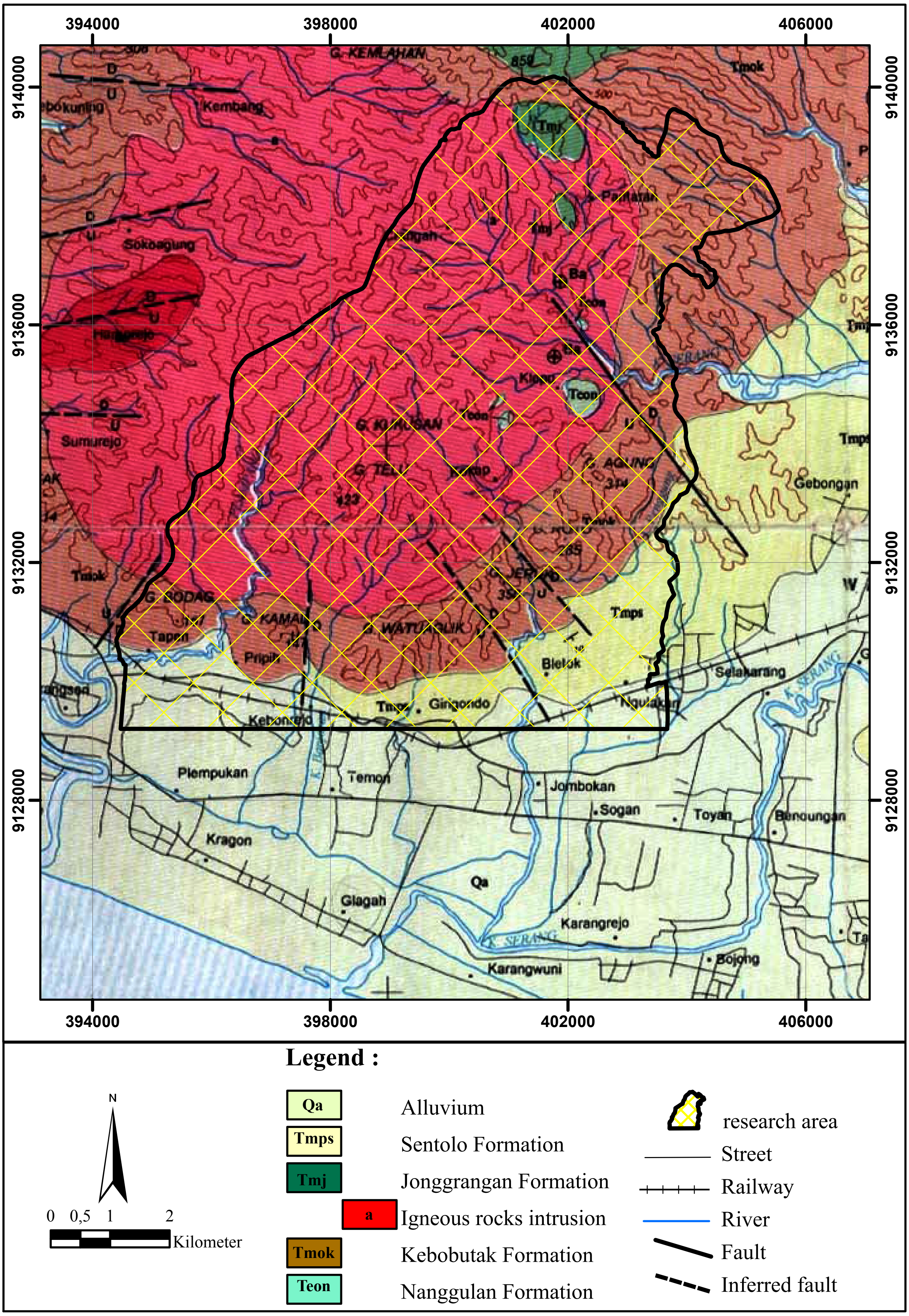

Figure 1: Location of research area and regional geology (Rahardjo *et al.*, 2012)

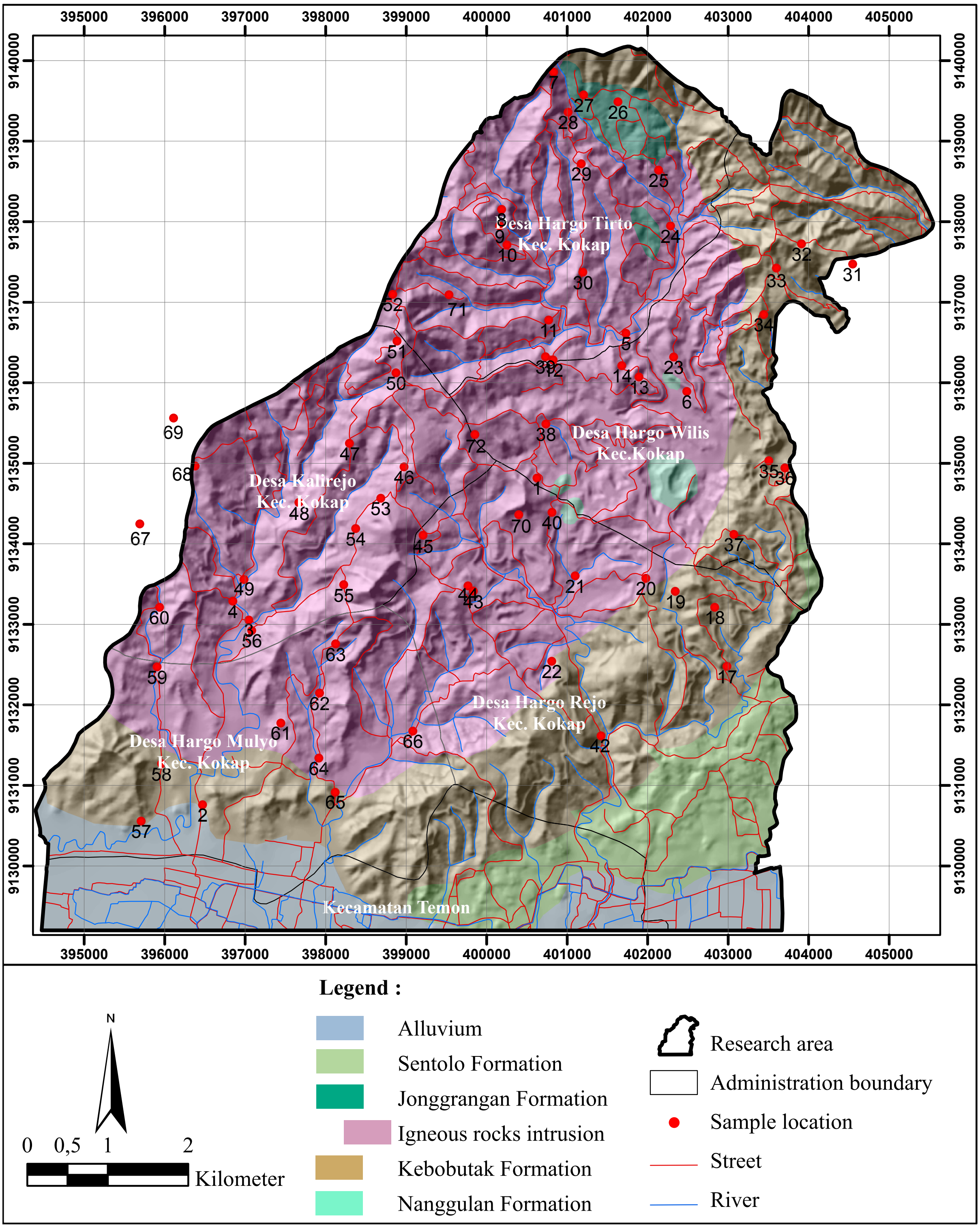

Figure 2: Location of sampling.

Table 1: Classification of rock hardness according to Atteewell & Farmer (1976, in Rai *et al.*, 2014).

Classification	Compressive Strength		Rock Type
	MPa	Kg/cm^2	
Very weak	10 – 20	102 – 204	Weathered and compacted sedimentary rocks – weak
Weak	20 – 40	204 – 408	Sedimentary rocks – weak, schist
Medium	40 – 80	408 – 816	Competent sedimentary rocks, some igneous rocks with coarse grained low fill weight
Strong	80 – 160	816 – 1632	Competent igneous rocks, some metamorphic rocks and fine-grained sandstones
Very Strong	160 – 320	1632 – 3265	Quartzite; igneous rocks with heavy weight – fine grained

ity rocks. There were 69 andesite rock samples taken from the field, in which 53 were taken from Andesite Igneous Intrusion and 16 from Kebo Butak Formation. The location of samples are shown in Figure 2.

The laboratory test were included sample preparation and sample testing. Andesite samples are prepared by cutting and leveling the surface. This sample preparation was done to adjust the dimensions of the sample to the test equipment and the testing method. This test method was based on the American Society for Testing and Material (ASTM) standard number D 5731-95 regarding standard testing methods to determine rock point load strength index. Point load test is an index test that has been widely used to predict the compressive strength of a rock indirectly. The advantages of this test method are relatively simple testing procedures and easy sample preparation. The test sample can be cylindrical, block-shaped (see Figure 3) and in irregular shape. Cylinder shape samples will give results of calculations through simple mathematical equations while irregular shape samples will give results through longer mathematical equations. The ideal sample is cylindrical shape with a diameter of 50 mm. If the diameter is not 50 mm, a correction factor is needed. The outer dimensions of the sample should not be less than 30 mm and not more than 85 mm and the recommended dimensions are 50 mm. The sample surface on the side should be flat, to avoid stress concentration.

Compressive Strength Index of Point Load without correction is calculated with the following equation:

$$I_s = P/D_e^2 \tag{1}$$

Where:

I_s = Compressive strength index of point load without correction (MPa)

P = broken load (N)

D_e = core equivalent diameter = D for diametral test type

D_e = D for core (mm)

D_e^2 = $4A/3{,}15$ for axial test, block-shaped or irregular shape (mm^2)

A = minimum width of cross section from the area that has contact with the machine plate.

After I_s found, the Compressive Strength Index of Point Load with correction is then calculated with the following equation:

$$I_{s(50)} = F \times I_s \tag{2}$$

Where:

$I_{s(50)}$ = Compressive strength index of point load with correction (MPa)

$F = (D_e/50)^{0.45}$

and the final estimated compressive strength value/Uniaxial Compressive Strength of the rock is calculated by the following equation:

$$\delta_{uc} = \mathrm{C} \times I_{s(50)} \tag{3}$$

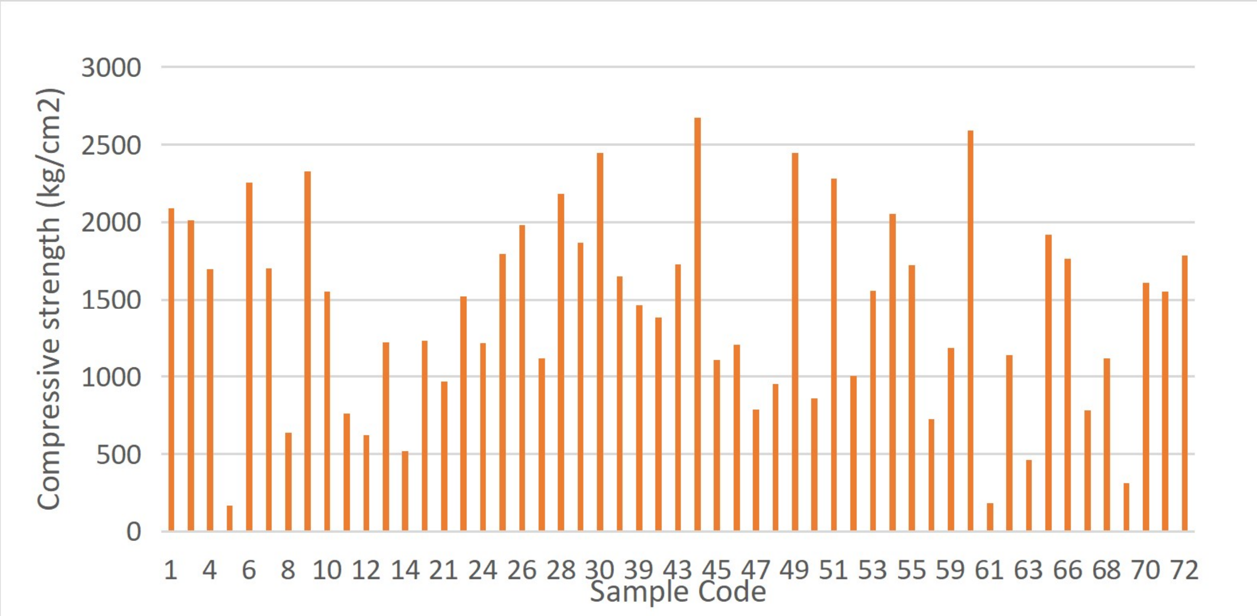

Figure 3: The compressive strength value of the testing samples taken from igneous rock intrusions in the study area.

in which C is the factor determined according to the correlation of δ_{uc} and I_s. The value of this factor can be seen in Table 2.

The results of testing the samples were then evaluated for quality classification and interpolated also extrapolated from each point to find out the zonation of good quality rock by spatial analysis module in the Geographic Information System (GIS) software. To further ensure the distribution of quality of andesite rocks in the study area reveals from GIS, validation of the map was conducting by re-check the boundaries directly to the field.

4 RESULTS AND DISCUSSION

4.1 Quality of andesite rocks as construction material

The results of rock quality testing were broadly grouped into samples from igneous rock intrusions and samples from Kebobutak Formation. The results of testing samples from andesite igneous intrusions can be seen in Figure 4. Andesite rocks found in igneous rock intrusion had a compressive strength ranging from 167.12 kg/cm^2 to 2671.55 kg/cm^2. According to the requirements as construction materials, it can be classified into 4 categories, namely:

a. Low quality with compressive strength values of less than 500 kg/cm^2 in 4 samples (7.55 %).
b. Medium quality with compressive strength values of 500 kg/cm^2 up to 800 kg/cm^2 in 7 samples (13.21 %).
c. Good quality with compressive strength values of more than 800 kg/cm^2 up to 1500 kg/cm^2 in 16 samples (30.19 %).
d. Very good quality with compressive strength values of more than 1500 kg/cm^2 in 26 samples (49.06 %).

The results of rock quality testing from the Kebobutak Formation can be seen in the Figure 5. Andesite rocks found in the Kebobutak Formation had compressive strength values ranging from 451.67 kg/cm^2 to 2783.37 kg/cm^2. According to the requirements in its use as building and road materials, it can be classified into 4 categories, namely:

a. Low quality with compressive strength values of less than 500 kg/cm^2 in 2 samples (12.50 %).
b. No Medium quality with compressive strength values of 500 kg/cm^2 up to 800 kg/cm^2 (0 %).
c. Good quality with compressive strength values of more than 800 kg/cm^2 up to 1500 kg/cm^2 in 3 samples (18.75 %).

Table 2: Compressive strength requirements for natural stone for building materials (Decree of the Minister of Public Works Number: 306/KPTS/1989).

Characteristic	Natural Rocks (used as)					
	Road & building foundation			Stakes and curb stones	Sidewalk floor covering	Ornament stone
	Heavy	Medium	Light			
Minimum average of compressive strength (kg/cm^2)	1500	1000	800	500	600	200

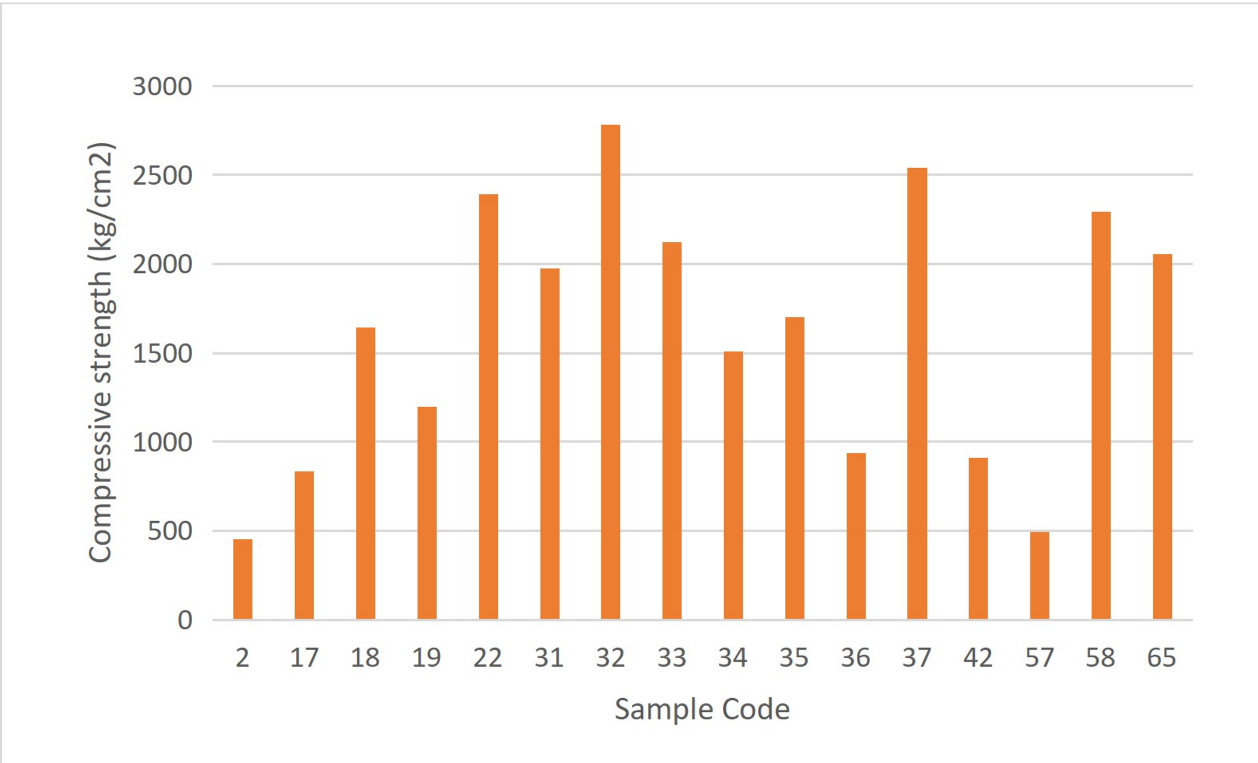

Figure 4: The compressive strength value of the testing result of the samples taken from Kebobutak Formation in the study area.

d. Very good quality with compressive strength values of more than 1500 kg/cm^2 in 11 samples (67.75 %).

From Figure 3 and 4, it can be concluded that about 80 % of andesite rock from both formation in the study area classify into good and very good quality rock for construction materials. In term of geology, the reason why this rock has a high compression strength, surely relate to the texture and the occuring of resistance mineral which composting the rock, such as plagioclase, labradonite, hornblende, hyperstene and quartz. According to Pratama, *et al.* (2017), there are two types of andesites in this region. Through the analysis of thin section, the first type of andesite had porphyritic-aphanitic texture with phenocryst crystal sizes ranging from 0.5 mm to 1 mm while the base mass was <1 mm. The rocks were composed of phenocrysts in the form of labradorite, hypersthene, quartz and calcite plagioclase, while the basic mass was composed of andesite type plagioclase.

The second type of andesite showed a significant abundance of hornblende mineral, having a texture of porphyroaphanitic-phaneroporphyritic, with phenocryst crystal size >4 mm, while the base mass was <1 mm. This second type of andesite was composed of phenocrystic plagioclase minerals with the types of labradorite, hornblende, quartz and hypersthene, while the base mass was composed of andesite type plagioclase minerals. Another finding is, it seem based on the value of compressive strength test results, andesite in the Kebo Butak Formation had a higher average compressive strength than andesite in igneous rock intrusion. However, the small number of samples from Kebo Butak Formation compare to the larger number of samples in igneous rock intrusion may not reflected the variation in the quality of andesite in the field.

4.2 The distribution of andesite rock quality

Based on the compressive strength test value on each sampling location and the distribution of rocks with weathered and massive conditions, a map showing distribution of rock quality was made by applying spatial analysis module in the GIS. Kriging geostatistic method is used to interpolate and extrapolate the point data to become spatial data. The final map of distribution is shown in Figure 5, which is already proven by re-checking the weathering condition of the outcrops. According to Figure 5, the distribution of the quality of andesite rocks in the study area is as follows:

a. 28.92 % had low-quality with compressive strength values of less than 500 kg/cm^2 and was associated with weathered rocks.
b. 2.52 % had medium quality with compressive strength values of 500 kg/cm^2 up to 800 kg/cm^2.
c. 37.68 % had good quality with compressive strength values of more than 800 kg/cm^2 up to 1500 kg/cm^2.
d. 30.88 % had very good quality with compressive strength values of more than 1500 kg/cm^2.

From above explanation, almost 70 % of the study area containing good and very good quality of andesite rock for construction materials and can support the need of material for the large scale projects running and planning in the region. But it should be bear on mind, that not automatically all of this area is potential for andesite mining activities. The map reveals on this study is only showing the quality of the rock but not the potential area for mining activities. For the mining activities, several other factor should be consider such as spatial planning policy, infrastructure like roads, the existing land use, and environmental aspects.

5 CONCLUSION

Based on the results and discussion, there are several important conclusion can be taken from this study, as follows:

a. The andesite rocks found in research area have a compressive strength ranging from 167.12 kg/cm^2 to 2783.37 kg/cm^2.
b. From 53 samples taken from igneous rock intrusion, it showed that 7.55 % had low quality, 13.21 % had medium quality, 30.19 % had good quality and 49.06 % had very good quality.
c. From the 16 samples taken from the Kebobutak Formation, it showed that 12.50 % had low quality, 18.75 % had good quality and 67.75 % had very good quality.

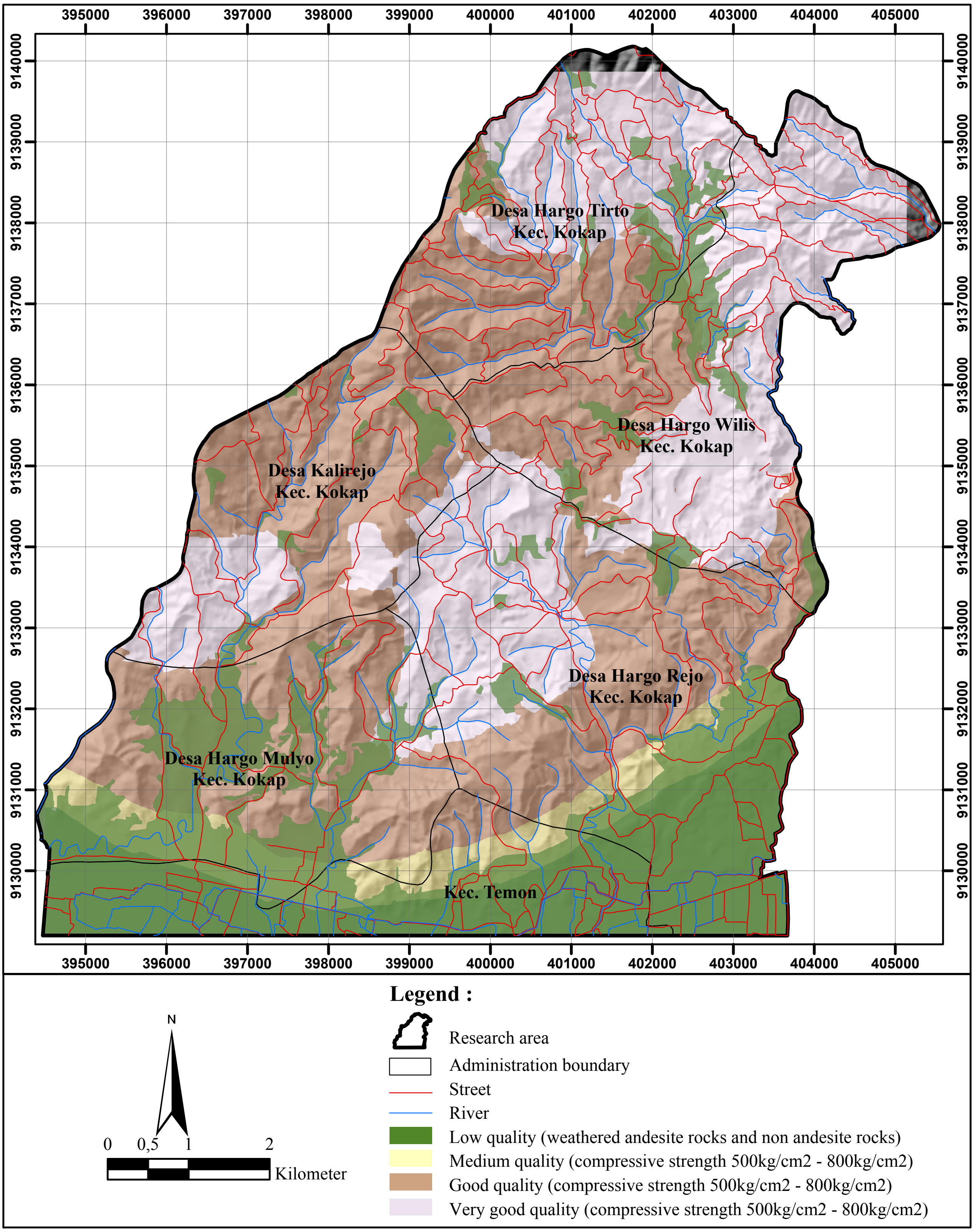

Figure 5: Distribution of andesite rocks quality (classification based on compressive strength requirements of rocks for building foundations and road according to Keputusan Meneri Pekerjaan Umum Nomor: 306/KPTS/1989, SK SNI S-04-1989-F).

d. The final map of rock quality zonation reveals 28.92 % of research area classify as low quality, 2.52 % medium quality, 37.68 % good quality and 30.88 % very good quality. This means almost 70 % of andesite in the Kokap and Temon District can be used to support the construction materials for the running large scale projects.

REFERENCES

ASTM, Designation: D 5731-95, Standard Test Method for Determination of the point load strength index of rock.

Badan Informasi Geospasial (2017) Peta Wilayah Kabupaten Kulon Progo: http://tanahair.indonesia.go.id/portal-web/download/perwilayah (accessed on: February 2018).

Dinas Penanaman Modal dan Pelayanan Terpadu Kabupaten Kulon Progo, Booklet Investasi 2017.

Keputusan Menteri Pekerjaan Umum Nomor: 306/KPTS/1989 Tahun 1989 tentang Pengesahan 32 Standar Konsep SNI Bidang Pekerjaan Umum, Jakarta.

Lazuardi, M., Rauf, A., dan Titisariwati, I. (2016) Potensi serta neraca sumberdaya dan cadangan batu andesit di Kabupaten Kulon Progo Daerah Istimewa Yogyakarta: Jurnal Teknologi Pertambangan, Vol. 1, No. 2 periode September 2015-Februari 2016, hal. 93–98.

Pratama, I.W., Hanif, I.M., Hidayatullah dan Pramumijoyo, S. (2017) Study petrogenesa batuan beku di daerah Semono dan sekitarnya Kecamatan Kaligesing dan Bagelen Kabupaten Purworejo Provinsi Jawa Tengah dengan metode sayatan tipis: Proceeding Seminar Nasional Kebumian ke-10.

Purwasatriya, E.B. (2013) Studi potensi sumberdaya andesit menggunakan metode geolistrik di Daerah Kokap, Kabupaten Kulonprogo, Daerah Istimewa Yogyakarta: Jurnal Dinamika Rekayasa, Vol.9, No.2, Agustus, hal. 54–60.

Rai, M.A., Kramadibrata, S. dan Wattimena, R.K. (2014) Mekanika Batuan: Laboratorium Geomekanika dan Peralatan Tambang Institut Teknologi Bandung, Bandung.

Rahardjo, W., Sukandarrumidi, dan Rosidi, H.M.D. (2012) Peta Geologi Lembar Yogyakarta, Jawa, Cetakan Ketiga: Pusat Survei Geologi, Skala 1:100.000, 1 lembar.

Sudiyanto, A., Probowati, D., and Arief, A.A. (2017) Analisis Kelayakan Ekonomi Rencana Penambangan Batu Andesit di Desa Hargorejo, Kabupaten Kulon Progo, Daerah Istimewa Yogyakarta, Prosiding Seminar Nasional ReTII 2017, STTNas, Yogyakarta, hal. 208–214.

Suwarno, Y. (2017) Analisis potensi wilayah Kabupaten Kulon Progo Provinsi Daerah Istimewa Yogyakarta dari Ekstraksi Peta Geologi: Prosiding Seminar Nasional Geografi UMS, 2017.