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A CASE STUDY OF LOSS QUANTIFICATION AND QUALITY ASSESSMENT IN GRAVEL QUARRIES IN EGYPT'S ASSIUT PROVINCE

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ABSTRACT

This reflects the fact that the Egyptian government's 2030 strategy provides for the creation of a variety of new cities, which necessitates the building of a multitude of highways that connect cities in order to encourage commerce between those cities and shoreline ports. The objective of the study is to evaluate the gravel materials for this purpose as well as to find out the percentage of losses in the quarries under study. The study will also analyze the economic losses associated with quarry operations by assessing many factors. Specimens are collected from the eleven quarries around the Assiut Governorate. The findings provide insight into how to best manage gravel resources in order to maximize their potential and minimize waste. Furthermore, this study can be used as a reference for future studies on gravel resources in Egypt. The results demonstrate that the gravel experiments had been straightforward to conduct and that the aggregate from these areas was appropriate for establishing roads and for blending with asphalt and cement. The analyzed quarries' gravel loss turned out to be 28.3 – 40.05%.

KEYWORDS: Gravel Specification, Construction Materials, Quarry, Chemical Properties.

دراسة حالة لتقدير حجم الفاقد وتقييم الجودة في محاجر الزلط في محافظة أسيوط في مصر

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الملخص

تعكس الدراسة استراتيجية الحكومة المصرية ورؤية الدولة 2030 لإنشاء مجموعة متنوعة من المدن الجديدة وهذا الأمر يتطلب بناء العديد من الطرق السريعة بغرض ربط المدن وتشجيع التجارة بين تلك المدن (مراكز المحافظة) والهدف من الدراسة هو تقييم الركام (الزلط) لهذا الغرض ومعرفة نسبة الهالك في تلك المحاجر. وقدمت الدراسة تحليل العوامل الاقتصادية المرتبطة بعمليات المحاجر من خلال دراسة العديد من العوامل. تم جمع العينات من احد عشر محجرا من محافظة أسيوط . منطقة الدراسة توفر النتائج نظرة ثاقبة حول كيفية إدارة موارد الحصى بشكل أفضل من أجل تعظيم إمكاناتها وتقليل النفايات .علاوة على ذلك، يمكن استخدام هذه الدراسة كمرجع للدراسات المستقبلية حول موارد الحصى في مصر وكانت نتائج الدراسة توصي بان الركام

(الزلط) الناتج من منقطة الدراسة مناسبا للاستخدام في انشاء الطرق وكذلك يمكن استخدامه في الخلطات الاسفلتية ووجد ان نسبة الهالك في تلك المحاجر يتراوح بين 28.3 -40.05%.

الكلمات المفتاحية : مواصفات الحصي، مواد البناء، المحاجر، الخواص الكيميائية

INTRODUCTION

In the construction of infrastructure and roadways, gravel plays a crucial significance as a construction and building material. Egypt has seen a considerable increase in investments, particularly in projects to create new roads and buildings. The grain size distribution, specific gravity, water absorption, and bulk density of the gravel samples were evaluated in order to assess their physical characteristics. The total organic carbon, total nitrogen, pH, and electrical conductivity of the gravel samples were measured in order to assess their chemical composition. Los Angeles abrasion value, unconfined compressive strength, and point load index measurements were used to examine the mechanical characteristics of the gravel samples. According to the study's findings, each of the five locations had favorable physical and mechanical characteristics that made them ideal for use in construction projects. The values for several parameters were, however, higher in some locations than others. For utilization in infrastructure projects, the chemical characteristics of the gravel samples was determined to be within allowable limits [1-2].

The study also found that the gravel from these quarries had a higher resistance to erosive abrasion, making it a more durable alternative for road building. The study also found that the gravel from these quarries was less affordable than that from other sources, making it a more affordable selection for highway construction [3]. Because of this, the viability of using gravel in building heavily depends on its mechanical and physical characteristics, which are normally determined by research laboratories and organizations. Size, shape, color, texture, porosity, strength, and durability are some of the characteristics of gravel. Gravel is frequently divided into several sizes [4]. Gravel can be collected in a variety of sizes, from small flecks to massive boulders. Shape: Gravel exists in a variety of forms, inCluding as spheres, angular pieces, and irregular shards. White, grey, black, red, and brown are just a few of the many variations of gravel that are offered. According to the type of material used in its production, gravel's texture can range from smooth to rough. Porosity: The capacity of a substance to permit the passage of water or air is referred to as porosity. The thick structure of gravel often causes a lack of porosity.

Gravel's strength is influenced by the empathetic quality of the materials used in its formation. In general, stronger gravel with more resistance to wear and tear over time will be produced using higher grade materials. Durability: When deciding whether to use gravel for constructions, durability is a crucial consideration because it establishes how long the gravel will endure before needing to be replaced or repaired. Generally speaking, gravel made from higher grade materials will be more resilient and able to survive severe weather and heavy loads for longer periods of time without degrading or breaking down quickly.

Gravel's morphological attributes, inCluding density, porosity, and water absorption capability, were identified. The mass to apparent volume ratio of a dry specimen is known as density. When compared to the same amount of rock containing only the solid phase, the weight of a unit volume of rock in its natural state is significantly. The porosity of stone is Closely related to significant traits inCluding mechanical strength and liquid behaviour. Higher prosity means the stone can absorb liquids more readily and has a lower mechanical strength. A stone's capacity for absorbing liquids and gases is referred to as its absorption capacity. Tests are carried out in this investigation on specimens that measure 50 x 50 x 50 mm [5–6]. The samples were dried at 105°C for 24 hours to ascertain their potential for absorption. They were then submerged in distilled water for 24 hours at 20°C and 2°C. The absorption capacity of the samples was calculated by subtracting the dry weight of the sample from its wet weight. The difference was divided by the area of the polished surface to obtain the absorption capacity in gm/cm^2 [7]. The Los- Angeles test is a standard test used to measure the mechanical properties of rocks. It involves applying a compressive load to a rock sample and measuring the amount of strain that is produced. The uniaxial compressive strength is calculated by dividing the maximum applied load by the cross-sectional area of the sample. The abrasion resistance is determined by measuring the amount of wear on the surface of the rock sample after it has been subjected to abrasive forces. The chemical composition of quartz is SiO_2, while the chemical composition of carbonate is $CaCO_3$. Other minerals present in the samples may inClude feldspar, mica, Clay minerals, and iron oxides. XRD can identify the presence of quartz and carbonate as well as other minerals in a sample [8].

Sand and gravel are the most common aggregates used in Egypt. These are usually extracted from the Nile River, which is the main source of sand and gravel in the country. Other sources inClude quarries, coastal areas, and desert regions. The sand and gravel extracted from these sources are used for various construction projects such as roads, buildings, bridges, and dams. In addition to this, they can also be used for landscaping purposes. Geotechnical evaluation of the exposed gravel quarries in Assiut should inClude a comprehensive assessment of the physical and chemical properties of the material. This should inClude tests such as grain size analysis, Atterberg limits, specific gravity, and compaction tests. Additionally, laboratory tests such as unconfined compressive strength, direct shear strength, and triaxial shear strength should be conducted to determine the geotechnical characteristics of the material. The results of these tests can then be used to determine the suitability of the material for various engineering applications. Furthermore, field investigations such as borehole logging and in-situ testing should be conducted to gain a better understanding of the subsurface conditions at the quarry sites. This information can then be used to develop an appropriate design for any engineering project that utilizes materials from these quarries [9].

Geotechnical behavior is the way in which soil and rock respond to external forces such as loading, vibration, and water pressure. It is important to evaluate the geotechnical behavior of soils and rocks to determine their suitability for use in various engineering applications. This evaluation inCludes testing the strength, compressibility, permeability, shear strength, and other properties of the material. The results of these tests can then be used to design foundations, slopes, embankments, retaining walls, and other structures that are safe and stable. Alkaline reactivity is an important parameter for assessing the quality and economic importance of gravel deposits. Alkaline reactivity is determined by measuring the pH level in a sample of gravel. A higher pH level indicates higher alkaline reactivity, which can lead to increased weathering and degradation of gravel deposits over time. These costs should also be in Cluded in any estimates presented to the quarry administration of Assiut Governate. The results of the study can be used to inform future studies on gravel losses in similar quarries as mention in Table 1. The findings can be used to develop strategies for reducing gravel losses, such as improved quarry management practices, better maintenance of equipment, and improved safety protocols. Additionally, the results can help inform decisions about the types of materials that should be used in quarry operations and how they should be managed. Finally, the findings can provide insights into how to better monitor and track gravel losses in order to ensure that operations are running efficiently and safely.

Table 1. Sieve analysis of samples.

Opening Size (mm)	20	10	5	pan
Passing (%)	100	74.7	2.3	0

GEOLOGY OF THE STUDY AREA

The area of study is mainly a rocky platform of relatively low to moderate altitude attains its maximum height in its eastern side. It has been characterized throughout its history by arid

Climatic conditions [10]. Geomorphologically, the study area can be divided into the following geomorphic units: 1. Structural Plateau, 2. Scarps, 3. Pediment, 4. Fanglomerate, and 5. Plains.

The percentage of gravel deposit loss is also an important parameter for assessing the quality and economic importance of gravel deposits. This parameter measures how much material has been lost due to weathering or other processes over time. A higher percentage indicates that more material has been lost from the deposit, which can reduce its economic value. For example, authors studied the sedimentary rocks of the area and found that they are mainly composed of limestone, sandstone, and shale. Additionally, they studied the mineralogy of Assiut province and identified several minerals including quartz, feldspar, mica, and Clay mineral which indexed during last and earlier studied related to articles review.

Furthermore, Mansour et al., [11] conducted a detailed study on the geochemistry of Assiut province and found that it is rich in calcium carbonate and iron oxide minerals. These studies provide valuable information about the geological nature of Assiut province which can be used to better understand its geology. Finally, it is important to consider any additional costs associated with removing or mitigating this issue, such as labor costs or equipment costs for excavation or removal of the Clay layer. Locations of the study area and the quarry are shown in Figure 1. This study focuses on the gravel evaluation beside that quarry evaluation to be suitable for main uses and the economical factor to be used this quarry, so one the focal points to evaluate the percentage of waste such as Clay, silt, or other harmful material for construction.

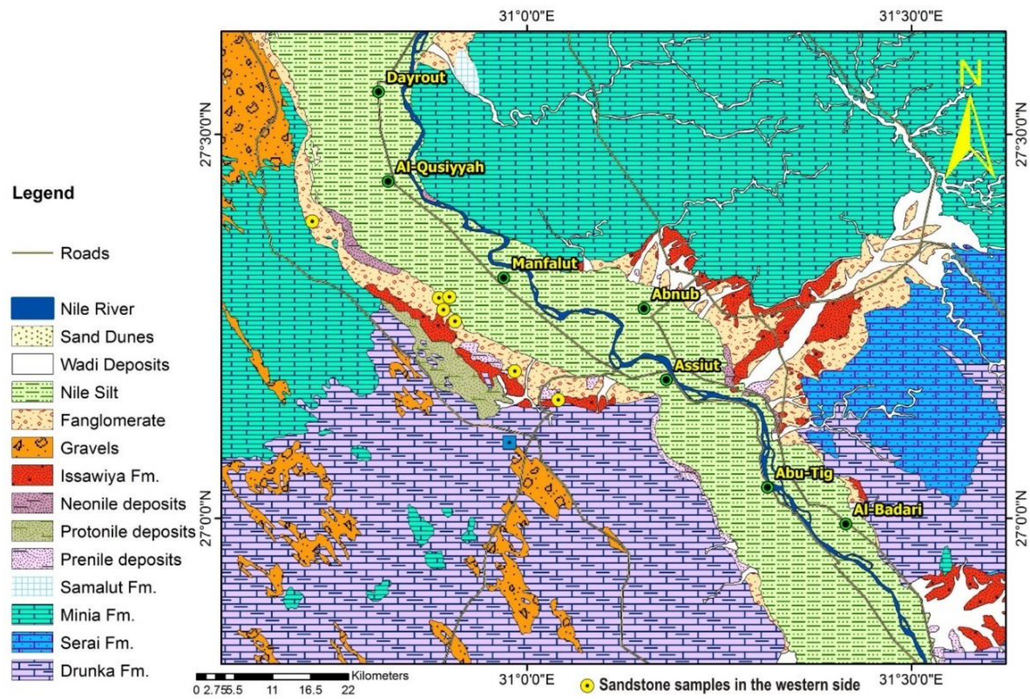

Fig. 1. Quarry locations in the study area [1].

DATA COLLECTIONS

In this study, gravel samples were taken from eleven different sites and its physical, chemical, and mechanical properties were analyzed. Building materials are extracted from the surface of the thick and dispersed sedimentary sequence that surrounds Assiut. Historical data on gravel loss in the Assiut province: This data can be collected from government records, reports, and studies conducted by local and international organizations. Data on potential solutions to reduce gravel loss in the Assiut province: This data can be collected through interviews with local stakeholders, focus group discussions, and literature reviews.

In collaboration with the Assiut governorate's quarry administration, business trips were organized to gather all samples from various quarries. Representative samples were taken from two operating sides of the quarries from two of the eleven distinct sites that were studied. The experiments were carried out at the Faculty of Engineering, Civil Engineering Department, Assiut, Assiut University, Egypt. Samples from G1 through G11 were retrieved. A total of 55 samples, ranging from 25 to 40 kg, were collected from the working side faces of the quarries. The working faces were 3-4.5 m thick, and fine materials covering the entire surface area had a thickness comparable to that of gravel covering gravel layers. Thin layers with a thickness of 0.50–1 m covered the quarry-ground deposits of G1 (Gahdam) (fine seeded soils). Investigate the gravel grains to determine whether they are silicone- or calcareous-based. A considerable amount of the tested grains was gritty quartz flint [12-13]. **Fig. 2** and **Fig. 3** show the working sides of the G1, G2, and G3 quarries as well as the sites where the samples were drawn. These areas are highlighted in Figure 3 for the G4, while **Fig. 4** shows the positions for the G5, and G6, respectively. The authors set out the impeded material in every location with different percentages according to sedimentology. All data were collected to be prepared for many various tests on of these the loss of amount Clay which associated gravel.

Fig. 2. The operational sides of quarries G1, G2, and G3.

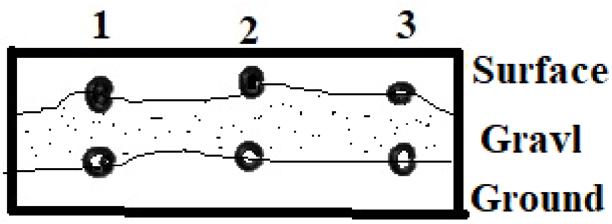

Fig. 3. Depict the G1, G2, and G3 quarries' working sides.

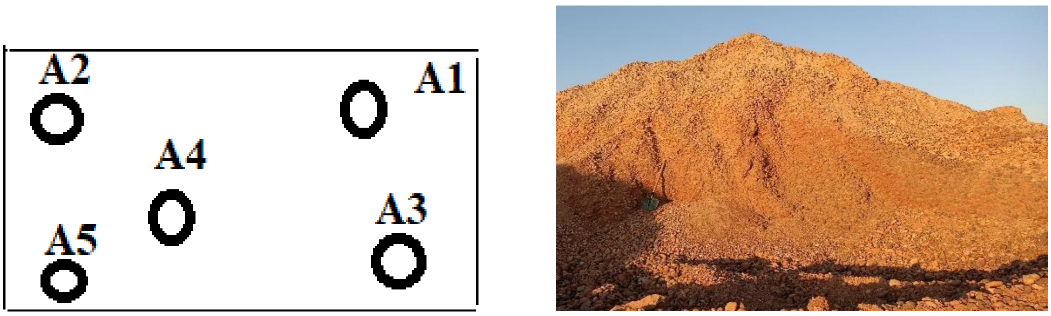

Fig. 4. Trenches that were obtained for G9.

METHODOLOGY

The physical characteristics, such as density, water absorption capacity, size fraction, shape, and chemical qualities, are used to evaluate the aggregates in the Assiut gravel quarries. Physical properties such as density, water absorption capacity, size fraction, shape, and chemical properties are evaluated in the gravel quarries of Assiut to determine the quality of the aggregates. The density of the aggregates is measured by weighing a known volume of material and then dividing it by the total volume. The water absorption capacity is determined by measuring the amount of water absorbed by a sample after being immersed in water for a certain period. The size fraction is determined by sieving the sample through different mesh sizes to determine the percentage of particles within each size range. The shape of the aggregates is evaluated based on visual inspection and comparison with standard shapes. Chemical properties such as acid solubility, alkali-silica reactivity, and sulfate resistance are also evaluated to determine their suitability for use in construction projects, additionally to the aggregates' mineral content. In accordance with ASTM Standard 295, a petrographic analysis of the gravel was performed to determine the composition of the samples and to identify the alkali-silica reactive components, such as opal, tridymite, chalcedony, cristobalite, and alkali carbonate reactive rocks. Concrete will expand and crack because of these minerals' reactions with the alkalis in the cement. Other components that could be present as coating contaminants include sulphides, sulphate, halite, iron oxide, Clay minerals, and anhydrite were also examined. Coatings prevent the development of strong bonds between the gravel and cement [14].

RESULTS AND DISCUSSIONS

The examination results indicate that samples from all locations had sulphate and chloride contents that ranged from 0.0001% to 0.0019% and 0.006 % to 0.052%, respectively. In general, water absorption ranges from 0.5386% to 1.3861%, and the pH is between 7.45 and 7.5. As a result, many applications were thought to be ideal for these quarries. The Egyptian Code states that this quarry is appropriate for use in civil and concrete applications. According to evaluations, the sample from quarry G1 has a density of 2.55 gm/cm^3, a pH of 7.45, an adsorption ability of 1.38%, and sulphate and Cl contents of 0.0013% and 0.009 %, respectively. These factors made this region suitable for roads and construction materials. Additionally, samples from the quarry G2 had Cl and sulphate concentrations of 0.024% and 0.0014%, respectively, as well as an adsorption capacity pH and density of 0.91%, 7.47% and 2.58%, respectively. In addition, it can be utilized as a building material as a replacement in soft places. Samples from the quarry G3 in west Assiut had Cl and sulphate concentrations of 0.027% and 0.0015%, respectively; they also had an adsorption capacity of 0.7103%, a pH of 7.5, and a density of 2.61 gm/cm^3. The Egyptian Code determined that gravel from all these areas was suitable for use in concrete. All the samples underwent thorough screening, and the findings showed that they all tested within the range of the Egyptian Code's higher and lower levels.

The quarry G4 in north Assiut had a density of 2.55 gm/cm^3, an adsorption capacity of 1.3042 %, and Cl and sulphate values of 0.026% and 0.0018%, respectively. Additionally, it can be used as a building material and is good for road construction. The Cl and sulphate contents of samples from the quarry G5 in east Assiut were 0.022% and 0.0019%, respectively. They also had an adsorption capacity of 0.5386%, a pH of 7.5, and a density of 2.59 gm/cm^3. We advise utilizing a crusher to make use of the gravel reserve because it is ideal for building and construction in general and moderate for highways due to size. While the Cl and sulphate concentrations in samples from the quarry G6 in northwest Assiut were 0.023% and 0.0015%, respectively. They also had an adsorption capacity of 0.6562%, a pH of 7.5, and a density of 2.62 gm/cm^3. It is suitable for building and road construction and can be used for both.

Samples from the G7 quarry in west Assiut had Cl and sulphate concentrations of 0.006% and 0.0001%, respectively, as well as an adsorption capacity of 0.7728%, a pH of 7.45, and a density of 2.58 gm/cm^3. Additionally, it can be used as a building material and is good for road construction. In addition to having Cl and sulphate concentrations of 0.015% and 0.0017%, respectively, and an adsorption capacity of 0.8230%, a pH of 7.5, and a density of 2.65 gm/cm^3, samples from the quarry G8 in west Assiut also showed these characteristics. Samples from the quarry G9 in south Assiut exhibited Cl and sulphate values of 0.035% and 0.0011%, respectively. They also had an adsorption capacity of 1.1287%, a pH of 7.40, and a density of 2.62 gm/cm^3. It can be used for both building and constructing roads because it is appropriate for both.

In addition to having Cl and sulphate concentrations of 0.052% and 0.0018%, respectively, and an adsorption capacity of 0.8256%, a pH of 7.5, and a density of 2.65 gm/cm^3, samples from the quarry G10 in west Assiut also showed these characteristics. It can be used as a replacement for soft building materials. In southwest Assiut, samples from the quarry G11 exhibited Cl and sulphate concentrations of 0.009% and 0.0012%, respectively. They also had an adsorption capacity of 0.8355%, a pH of 7.45, and a density of 2.45 gm/cm^3. Many uses were therefore thought to be suitable for these quarries. This quarry is suitable for use in civil and concrete applications, according to the Egyptian Code. Table 1 summarizes the chemical and physical properties for the samples obtained from different locations [15].

Table 1. Chemical and physical properties for gravel from quarry sites in Assiut

Quarry	**Properties**					
	Cl, %	**Sulfate, %**	**Adsorption %**	**Ph**	**Density, gm/cm^3**	**Abrasion test, %, using Los- Angeles**
G1	0.009	0.0013	1.3861	7.45	2.55	16.51
G2	0.024	0.0014	0.9160	7.47	2.58	16.1
G3	0.027	0.0015	0.7103	7.5	2.61	12.42
G4	0.026	0.0018	1.3042	7.45	2.55	16.21
G5	0.022	0.0019	0.5386	7.5	2.59	15.77
G6	0.023	0.0015	0.6562	7.5	2.62	12.71
G7	0.006	0.0001	0.7728	7.45	2.58	13.80
G8	0.015	0.0017	0.8230	7.50	2.65	12.52
G9	0.035	0.0011	1.1287	7.40	2.62	11.95
G10	0.052	0.0018	0.8256	7.5	2.65	11.85
G11	0.009	0.0012	0.8355	7.45	2.45	18.73
Limits*	<0.06	<0.002	<2.5 %	7.5	-------	< 27%

* **These values are based on the Egyptian Code (2003) [15]**

A thorough discussion of soil categorization was conducted [16-17]. The code was develo ped to ensure the quality of construction materials used in civil engineering projects. It includes st andards for the physical and chemical properties of gravel, as well as requirements for its producti on and use. The code also outlines the responsibilities of producers, suppliers, and users of gravel.

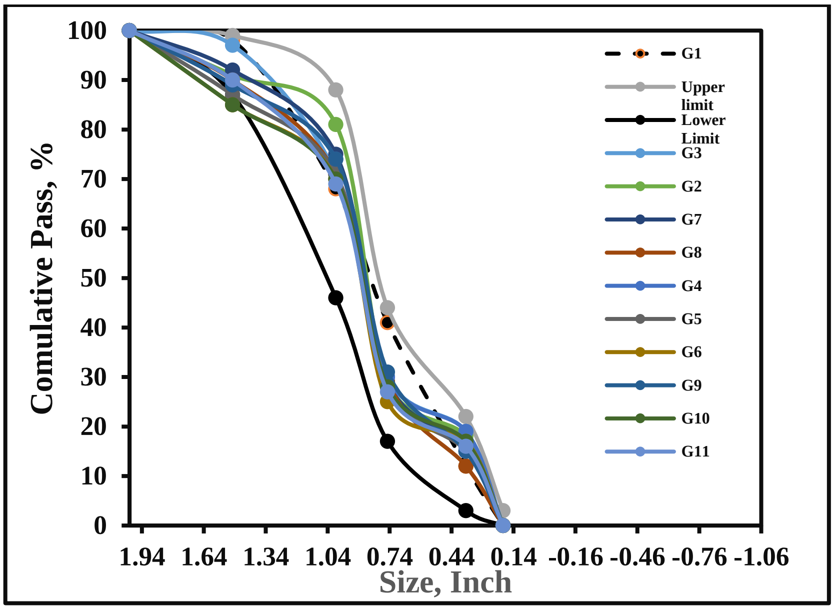

Fig. 6. Quarries 1–11's particle size distribution.

This classification is dependent on size, as shown in Table 3 (Egyptian Code ECP 203-2017). All the samples were evaluated to determine the corresponding losses for every quarry, The amount of clay or another material used determines the amount of loss, as indicated in Tables 2 which provide an overview of typical standards for soil particle size classification such as boulders, cobbles, gravel, sand, silt, and clay. The Egyptian code should be followed for the main uses of these materials; this code is the standard code for use with concrete. The losses were calculated to the main test for sieve analysis and checking the different sizes and Classified gavel according to main uses and estimated the amount of clay to determine the total amount of gravel in the quarry, annual production of the quarry should be disregard the losses according to the general rules of the Quarries Administration. Finally, Table 4 shows the percentage of losse associated with each location [18-21].

Table 2. Soil partiCle size Classification [18, 20].

Types of material		Sizes (mm)
Boulders		Over 200
Cobbles		60-200
Gravel	Coarse	20-60
	Medium	6-20
	Fine	2-6
Sand	Coarse	0.6-2
	Medium	0.2-0.6
	Fine	0.06-0.2
Silt	Coarse	0.02-0.06
	Medium	0.006-0.02
	Fine	0.002-0.006
Clay		Less than 0.002

Table 3. Standard code for use with concrete [9, 20].

No.	Size (inch)|	Size (mm)	uses	remark
1	1.5-0.75	37.5-19	All concrete type	
2	2.5-2	50-63	Asphalt	
3	<63		Not economic	Should be crushed

Table 4. Estimated losses of gravel in the samples [15].

locations	No. of Samples	Average loss for every location%
G1	**3**	**40.01**
G2	**5**	**28.8**
G3	**6**	**31.5**
G4	**4**	**34.20**
G5	**6**	**39.56**
G6	**5**	**40.05**
G7	**4**	**29.35**
G8	**5**	**28.30**
G9	**4**	**28.45**
G10	**5**	**35.56**
G11	**4**	**29.53**

CONCLUSIONS

The results demonstrate that the gravels were significant and strong. Their ability to absorb water ranged from 0.5386% to 1.3861% (or more than 5 related to Egyptian Standards)
These results indicated that, in agreement with the Egyptian Code for cement, asphalt, and road infrastructure components, the gravel from the examined quarries was suitable for usage as foundation and sub-base layers. The Los Angeles abrasion test results revealed that the gravels had low abrasion resistance, ranging from 11.85% to 18.73%.

The gravel was mainly composed of coarse and fine particles with a wide range of Particle sizes, according to the results of the Particle size study. The Unified Soil Classification System characterized the gravel as coarsely sorted sand. The chemical composition of the analyzed gravel can be determined by using various analytical techniques such as X-ray fluorescence (XRF). These techniques can provide information on the major and minor elements present in the sample. In the studied quarries, the loss of gravel deposits amounted to 28.3 – 40.05%. G6 exhibited the highest loss of gravel deposits with thicknesses ranging from 1 m to 1.80 m, which was attributed to the fill layers. Lastly, the gravel deposits at the eastern bank of the Nile valley in the Assiut region were widely distributed and of a high quality.

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