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ASSESSMENT OF ROCK AGGREGATES QUALITY FROM VARIOUS QUARRIES IN AND AROUND GONDAR TOWN, ETHIOPIA

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Abstract

Good access to aggregate materials is essential for future infrastructure development and continued economic growth. During the early stages of any project such as in roadway, construction and quarry prospecting there is need to estimate the quality of crushed rock aggregates. This study summarizes a general series of common strength tests carried out on rock aggregates from quarries in surroundings of northern Gondar, Ethiopia. For the investigation, crushed rock aggregate samples were obtained from eight different quarry sites to evaluate their quality based on different physical and mechanical properties. The locations of quarry sites are recorded by using handled GPS. Generally spatial technology are widely used for creation of spatial data, in this study a different approach for creating base map was carried out by using an open source python programming language. This method of map making technique also be used as alternate resource in spatial technology, government organizations and research communities. The major rock sources identified in study area are such as aphanitic basaltic rock, very aphanitic basaltic rock and phanitic basaltic rock. These rocks where predominantly excavated and produce various qualities of crushed stones aggregates for road materials and construction industry. But there is a lack in data about the quality of aggregates in this region. Laboratory testing was performed on samples obtained from the quarry sites to evaluate the suitability of the materials for use as aggregate in road and construction. The specific gravity, water absorption, aggregate crushing value and Los Angeles tests were performed on samples. The overall results indicates that the moisture content various about 0.2% to 0.72%, with specific gravity value of

about 0.41 to 2.94, aggregate crushed value is of 9.5% to 28.3%, water absorption is of about 0.54% to 1.82% and los angeles abrasion is of about 8.8% to 11.4%. Based on the results, the study concluded that the available quarry materials are suitable for use as coarse aggregate for road pavement and concrete. The study also recommends that good quality coarse aggregate are available in enormous quantity within in the study area. These rich sources of aggregate can be widely used as engineering material with sustainable uses of resources.
Keywords: Aggregates, Gondar, Python, ACV

1. Introduction

Locating sources for aggregate, armourstone and other building materials is often a task for an engineering geologist. Natural aggregates are most commonly obtained and are relevant for Ethiopian construction sector since artificial aggregates are hardly produced in the country. (Abebe Dinku, 2006). Materials represent a major expense in construction, so minimizing procurement costs improves opportunities for reducing the overall project costs. Many developing countries have trusted comprehensively, in the past, on hard granites and granitic gneisses for the production of rock aggregates and rock products for civil engineering works including the construction of roads and buildings Kamal (2006). According to Millard (1990), quarries can provide various qualities of aggregates and crushed stones for construction industry, road and railway development. Concrete is of great importance as a structural material and special attention has to be paid to the nature of the aggregates used (Dawit Alene, 2012). Generally an aggregate should be hard, durable, uniform and clean, as well as high abrasion resistant. Ahmet Teymen (2019) used the regression analyses which indicated strong correlations between Los Angeles abrasion and mechanical tests of aggregate. Abbas Mohajerani (2017) in addition, field observations were made to identify and recognize different rock types and geological structures. Generally there is a demand for crushed stone aggregates has increased, supplies of good quality aggregates close to urban areas are becoming depleted (Grattan-Bellew, 1978; Witczak et al., 1971).This study is significant to make aware the people, the contractor, policy maker, municipality and stakeholders. Therefore, aim of this study was to assess the availability of rock aggregate and characterize the physical and mechanical properties of the aggregates in the study area. The specific objectives of this project are (i) To evaluate the rock

aggregate materials from different quarries in the study area. (ii) To identify the various rock types, create a location and base map of the study area using python. (iii) To determine the specific gravity and water absorption of the samples. (iv) To determine the aggregate crushing value of the samples. (v) To determine the los angeles abrasion test value of the samples.

2. Materials and Methods

The materials obtained for the experiments were sourced from the Near to Lozza Mariyam Church, Near to Abuneharra Church, Dengay Gores, Megech (Tensaee), Loza Mariam Blajigie, Near Airport and Surur. The scope of the study was to assess the availability and characteristics of rocks aggregate quality. The physical properties of aggregates such as the moisture content, the water absorption and the specific gravity were determined and the mechanical properties of aggregates such as crushing strength value and Los Angeles abrasion test were determined in the laboratory. The generalized methodology used for the present study is shown in the following figure1.

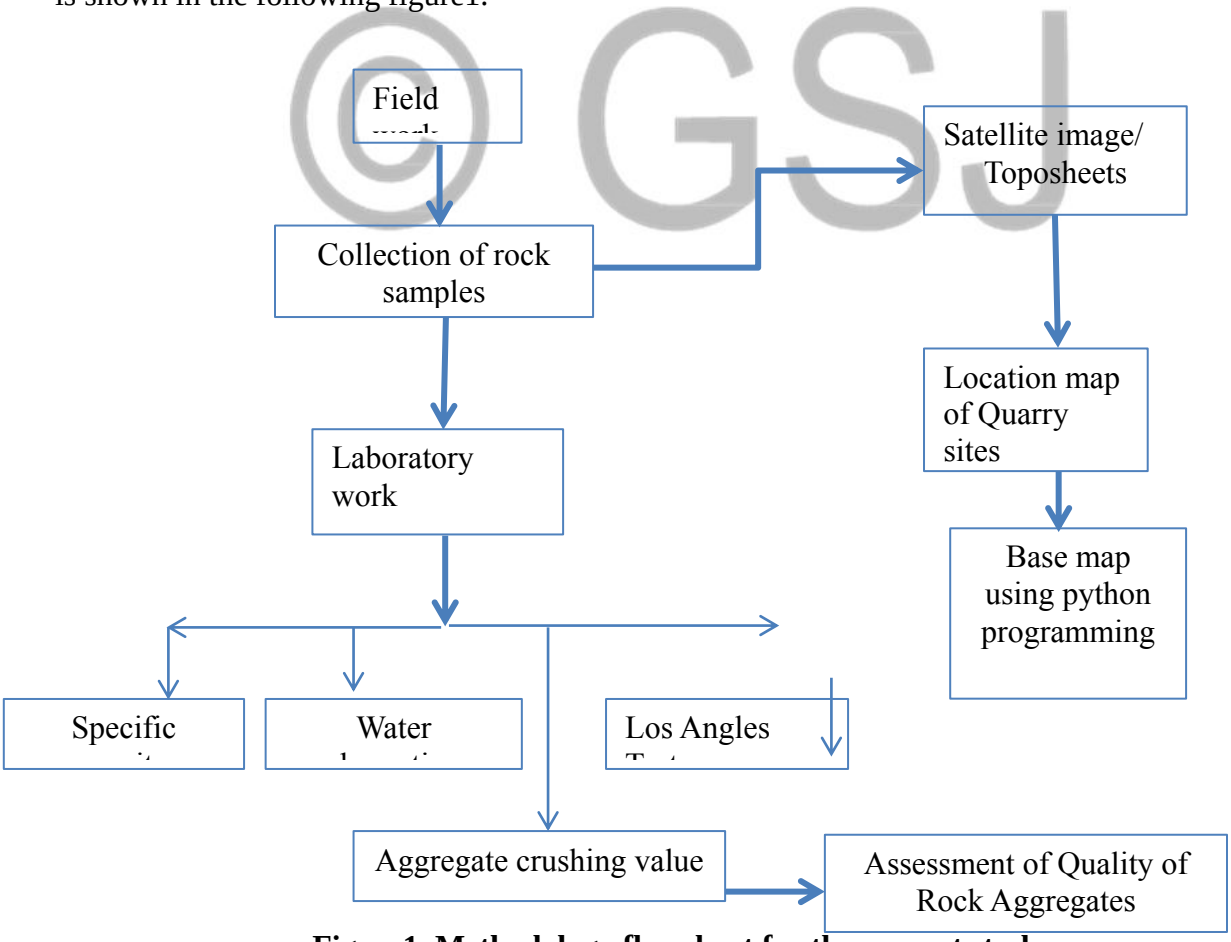


Figure1. Methodology flowchart for the present study

3. Study area

The study area is located in the North Gondar Zone of Amhara Region, Ethiopia. It is located North of Tana Lake and South West of the Semien Mountains. It has a latitude and longitude of 12°36′N 37°28′E and 732 km far from Addis Ababa. The altitude of the study area is around 2133m above mean sea level (msl). The area is highly undulated with different topographic features and various quarries are operated (Figure1). The locations of the collected rock samples from various quarries are recorded by using a handheld GPS and given in the table1. The samples in the field were broken by using sledge hammer. Two major rock units are identified during the filed investigation as aphanitic basalt and phanitic basalt. Aphanitic basalt unit is characterized by very fine grained granular rocks. The crystals are so small that cannot be observed by naked eye. This aphanitic basalt characterized by grey to black color and it is highly strong to cut, which are located around airport quarry site and in Loza Mariam quarry. Phaneritic basalt unit has some minerals that can be seen by naked eye in Blajigie quarry site it has dark grey to black color for the fresh and reddish color for the weathered part. Also the study area specifically near to airport quarry site there is an intercalation of basaltic rock and paleo sediment rock is exposed well (Figure2).

Figure2. Various rock samples and field investigations

Table 1 Sample location with their GPS values

Sl NO	Sample ID	Latitude (N)	Longitude (E)	Location Name
1	QS1	12.5979	37.4372	Near to Lozza Mariyam Church
2	QS2	12.5799	37.4504	Near to Abuneharra Church
3	QS3	12.6025	37.4317	Dengay Gores
4	QS4	12.4944	37.4447	Megech (Tensaee)
5	QS5	12.52957	37.42852	Loza Mariam
6	QS6	12.52601	37.43015	Blajigie
7	QS7	12.52325	37.4301	Near Airport
8	QS8	12.52	37.42346	Surur

4. Results and Discussion

(i) Prepartion of base map using python

The base map is prepared by using an open source software based on python progamming under the Jupyter Notebook environment. The sample locations where collected by using a handheld GPS and stored in a CSV file format. For creating this base map some of the modules such as pandas and geopandas where imported within the jupyter notebook. Intially the sample locations are read by using the following command "pd.read_csv" and entering the file locations. The quarry locations are tranformed to a geometry and set to a crs ={'init: epsg:4326'}. For creating the geometry we have used the commands like "from geopandas, import GeoSeries and to convert the locations to point "from shapely.geometry import Point" was used. Further to show the quarry loaction in a GIS envirnment the following commmands like "import folium" was used and to display the map the folling three lines will help to diplay the overall location map.

m = folium.Map(location=[12.526005, 37.430145], zoom_start=10),
folium.GeoJson(qloactions.to_json()).add_to(m); m.

Here the module folium uses the open source Leaflet maps as a refrence and the sample loctions are overlaid above it. The prepared map can be further exported or saved in variours format.The prepared study area map with the quarry locations was expoted or saved as an "html" format and viewed for better resolutions.

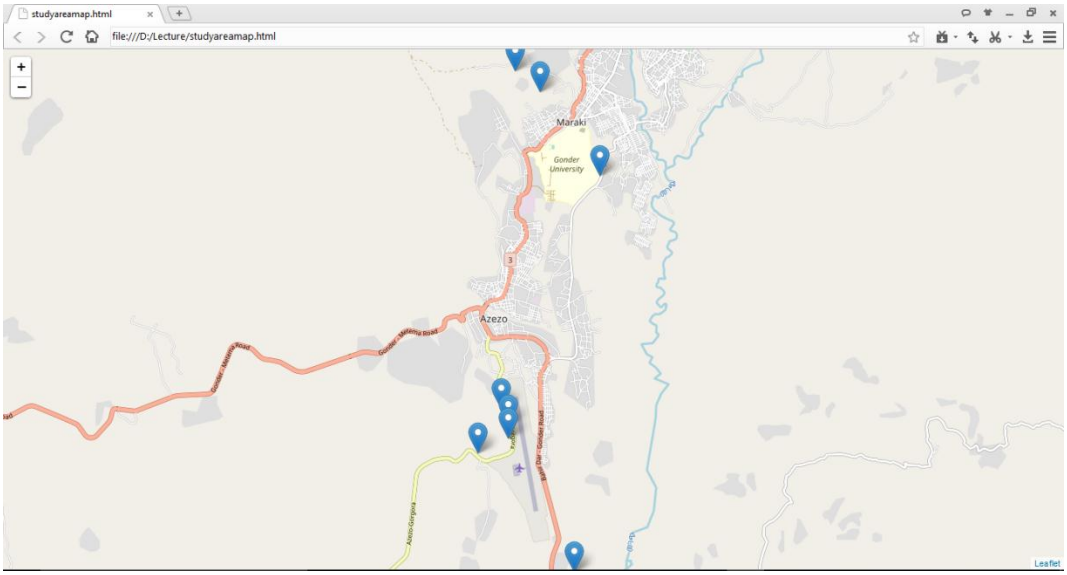


Figure3. Study area with quarry site locations

(ii) Laboratory test results on rock samples

Due to rapid infrastructure development in Gondar town, it was necessary to identify in-situ crushed rock aggregate sources that could potentially be developed into quarries in the future. Apart from active quarries, construction aggregates are mostly sourced from the outcrops in this area. A number of in-situ hard-rock samples were collected from potential sites during the field investigation. Knowledge of physical and mechanical properties of any rock is very important in determining what sort of application it can be used for. The strength and durability of a rock can be determined by the use of appropriate testing equipment. Laboratory testing was performed on samples obtained from the quarry sites to evaluate the suitability of the materials for use as aggregate in road/construction. The moisture content, specific gravity, water absorption, aggregate crushing value and los angles tests were performed on samples and the results are given in the table 2 and the simple line chart was prepared by using python code as shown in the figure4.

The results indicate that the moisture content ranges between 0.2% to 0.72% (Table2). Specific gravity is the ratio of the mass of a given volume of aggregate to the mass of an equal volume of water. The results indicates that the moisture content with specific gravity value of about 0.41 to 2.94 (Table2) and plotted as spatial data (Fig 4). Absorption for aggregates is important since it influence the performance of aggregates due to the drying process. Water

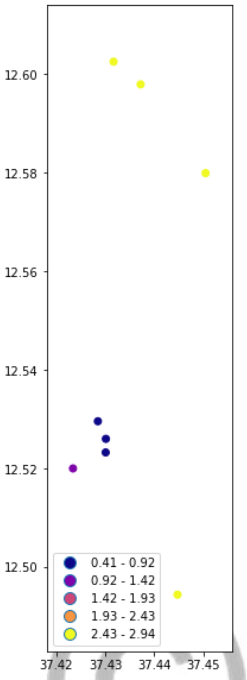
absorption is an indirect measure of the permeability of an aggregate, which, in turn can relate to other physical characteristics such as mechanical strength, shrinkage and to its general durability potential.

Table 2 Laboratory test results of the analyzed samples

SL. NO	Sample ID	Specific gravity	Moisture content	Water absorption	Aggregate Crushed Value	Los Angeles Test
			(Values in %)			
1	QS1	2.91	0.57	0.77	28.30	10.40
2	QS2	2.91	0.44	0.73	23.00	10.00
3	QS3	2.89	0.61	0.86	20.00	9.80
4	QS4	2.94	0.72	0.74	26.00	10.10
5	QS5	0.84	0.32	0.83	11.50	8.80
6	QS6	0.41	0.20	0.54	9.50	10.10
7	QS7	0.68	0.37	0.73	10.70	11.40
8	QS8	1.09	0.65	1.82	16.80	9.45
Min		**0.41**	**0.20**	**0.54**	**9.50**	**8.80**
Max		**2.94**	**0.72**	**1.82**	**28.30**	**11.40**
Average		**0.76**	**0.39**	**0.98**	**12.13**	**9.94**

The water-absorbing capacity of any rock is influenced by its compaction, size and proportion of the pores, minerals present and their mode of occurrence, degree of weathering and alteration of the rock, and in some cases the existence of micro fractures within the rock. In general, less absorptive aggregates often tend to be more resistant to mechanical forces and to weathering. The results indicate that the moisture content water absorption is of about 0.54% to 1.82% (Table2). Mechanical tests are routinely carried out on aggregates to assess their physical behavior, such as strength, susceptibility to polishing, attrition and abrasion. The aggregate crushing value gives a relative measure of the resistance of an aggregate crushing under gradually applied compressive load. The aggregate crushing value ranges between 9.5% to 28.30% (Table2). Generally if the aggregate crushing value is 30% or higher the result may be anomalous and in such cases the aggregate is not recommended. Whereas in the study area the aggregate crushing value lies below the threshold values. One of the most important properties for determining the quality of aggregates is its abrasion resistance, the best known and most widely applied test used to measure abrasion resistance is the Los Angeles abrasion test (LA).

The results indicate that the Los Angeles abrasion is of ranges between 8.8% to 11.4% (Table2) and plotted as spatial data (Fig 5). The comparison of data is shown with simple line chart of the analyzed samples which is prepared by using python(Fig 6).



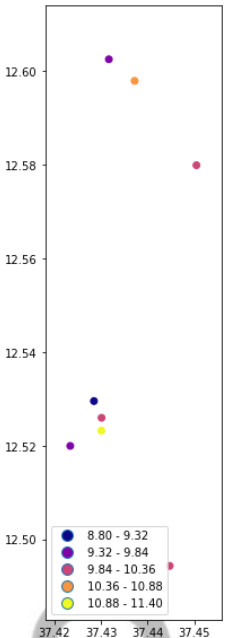


Figure4. Spatial data of specific gravity **Figure5. Spatial data of Los Angeles test**

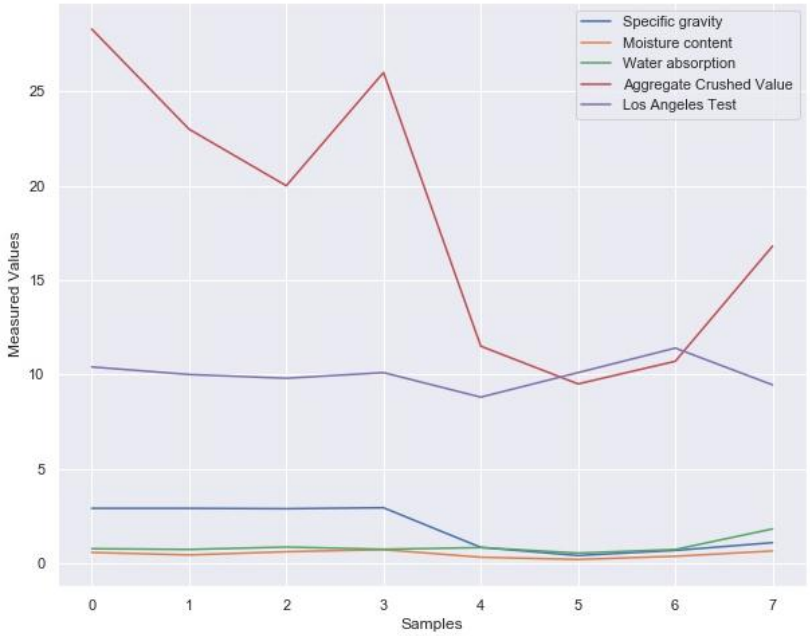


Figure 6. Comparison with simple line chart of the analyzed samples

5. Conclusion

This study summarizes a general series of common strength tests carried out on rock aggregates from quarries in surroundings of northern Gondar, Ethiopia. The overall results indicates that the moisture content various about 0.2% to 0.72%, with specific gravity value of about 0.41 to 2.94, aggregate crushed value is of 9.5% to 28.3%, which is generally below 29% is regarded adequate for road materials. Water absorption is of about 0.54% to 1.82% and los angeles abrasion is of about 8.8% to 11.4%. Los angeles values below 15 % are regarded as good and values above 25% are regarded as poor resistance with respect to disintegration. Python is a simple and powerful programming language, it does not need any pre programming knowledge. An attempt has been made with new approach for creating a base map and spatial data by using an open source python programming. For plotting these data python based modules are used. Based on the results, the study concluded that the available quarry materials are suitable for use as coarse aggregate for road pavement and concrete. The study indicates that good quality coarse aggregate resources are available in enormous quantity within in the study area. These rich sources of aggregate can be widely used as engineering material for development purpose. The quarry sites around Gondar town are not systematically selected for engineering activities. The quarry sites are also not properly rehabilitated after mining; therefore a clear balance and careful environmental management is also needed for future development. The study also recommends a need for periodic environmental auditing and monitoring of quarry sites and also should encourage sustainable use of resources.

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