ISSN: 2579-5821 (Print)
ISSN: 2579-5546 (Online)
URL address:http://journal.unhas.ac.id/index.php/geocelebes
DOI: 10.20956/geocelebes.v8i1.27319

Jurnal Geocelebes Vol. 8 No. 1, April 2024, 98 – 107

Andesite Quality based on Compressive Strength Tests in the Ulujadi area, Palu City and the Banawa Area, Donggala Regency

Fauziah Alimuddin*, Asri Jaya, Haerany Sirajuddin

Department of Geology, Faculty of Engineering, Hasanuddin University, Makassar, 92171 Indonesia.

*Corresponding author. Email: fauziahalimuddin94@gmail.com

Manuscript received: 21 June 2023; Received in revised form: 24 March 2024; Accepted: 31 March 2024

Abstract

The research location is located in the Ulujadi area, Palu City, Central Sulawesi Province, which is one of the areas that has abundant andesite mineral content. This research aims to optimizing use of andesite rocks in the Ulujadi area of Palu City. The research was carried out using qualitative and quantitative methods in the form of rock sampling and laboratory analysis, namely compressive strength test analysis to determine the technical properties of rocks and petrographic analysis to determine the quality of andesite based on the minerals that make up it. The results of petrographic analysis show that the andesite rocks in the study area are composed of minerals that have a good level of resistance. ST 07 has a mineral composition of plagioclase (38%), pyroxene (5%), biotite (5%), hornblende (7%), and soil mass (45%), and has a compressive strength test of 123 MPa, included in the classification *strong*, and is used as a foundation for light to medium buildings (SNI 03-0394-1989). ST 08 has a mineral composition of plagioclase (32%), ground mass (50%), opaque minerals (5%), orthoclase (5%), quartz (4%), and hornblende (4%), with a compressive strength test value of 97MPa, including in the strong classification, and can be used as a foundation for light to medium buildings. Meanwhile, ST 09 has a mineral composition of plagioclase (30%), hornblende (12%), quartz (3%), biotite (3%), orthoclase (7%), pyroxene (5%), and soil mass (40%).), it is included in the weak category due to the relatively high degree of weathering, and can only be used as an ornamental stone.

Keywords: andesite; building materials; Ulujadi area; compressive strength; petrography.

Citation: Alimuddin, F., Jaya, A., & Sirajuddin, H. (2024). Andesite Quality based on Compressive Strength Tests in the Ulujadi area, Palu City and the Banawa Area, Donggala Regency. *Jurnal Geocelebes*, 8(1): 98–107, doi: 10.20956/geocelebes.v8i1.27319

Introduction

Indonesia is known as an archipelagic country that has conditions The most complex geology in the world. The uniqueness and complexity of geological conditions in the Indonesian archipelago is very interesting to study and study, because the products of these geological processes have the potential to be utilized and used to support development in Indonesia (Wisonir et al., 2018).

The Central Sulawesi region is one of the regions in the world that experiences active geological processes, and this area is included in the Geological Mandala area of Central Sulawesi which has positive and negative impacts. One of the positive things mentioned was the discovery of natural resources in the form of various kinds of minerals and rocks which have quite large potential, such as rock minerals which are useful in the fields of science and engineering, especially in the construction sector. One of the rocks which is a mineral with great potential is andesite.

The use of class C minerals, especially andesite, in the industrial world and construction sector has a very important role in supporting a development project (Alkhabsi et al., 2020). The rapid development of Indonesia has caused an increase in the need for mining materials such as andesite which meets certain criteria (Adjie et al., 2020).

Andesite is a common type of volcanic rock, composed primarily of plagioclase feldspar and amphibole minerals. Its identification and characterization are essential for geological and environmental studies, as well as resource exploration (Sidik et al., 2023).

The increasing need for building materials is marked by an increase in demand for basic raw materials, including andesite stone. This has caused many companies to increase their efforts to increase andesite stone production, either in the form of developing activities to search for new sources in areas that have never been touched to search for main sources or increasing existing production capacity (Ilmi et al., 2018).

The volume of mining production of minerals tends to decline, for this reason, efforts are needed to increase the production of minerals, especially andesite which is the basic material for road construction (Setiawan et al., 2023).

Andesite lava igneous rock has a porphyritic texture and has a sheeting joint, massive and vesicular structure and has a mineral composition of plagioclase and pyroxene (Soviati et al., 2017). Andesite rock must meet the requirements and quality of natural stone for building materials in accordance with the Indonesian Industrial Standard (SII0378-80) (Karim & Suriadi 2019).

Petrographic analysis is used to see the composition of the minerals in rocks. Composition This is done by entering the mineral percentage so that the rock type is obtained. Petrographic analysis can analyze the genesis of its formation something rock. Observations through rock incisions were madeto classify mineralsmainand secondary rock constituent (Yani et al., 2019).

Based on petrography, andesite rocks are composed of several materials and minerals that have microscopic properties that can only be seen with the help of a microscope. These materials include (1) silica (SiO_2) with an amount between 52 – 63%, (2) quartz with an amount of around 20%, (3) biotite, (4) basalt, (5) felsic, (6) plagioclase feldspar, (7) pyroxene (clinopyroxene and orthopyroxene), and (8) hornblende with a very small percentage (Imron et al., 2019).

There are many studies regarding the quality of andesite developed, one of which is in the Batujajar East area, West Bandung Regency. According to Ridwan et al. (2018) andesite in this area can be utilized as road covering material, sidewalks, and decorative stone.

Andesite rock is one of the promising natural resource potentials in Central Sulawesi because it is a raw material for infrastructure development activities. One area in Central Sulawesi that has relatively abundant mineral content is the Ulujadi area, Palu City and is a rock sampling area (Figure 1).

In the research area, the distribution of andesite stone is quite wide, so it is important to provide information about the quality of andesite stone and its use. One way to determine the quality of andesite stone is to determine the mechanical properties of the rock, which is testing carried out by crushing the rock or (destructive testing). For construction needs, it is very important to know the mechanical properties of rock as a benchmark for the quality of the materials used. (Andika & Purnawan, 2020). Noor (2021) states the compressive strength test as one technical property, it is important to know the rock's crushing point against maximum pressure application.

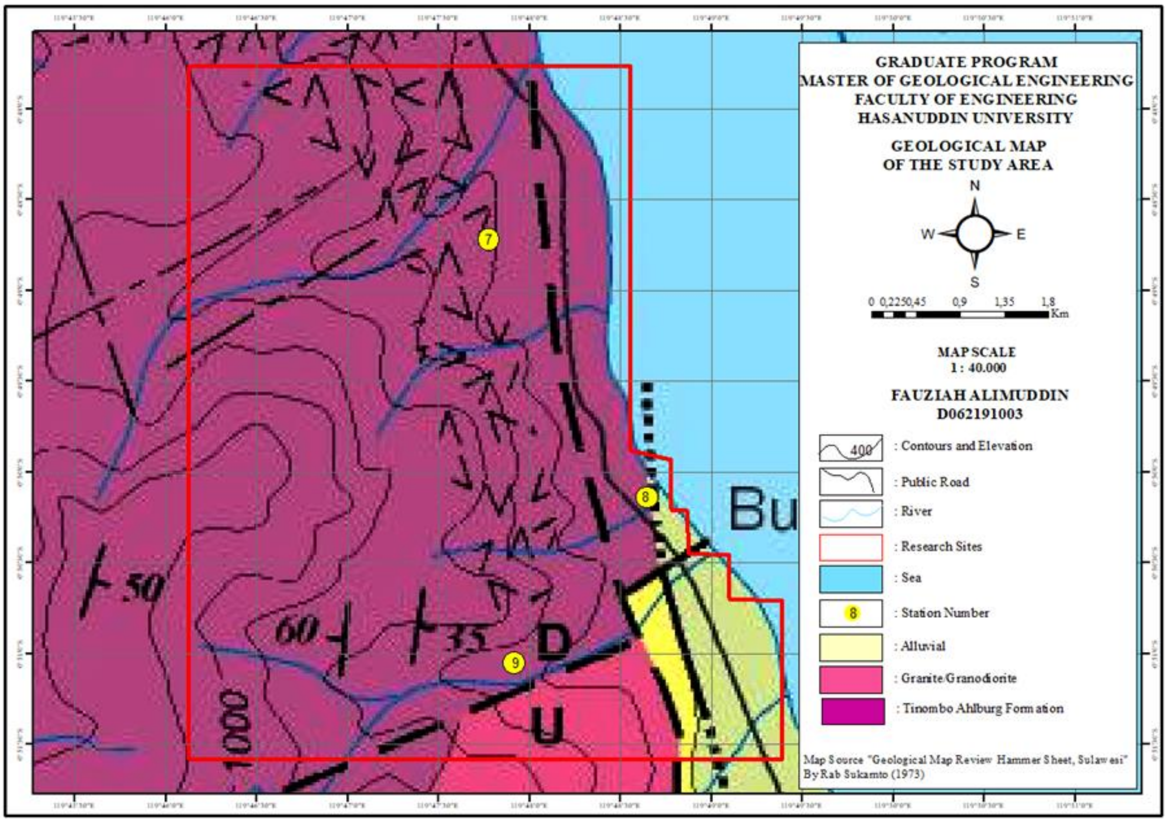

Figure 1. Geological map of research location (Sukamto, 1973).

The uniaxial compressive strength test is one of the important tests in rock mechanics. This compressive strength test is carried out to measure the uniaxial compressive strength of a block-shaped rock sample in one direction (uniaxial). The main purpose of this test is to classify rock strength and compact rock characteristics. This test produces several information, such as stress-strain curve, Poisson's ratio, uniaxial compressive strength, fracture energy, and specific fracture energy (Leba et al., 2020).

Uniaxial Compressive Strength carried out to determine the suitability of andesite stone as a basic material for highway construction. The uniaxial compressive strength of various types of rock varies greatly. Uniaxial compressive strength of intact rock is influenced by its physical properties (Melati, 2019).

The use of rocks is closely related to the physical properties of the rock itself. SNI 03-0394-1989 is generally used to determine the physical and mechanical properties of rocks, and is used as a quality requirement for natural materials for building materials. Table 1 – 3 are used as a reference to determine the quality of a rock based on the results of the compressive strength test.

Rock compressive strength measurements were carried out on each intact rock in the research area. The rock compressive strength test is one of the laboratory tests using a point load test, then the final value is converted into a UCS value in Table 1 (Asupyani, 2020).
Ariyanto et al. (2020) stated that the UCS test is a comparison between the pressure exerted on a rock sample and the surface area of the rock sample under pressure. This compressive strength is calculated when each rock sample experiences failure with the load (P) acting at the time the failure occurs. In the stress-strain curve, the uniaxial compressive strength of each rock sample is at the peak.

Table 1. Strength of Materials (Bienawski, 1989).

Qualitative Description	**UCS (MPa)**	**MORE (MPa)**	**Rank**
Very strong (very strong)	>250	>10	15
Very strong (very strong)	100-250	4-10	12
Strong	50-100	2-4	7
Medium (average)	25-50	1-2	4
Weak	5-25	The use of UCS	2
Very weak	4-5	was continued	1
Very weak (very weak)	1	further	0

UCS: Uniaxial Compressive Strength

Table 2. Quality Requirements for Natural Stone Building Materials (SNI. 03-0394-1989).

	Property	Natural Stone For					
		Foundation Building			Historical Milestones and Roadside Stones	Covering the Floor or Sidewalk	Decorative Stone or Paste
		Heavy	Medium	Light			
1	Press the minimum average strength (Kg/cm^2)	1500	1000	800	500	600	200
2	Rudel off crush resistance a. Index, minimum b. Chapter. Penetrate 2 mm max %	-16	-24	-30	-	-	-
3	Los Angeles shear resistance, through section 1.7 mm, max%	27	40	50			
4	friction wear resistance with Bauschinger, mm/ min, max	-	-	-			
5	Maximum water absorption %	5	5	8	5	5	5* 12**
6	Form immortality with a. Destroyed, maximum %	12	12	12	12	12	12
	B. Cracked/ broken/ deformed	No cracks and no defects			No cracks and no defects		

Table 3. Utilization of andesite stone in the research area based on SII 0378-80.

No	Testing	Quar Press Stone/ Mineral Minimum Kg/cm^2
1	Foundation Building	
	a. Building Pressure Axles Heavy > 7,000 Kg	1500
	b. Building Under Axles Heavy < 7,000 Kg	1000
	c. Building Pressure Axles Heavy > 7,000 Kg	8000
2	Heavy Class	
	a. Class III Heavy Concrete Construction	1200
	b. Class II Heavy Concrete Construction	800
	c. Class I Heavy Concrete Construction	600
3	New Roadside Milestone	500
4	Covering Floor Pavements	400
5	Decorative Stone or Stick Stone	200

The aim of this research is to determine the characteristics of andesite stone based on its constituent minerals and the presentation of chemical elements, as well as to determine the quality of andesite stone in the Ulujadi area, Palu City based on the results of compressive strength tests.

Materials and Methods

In this research, the author used 2 methods, which are qualitative methods and quantitative methods. The qualitative method is the result of data collection in the field, while the quantitative method is the result of petrographic analysis of rocks and the results of laboratory tests on compressive strength which are then adjusted to the quality requirements of natural stone for building materials (SNI 03-0394-1989).

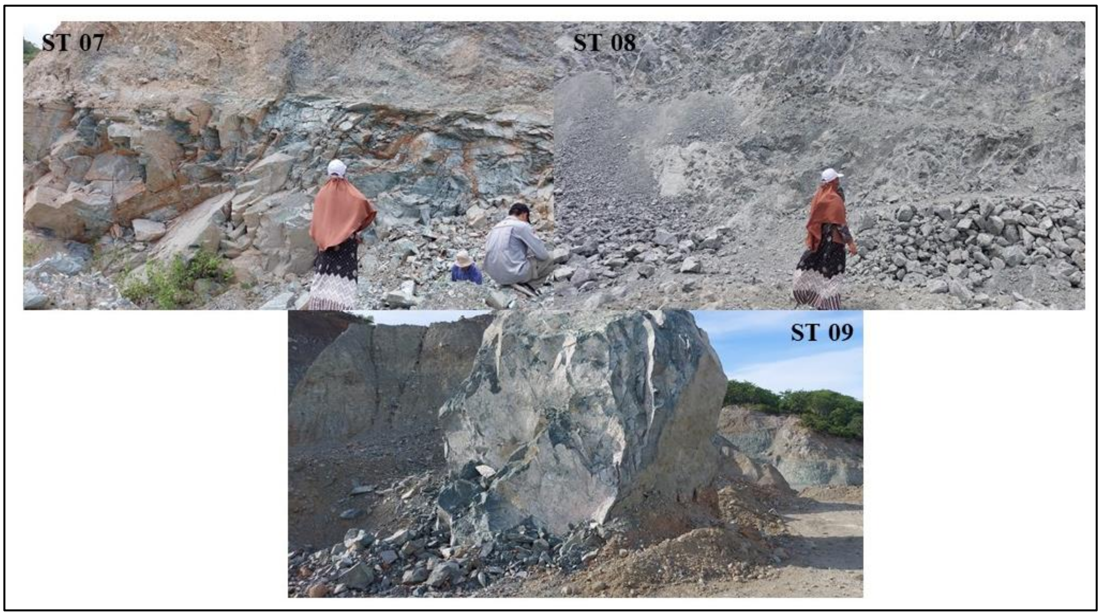

Figure 2. Andesite rocks on the surface.

Figure 3. Rock example cut to size 4x4x4 cm.

Research is carried out by observing andesite rock outcrops on the surface at 3 points (Figure 2). Before the compressive strength test is carried out, rock samples were cut to size 4x4x4 cm (Figure 3), Next a compressive strength test is carried out by applying a one-way load using a uniaxial compressive strength testing machine. The load applied to the sample will increase every second until the sample reaches its elastic limit which is marked by the rock sample breaking.

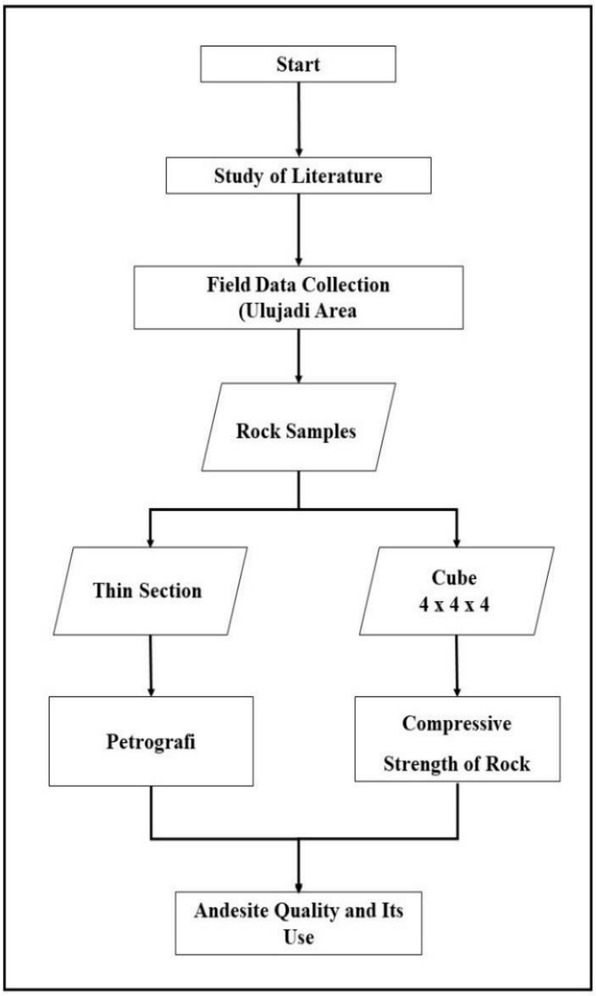

Figure 4. Flow diagram.

Petrographic analysis is needed to prove that the sample taken is indeed andesite rock, and this step includes making a thin incision and then observing the incision under a polarizing microscope to determine the color, texture, structure, and presentation of the mineral composition.

After obtaining the results of the compressive strength test and petrographic analysis, the two were correlated to obtain the type of andesite stone with its compressive strength value. The assessment obtained will determine the quality of the andesite stone and its optimal use. The use of andesite stone refers to the quality requirements of natural stone for building materials based on SNI 03-0394-1989. The research flow diagram can be seen in Figure 4.

Results and Discussion

Rock Compressive Strength Test

Testing the mechanical properties of andesite rock at the research location by analyzing the compressive strength of the rock at several observation locations. Each observation location produces different values (Table 3).

Based on classification Bienawski (1989), very significant differences were found, which are samples ST 07 = 123 MPa, ST 08 = 97 MPa and ST 09 = 17 MPa. Differences in compressive strength are influenced by several internal factors such as rock composition and external factors such as weathering. The average compressive strength value is 79 MPa. Based on the average compressive strength value, the rock unit is included in the strength classification (Table 1).

The differences in the variations in each value in the research area are of course influenced by several factors, such as the mineral composition where the minerals that make up the rock have experienced weathering so that they are less resistant and affect the compressive strength value of the rock. The level of intensive weathering is influenced by weather conditions, if it rains frequently then weathering takes place intensively, as well as the geological conditions of the research area which are greatly influenced by the structure of the Palu Koro so that the rocks are easily fractured and become weathered.

Petrographic Analysis

The results of petrographic analysis using thin section media show that the rocks at the observation location are porphyry andesite rocks. Apart from that, petrographic analysis is also carried out to determine weathering of rocks. The weathering value affects the compressive strength value (Table 4).

Table 4. Compressive Strength Test Data.

No	No. Station	Weight (g)	Size			Content Weight (gr/cm^3)	Cross-sectional area (mm^2)	Maximum Load (N)	Compressive Strength (MPa)
			Length (cm)	Width (cm)	Height (cm)				
1	ST 07	185.7	4.1	4.1	4.1	2.65	1701.00	209.842	123
2	ST 08	150.8	3.6	3.7	3.5	3.23	1332.00	129.862	97
3	ST 09	129.5	3.5	3.6	3.5	2.94	1260.00	21.096	17

Table 5. Results of petrographic observations.

No	Sample code	Matter	Md	Opq	Or	Qz	Hbd	Pixels	Bt	Stone Name
1	ST 07	38	45	-	-	-	7	5	5	porphyry andesite
2	ST 08	32	50	5	5	4	4	-	-	porphyry andesite
3	ST 09	30	40	-	7	3	12	5	-	porphyry andesite

Minerals formed in the study area are plagioclase, orthoclase, quartz, hornblende, opaque, pyroxene, biotite, and groundmass (Table 5). Table 5 discusses the presentation of the constituent minerals and the naming of rock types based on the composition of the minerals contained therein. In addition, there are photos of the incision and the special texture that forms in the incision. Cross-sections of parallel nicol and cross nicol in samples ST 07, ST 08 and ST 9 can be seen in Figure 5 – 7.

The results of microscopic observations of thin sections with sample code ST 07 show the appearance of a yellowish white absorption color, blackish gray interference color, the texture consists of holocrystalline crystallite, aphanitic porphyry granularity, inequigranular relations, mineral size 0.03 mm - 24 mm. The mineral composition consists of plagioclase (38%), hornblende (7%), pyroxene (5%), biotite (5%), and basal mass (45%) with the name Porphyry Andesite (Travis, 1955).

The results of microscopic observations of thin sections with sample code ST 08 show the appearance of a yellowish white absorption color, blackish gray interference color, the texture consists of holocrystalline crystallite, aphanitic porphyry granularity, inequigranular relations, mineral size 0.03 – 22 mm. The mineral composition consists of plagioclase (andesine) (32%), hornblende (4%), quartz (4%), opaque (5%), orthoclase (5%), and glass base mass (50%) with the name Porphyry Andesite. (Travis, 1955).

The results of microscopic observations of thin sections with sample code ST 09 show the appearance of a yellowish white absorption color, a blackish gray interference color, the texture consists of holocrystalline crystallite, aphanitic porphyry granularity, inequigranular relations, subhedral-anhedral mineral shape, mineral size 0.05 mm - 12mm. The mineral composition consists of plagioclase (30%), quartz (3%), hornblende (12%), pyroxene (5%), orthoclase (7%), and glass base mass (40%) with the name Porphyry Andesite (Travis, 1955).

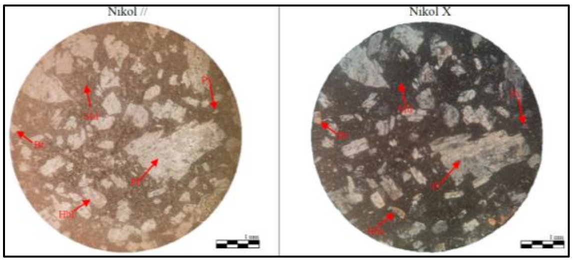

Figure 5. Thin section of andesite stone at ST 07.

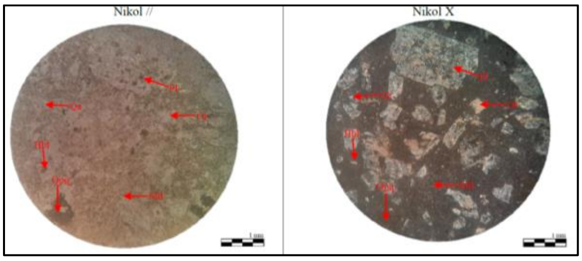

Figure 6. Thin section of andesite stone at ST 08.

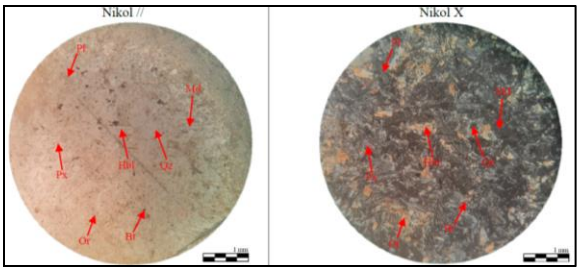

Figure 7. Thin section of andesite stone at ST 09.

Based on the petrographic analysis above, it can be concluded that this rock is an intermediate type of igneous rock with the name Porphyry Andesite (Travis, 1955).

Correlation analysis and recommendations for its use

The research area is porphyry andesite rock, where texture and mineral composition are the dominant factors that influence the compressive strength value. Based on the quality requirements for natural stone for building materials, the compressive strength test results of andesite rocks in the research area (ST 07 and ST 08) meet the qualification standards as rocks that have the potential to be used in the light sector medium building foundations, while

ST 09 has the potential to be used as decorative stone or plaster stone.

Then, based on the specifications issued by the Ministry of Public Works (Indonesian Industrial Standard (SII) 0378-80), andesite stone in the research area can be used as building materials (ST 07 and ST 08), which is for light to medium construction.

Conclusion

Analyzed results of petrographic observations related with the compressive strength of andesite rocks in the research area. The compressive strength values obtained at the research location were ST 07 = 123 MPa, ST 08 = 97 MPa, both of which are included in the strong and very strong specifications, while ST 09 = 17 Mpa including in the weak category because the level of weathering is quite high compared to the two other locations.

Based on the quality requirements for natural stone for building materials (SNI 03-0394-1989), andesite rocks at ST 07 and ST 08 stations can be used as building foundation material, while ST 09 is only intended as decorative stone or plaster stone. Then, based on SII 0378-80, andesite rocks in the ST 07 and ST 08 research areas can also be used as road construction concrete, while ST 09 can only be used as decorative stone or plaster.

Acknowledgements

Thanks to laboratory geological engineering and civil engineering at Tadulako University for allowing me to carry out this research in their laboratory, as well as to all parties who have helped and give enthusiasm for this research.

Author Contributions

Fauziah Alimuddin designed and performed all experiments and wrote the manuscript. All authors have read and approved the final manuscript.

Conflict of interest

The authors declare no conflict of interest.

References

Adjie, M., Sukartono, S., & Trianda, O. (2020). Kualitas Batu Andesit Berdasarkan Analisis Kuat Tekan Daerah Sumberejo Dan Sekitarnya, Kecamatan Durenan Kabupaten Trenggalek, Provinsi Jawa Timur. *GEODA Jurnal Mahasiswa Teknik Geologi*, 1(1), 87–94. https://journal.itny.ac.id/index.php/geoda/article/view/1780

Alkhabsi, G. A., Sukartono, S., & Trianda, O. (2020). Geologi dan Potensi Andesit sebagai Bahan Bangunan berdasarkan Kuat Tekan Daerah Pule dan Sekitarnya, Trenggalek, Jawa Timur. *GEODA Jurnal Mahasiswa Teknik Geologi*, 1(1), 9–15. https://journal.itny.ac.id/index.php/geoda/article/view/1824

Andika, B., & Purnawan, A. (2020). Studi Sifat Fisik dan Sifat Mekanik untuk Mengetahui Karakteristik Batupasir Formasi Balikpapan pada Lereng Penambangan Batupasir, Samarinda. *Prosiding Seminar Teknologi Kebumian dan Kelautan (SEMITAN)*, 2(1), 67–70. https://ejurnal.itats.ac.id/semitan/article/view/1058/861

Ariyanto, K. D., Rabin, S., Saleky, D. B., Titirloloby, A., & Cahyono, Y. D. G. (2020). Analisis Pengaruh Porositas Terhadap Uji Kuat Tekan Unikasial Pada Batu Gamping. *Prosiding Seminar Teknologi Kebumian dan Kelautan (SEMITAN)*, 2(1), 467–471. https://ejurnal.itats.ac.id/semitan/article/view/1058/861

Asupyani, H., Zakaria, Z., Sophian, R. I., & Pratama, R. (2020). Analisis Kekuatan Masa Batuan Pada Tunnel Gudang Handak Berdasarkan Metode Rock Mass Rating (RMR) Bieniawski 1989 PT Aneka Tambang

UBPE Pongkor. *Padjadjaran Geoscience Journal*, 4(4), 365–375. https://jurnal.unpad.ac.id/geoscience/article/view/32177

Bieniawski, Z. T. (1989). *Engineering Rock Mass Classifications, A Complete Manual for Engineering and Geologists in Mining, Civil, and Petroleum Engineering*. The Pennsylvania State University.

Ilmi, I., Taufan, Y. A., Denis, M., Nur, A.A., & Syafri, I. (2018). Identifikasi Prospek Andesit Menggunakan Metode Geolistrik di Kecamatan Cilaku, Kabupaten Cianjur, Jawa Barat. *Bulletin of Scientific Contribution: Geology*, 16(3), 229–236. https://jurnal.unpad.ac.id/bsc/article/view/19927/pdf

Imron, T., Nazli, R. S. S., & Raharja, S. (2019). Strategi Pengembangan Pemasaran Batu Andesit (Studi Kasus pada PT Duta Keluarga Imfaco, Bogor Jawa Barat). *MANAJEMEN IKM: Jurnal Manajemen Pengembangan Industri Kecil Menengah*, 13(2), 127–136. https://doi.org/10.29244/mikm.13.2.127-136

Karim, R., & Suriadi, S. (2019). Kajian Karakteristik Batuan Beku Andesit Sebagai Bahan Bangunan di Daerah Sulamadaha Kecamatan Ternatebarat Kota Ternate. *Dintek*, 12(2), 1–9. https://jurnal.ummu.ac.id/index.php/dintek/article/view/157/181

Leba, E. P., Erong, F. N. O., Marasabesy, Z., & Cahyono, Y. D. G. (2020). Analisis Pengaruh Kuat Tekan Batu Andesit Terhadap Model Dan Arah Rekahan. *Prosiding Seminar Teknologi Kebumian dan Kelautan (SEMITAN)*, 2(1), 417–421. https://ejurnal.itats.ac.id/semitan/article/view/1046/872

Melati, S. (2019). Studi Karakteristik Relasi Parameter Sifat Fisik dan Kuat Tekan Uniaksial pada Contoh Batulempung, Andesit, dan Beton. *Jurnal Geosapta*, 5(2), 133–139. http://doi.org/10.20527/jg.v5i2.6808

Noor, D. (2021). *Kualitas Batuan Andesit Gunung Cipinang, Desa Mekarsari Kecamatan Cikalong Kulon - Kabupaten Cianjur - Jawa Barat Sebagai Bahan Baku Kontruksi Dasar*. Teknik Geologi, Universitas Pakuan.

Ridwan, P., Arfiansyah, K., Kusuma, A. P., Amrullah, F., & Gani, R. M. G. (2018). Identifikasi Karakteristik dan Kualitas Andesit sebagai Bahan Bangunan Daerah Batujajar, Kecamatan Batujajar Timur, Kabupaten Bandung Barat. *Padjadjaran Geoscience Journal*, 2(3), 193–200. https://jurnal.unpad.ac.id/geoscience/article/view/17262/8238

Setiawan, D., Antosia, R. M., & Nugraha, P. (2023). Identifikasi Persebaran Batuan Andesit Sebagai Bahan Utama Agregat Menggunakan Metode Geolistrik Profiling Konfigurasi Wenner-Alpha. *Jurnal Geosaintek*, 9(2), 62–69. http://doi.org/10.12962/j25023659.v9i2.16986

Sidik, F. B., Nurawi, R. W., Muhlisin, H., Giamboro, W. S., & Hidayat, W. (2023). Identification of Andesite Rocks Using Dipole-Dipole Geoelectric Method in Batursari Subdistrict, Pekalongan Regency, Central Java. East Asian Jurnal of *Multidisciplinary Research (EAJMR)*, 2(10), 4149–4160. https://doi.org/10.55927/eajmr.v2i10.6459

SII 0378-80. (1980). *Standar Industri Indonesia No. 0378 – 80, Mutu dan Cara Uji Batu Alam Untuk bahan Bangunan*. Kementerian Pekerjaan Umum.

SNI 03-0349-1989. (1970) *SNI 03-0349-1989 Batu alam untuk bahan bangunan, Mutu dan cara uji*. Badan Standar Nasional (BSN).

Soviati, A. E., Syafri, I., & Patonah, A. (2017). Petrogenesis Batuan Andesit Bukit Cangkring, Daerah Jelekong, Kecamatan Baleendah, Kabupaten Bandung, Jawa Barat. *Padjadjaran Geoscience Journal*, 1 (2), 98–105. https://jurnal.unpad.ac.id/geoscience/article/view/14309/6912

Sukamto, R. (1973). *Peta Geologi Tinjau Lembar Palu, Sulawesi*. Puslitbang Geologi.

Travis, R. B. (1955). *Classification of Rocks*. Colorado School of Mines Quarterly.

Wisonir, W., Anugrah, D., Kusuma, D., Oka, P., Refiyanti, D., Mukti, R. G., & Trisnaning, P. T. (2018). Studi Karakteristiik Andesit Berdasarkan Analisis Petrografi Dan Sifat Keteknikan Batuan Sebagai Bahan Bangunan Di Daerah Mayang, Kecamatan Cisalak, Kabupaten Subang, Jawa Barat. *Geoweek 2018 Proceeding Seminar Nasional Kebumian Ke-11*, 65-73.

Yani, Y., Susilo, B. K., & Falisa, F. (2019). Perbandingan Kualitas Andesit Daerah Gunung Geblegan dan Pondokrasa, Kabupaten Lebak, Provinsi Banten Melalui Metode Kuat Uji Tekan Batuan dan Petrografi. *Proceeding Seminar AVOER XI 2019*.