Polytechnic Journal
Polytechnic Journal

Volume 13 | Issue 2 Article 10

November 2023

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Nawzat Rashad Ismail
Dept. of Geotechnical engineering, Faculty of Engineering, Koya University- Koya Kurdistan Region, Iraq., nawzat.rashad@koyauniversity.org

How to Cite This Article
Ismail, Nawzat Rashad (2023) "A Comparative Study The Effect Of Aggregate Type On The Strength And Abrasion Resistance Of Concrete ,Kurdistan Region ,Iraq," *Polytechnic Journal*: Vol. 13: Iss. 2, Article 10.
DOI: https://doi.org/10.59341/2707-7799.1722

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Keywords

Aggregate, Compressive strength, Limestone, Marlstone, Shiranish formation

ORIGINAL ARTICLE

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This research assessed the utilization of substantial limestone and marlstone outcrop aggregates surrounding the city of Koya in the Shiranish Formation for building and concrete work. This study examines the effects of using two types of locally accessible aggregates on compressive strength qualities in the concrete mix as a partial replacement for using typical coarse aggregates to determine the acceptability of using the aggregates for typical concrete production. Physico-mechanical and chemical properties of the aggregates were investigated in a preliminary laboratory study shows that the average values of dry density, water absorption, porosity, moisture content, point load index, compressive strength and aggregate abrasion value (AAV) of the limestone and marlstone are (2.38g/cm3, 4.4 %, 10.46 %, 0.71 %, 4.14 MPa, 93.1 MPa, 18.2 %) and (2.45g/cm3, 3.25 %, 7.97 %, 0.65 %, 1.84 MPa, 41.7 MPa, 36.9 %) respectively. Simple regression analysis has been used to illustrate how physical and mechanical properties are related. Concrete with a nominal mix ratio of 1:2:4 was used for this research, and mix compositions were determined using the absolute volume method. In order to monitor the compressive strength at 28 days, 15 cubes (10 × 10 × 10 cm) of each type of coarse aggregate were cast. This provided as a guidance for people using concrete as to the best alternative fine aggregate for concrete productions. All parameter values were compared to each other and to the BS, ASTM, and NZGS standards for their qualification as an aggregate source for domestic building and highway pavement.

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1. Introduction

Natural construction aggregate is one of the most abundant natural resources and one of the most widely used. Aggregates are essential components of concrete. Three phases, namely the mortar, the mortar/aggregate interface, and the coarse aggregate phase, make up the multi-phase composite material that is concrete [1] assert that the majority of coarse particles in typical concrete are made of strong rock [2] concluded that the components of high-quality aggregates should be sufficiently strong, have appropriate engineering features, and be resistant to environmental conditions. In concrete, aggregate serves as a rigid component [3] finding out alternate aggregate sources to solve shortages is a significant concern for the construction and aggregate sectors. Their volume contribution to concrete ranges from 65 % to 80 %, and their characteristics and qualities have an impact on how well these materials function when used [4] proved that the type of aggregate influences the compressive strength of conventional concrete [5] show that the fundamental specifications of aggregate for concrete must be quantified by choosing pertinent test and assessment methods and defining suitable acceptance criteria [6] reported that the quality of the aggregate primarily controls the durability and crack resistance of both freshly mixed concrete and hardened concrete. In addition [7] studied the most durable and stable raw material used in concrete/mortar compositions, aggregates also greatly influence the cost and workability of concrete/mortar [8] indicated that the

Received 16 August 2023; accepted 8 October 2023.
Available online 25 November 2023
E-mail address: nawzat.rashad@koyauniversity.org.

https://doi.org/10.59341/2707-7799.1722

qualities of concrete, such as strength, typically serve as indicators of the quality of the concrete produced by any procedure [9] reported that there has long been interest in the relationship between the composition of concrete and its mechanical properties [7] finding out for the purpose of proportioning concrete/mortar mixtures, knowledge of certain aggregate parameters, such as density, porosity, grading, and moisture condition, is necessary. Additionally, The mineral makeup of aggregates impacts their crushing strength, hardness, and soundness, and these characteristics, in turn, affect a variety of properties of hardened concretes and mortars [10] show that the concrete is widely used in the building and road construction industries (concrete pavement). The most prevalent sources of crushed rock aggregate and raw materials are sedimentary rocks like limestones and marlstones. Due to their advantages as aggregate, these rocks are increasingly being used in the construction industry. Good strength, a reduced likelihood of an alkali−silica reaction, and a reduction in drying shrinkage in concrete are some of these advantages has been reported by [11]. These types of rocks are easily used in a number of structural and architectural applications due to their wide range of characteristics and high quality. There are additional justifications for selecting a proponent of these rocks for study, including their extensive distribution and thickness throughout most of Iraq, particularly in the Kurdistan region. There have been some studies done for various reasons, several writers investigated the sequence stratigraphy of the Shiranish Formation in Jabal Sinjar; sequence stratigraphy of the Shiranish Formation in the Dokan area; planktonic foraminiferal biostratigraphy of the Shiranish Formation in Dohuk Area, have been recorded by [12−14] respectively. According to previous studies, currently, this study is the first to be conducted on the Shiranish Formation in order to evaluate the impacts of using locally accessible limestone and marlstone aggregates as a substitute for natural fine aggregate in concrete and as a potential source of aggregate for the local construction sector. Table 1 and Figure 1 show the locations of the examined samples, which are constrained by UTM grid 3,998,457 and 4,000,777 North, 0471,040, and 0472,479 East.

Table 1. Outcrop locations by UTM (Universal Transverse Mercator).

Location No.	Formation	Coordinates (North and East line)
1	Shiranish Formation	3,998,457 N and 0471,040 E
2	Shiranish Formation	3,998,867 N and 0471,593 E
3	Shiranish Formation	3,999,333 N and 0471,783 E
4	Shiranish Formation	3,999,339 N and 0471,840 E
5	Shiranish Formation	4,000,777 N and 0472,479 E

Geological setting of the study area is very important to understand the geology of the resources, standards specifications, and test procedures used to assess their suitability as construction aggregate is essential to guaranteeing that any naturally occurring geological materials are suitable for their intended use and satisfy the requirements of the end uses. Crushed rock, which originates from hard, sturdy rock formations like sedimentary rocks, such as limestone and marlstone, is used to make primary aggregates. However, the physicomechanical, chemical and thickness of these sedimentary rocks can vary greatly, affecting how well they can be used to produce concrete on a large scale. The majority of these rocks can be discovered in Iraq, either as the surface or the subsurface outcrops; the Shiranish Formation is one of the principal limestone and marlstone bearing units (Upper Cretaceous). On Haibat Sultan Mountain's northeastern side, it is exposed. The research area (Koya) is situated in the High Folded Zone which belongs to the Unstable Shelf Zone, and its axial surface is directed (NW−SE) parallel to the axial plane of the Zagros Thrust Zone has been reported by [15,16] in the type locality, proved that the formation is composed of marly limestone and limestone in the lower part and dark grey marls in the upper part. The thickness of the Shiranish Formation in the type section near the Shiranish village is about 227.5 m. In Shaqlawa 150 m, in NE Koisanjaq 300 m highlighted by [17]. Light grey marlstone and yellowish-white colored limestone that is thinly and moderately bedded with extremely thin layers of marly limestone, characterized by their conspicuous outcrop appearance, compose the Shiranish Formation of the study area. The bedding planes are inclined (20°−25°) to the NE direction (Figure 2).

2. Materials and methods

2.1. Sample collection and description

The Shiranish Formation outcrops in the Koya area served as the raw material for the examination and assessment of coarse limestone and marlstone aggregate. In Figure 1, all of the representative samples' locations are indicated. To evaluate the effects of their qualities on the strength of concrete, a total of 30 coarse aggregates, representative of limestones and marlstones were collected from 5 separate outcrop locations (6 samples for each location) within the Shiranish Formation. The samples were subsequently taken to the relevant labs

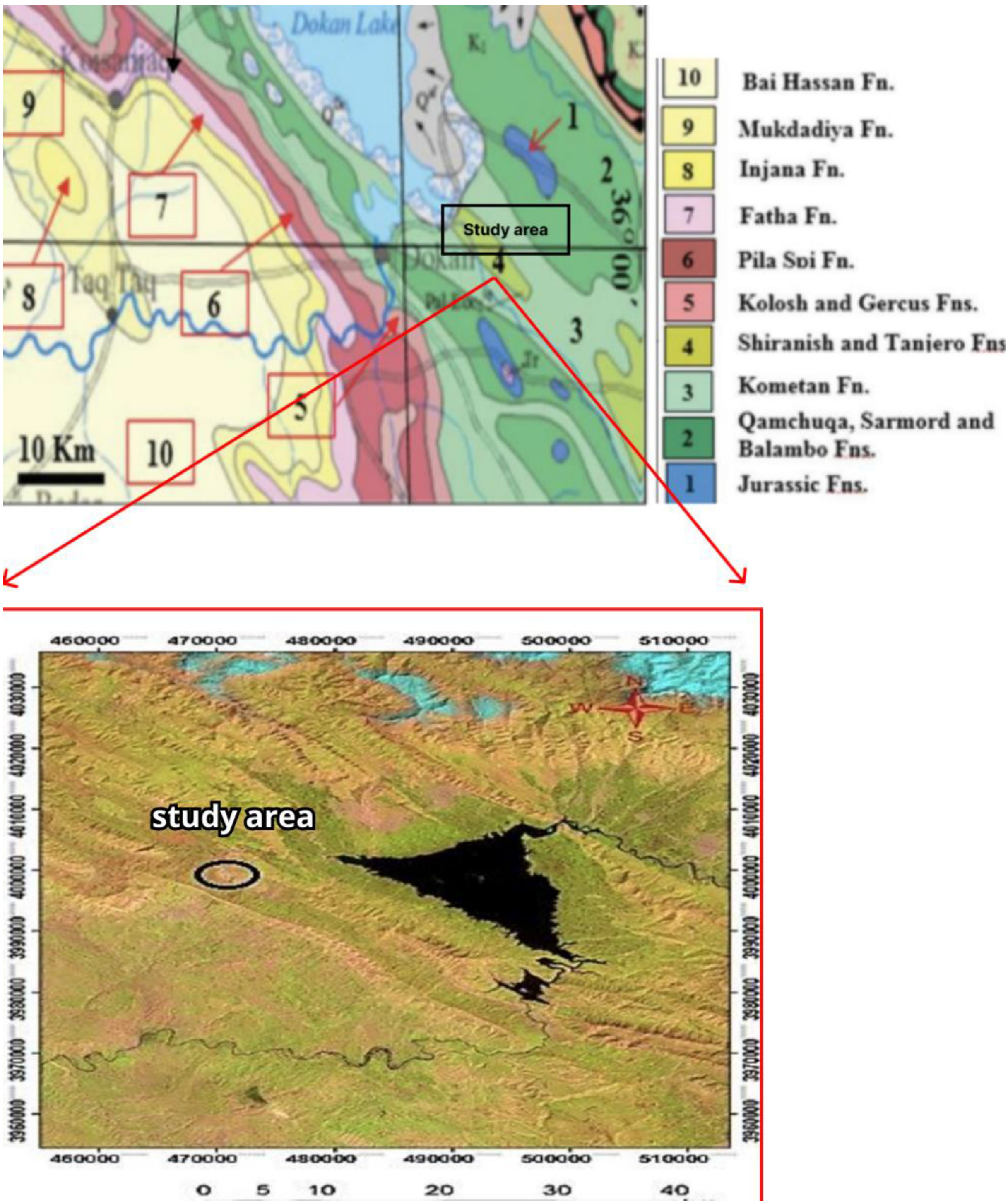

Figure 1. Locations of the study samples are shown on a geological map and satellite image within the Shiranish Formation.

for analysis and testing. The researcher used the technique proposed by [18] to construct the descriptions of the rock composition. They also made measurements of the rock mass characteristics in the field research, including color, grain size (1/16−1/256 mm), clasts visible with a hand lens, orientation (as measured by a compass clinometer), bedding plane, and weathering state of the rock components, as indicated in Table 2.

2.2. Rockmass characteristics

Classifications of rock masses serve as the foundation for the empirical design approach, which is

Figure 2. The Cyclic alternation of limestone and marlstone in the outcrop of Shiranish Formation.

Figure 3. Limestone showing 2 sets of joints.

frequently used in the field of rock engineering. The rock masses are composed of the rock material and discontinuities that have been identified since the first geological studies [19] proved that the description and classification of the variables that control or influence the behavior of the rock mass is the process of rock mass characterization, and the outcomes of the characterization process will be used to evaluate the rock mass quality. A structural or geological feature known as a discontinuity changes the homogeneity of a rock mass indicated by [20]. Discontinuities in the physical continuity of the rocks include bedding surfaces, joints, faults, and foliations. It is located at the foot (NE side) of Haibat Sultan Mountain. It lies within the Shiranish Formation. A series of parallel joints is called a joint set and two or more intersecting sets produce a joint system. There are two major sets of prominent joints, particularly in limestone. These joints are mostly perpendicular to each other. The orientation of the discontinuities can be described by (dip direction/dip angle), some orientation values of joints recorded in limestone show dip direction to NE such as(164/30°, 165/28°, 092/25°, 98/22°) (Figure 3). Spacing is the perpendicular distance between individual discontinuities. Joint spacing varies from 0.3 m to 0.5 m which means joints are moderately widely spaced. Persistence implies the size, length, or area extent, within a discontinuity (joint) plane, and can be crudely quantified by observing the trace lengths on the surface exposures. Often, rock exposures are small compared to the area or length of persistence of joints, and in such cases, the real persistence can only be guessed according to [19]. The study area describes and accounts for persistence based on its length, with a range of values of about 10−20 m. The discontinuity surface (roughness) has a planar (smooth) shape with a large scale (several meters). The term of the aperture is tight (closed discontinuity) without infilling soil materials. Faults are discontinuities that have an observable movement of displacement of a rock on the opposite sides of a fault plane. There are exposed normal faults over lengths of a few meters. Fault-related, calcite-filled structures characterize the fault zones. They cut through several limestone layers with thinner interlayers, and commonly stop where thicker interlayers are present (Figure 4).

2.3. *Physical and mechanical properties of coarse aggregates*

Understanding the physical, mechanical, and chemical properties of these aggregates is advised before replacing locally accessible limestone and marl aggregates in concrete mix designs. [21] assert that, to create high-strength concrete, a number of parameters must be taken into account, including the water-cement ratio, the quality of the fine and coarse aggregates, and the inclusion of additional mixture (chemical and mineral). The varied properties of the

Table 2. Visual observations of limestone and marlstone as defined by [18].

Loc.No	Rock type & Bedding plane	Color	Grain size	Orientation (dip direction/amount)	Weathering state
1	Thinly bedded (Lst& Marl	Yellowish white&grey	Fine to very fine	123/25°	Moderately weathered
2	Moderately bedded(Lst&Marl)	White&light grey	Fine to very fine	120/20°	Moderately weathered
3	Thinly bedded (Lst& Marl)	White&light grey	Fine to very fine	156/20°	Slightly weathered
4	Thinly to moderately bedded(Lst&Marl)	White&light grey	Fine to very fine	162/22°	Slightly weathered
5	Moderately bedded (Lst& Marl)	Yellowish white&grey	Fine to very fine	160/20°	Slightly to moderately weathered

Figure 4. Normal fault due to extension.

different concrete components must be thoroughly investigated in order to produce the best concrete with the desired strength and with very little detrimental impact on other qualities. Table 3 lists these characteristics based on ASTM, BS, and NZGS standards.

2.4. Aggregate tests

The primary building block for all projects are aggregated [29] finding out they are essential components in the building of pavement and are frequently employed as a stabilized foundation or sub-base courses. Understanding these materials' characteristics is essential for creating high-quality construction, particularly pavement. On the basis of their strength and durability, aggregates have been categorized in a number of ways that are applied globally. Strength measures like the aggregate abrasion value and the point load index. These have to withstand the strains brought on by the weight of the wheels, thus they must be strong and durable enough to withstand wear from the abrasive action of traffic. Materials for the pavement's structural layers should be chosen based on accessibility, cost, and prior experience. This study will be helpful in choosing the limestone and marlstone aggregates for the manufacturing of aggregates to be used as efficiently as possible in the construction of sustainable roads. ASTM C 131 often conducts this test (Figure 5).

Table 3. Physical and mechanical tests conform to ASTM, BS, AND NZGS of samples.

Quality test	Standard Method
Moisture content	ASTM C566 − 19 [22]
Water absorption	ASTM C127 − 15 [23]
Dry density	ASTM C127 − 15 [23]
Porosity	ASTM C29/ C29M− 17a [24]
Uniaxial Compressive Strength (UCS)	ASTM D5731-16 [25]
Los Angeles Abrasion(LAA)	ASTM C131-20 [26]
Field descriptions, Weathering be haviour& Rockmass Characteristics	[18]
Method for making test cubes from fresh concrete	BS 1881: Part 108, (1983) [27]
Method of normal curing of test specimen	BS 1881: Part 111, (1983) [28]

2.5. Chemical properties of samples aggregates

A typical method for chemical investigations that has been used to determine the percentages of the principal oxide elements in rocks and minerals is X-Ray fluorescence (XRF) (Table 4).

2.6. Concrete mix, casting and curing stage of specimen

[30] suggested that the aggregate (fine and coarse), cement, water, admixture, and other ingredients make up modern concrete. A number of elements are known to influence the strength of concrete. They consist of the batch ratios, procedures, texture, and shape of the aggregate, as well as the makeup of additional constituent elements. Limestone and marlstone were the two types of coarse aggregates used for this project. The purpose of this paragraph was to look at how these aggregates affected the grade of mix concrete design's compressive strength. In carrying out the tests, ordinary Portland cement (CEM I 42.5 R), fine aggregate passing sieve No.4 (4.75 mm)and retain on 0.075 mm sieve, coarse aggregate retains on sieve No.4 (4.75 mm). The chemical make-up of cement [31] is shown in Table 5. In this investigation, limestone and marlstone, which are locally available and naturally occurring fine aggregate, were used in place of a portion of the typical fine aggregate material. For the normal concrete mixtures used in this study, Adopting a suitable W/C ratio(0.5 %), the proportions of cement, fine alluvial sand, and coarse aggregate(gravel) were 1:2:4 by weight. Only the sources of the fine aggregate (river sand) were chosen as a variable, while the cement, coarse aggregate, and water were maintained constant for each mix ratio. The researcher added the fine aggregate of limestone and marlstone to the concrete mixture at four different levels, in place of a portion of the fine aggregate (sand): 25 %, 50 %, 75 %, and 100 % by weight (Table 6). According to [32], compressive strength testing was done on a hardened concrete mixture. 15 cubes (10 × 10 × 10cm) of each type of coarse aggregate were cast in accordance with [27]. The concrete cubes were taken out of the mold after one day of casting and placed in a water tank to cure until the test was conducted. The cube was cured in accordance with [28]. At 28 days, the concretes performed a compressive strength test (Figure 6).

(a)limestone aggregate before abrasion. (b)limestone aggregate after abrasion.

(c)Marl aggregate before abrasion. (d)Marl aggregate after abrasion.

Figure 5. Shows how abrasion affects the aggregate's size and shape.

Table 4. Chemical compositions of limestone and marlstone aggregates.

Loc. No.	CaO%	SiO_2%	Fe_2O_3%	Al_2O_3%	MgO%	Na_2O%	K_2O%	SO_3%
L1	51.4	33.3	2.10	8.50	2.40	0.52	1.55	0.25
L2	58.7	28.2	1.82	7.46	1.31	0.45	1.88	0.23
L3	51.4	33.3	2.10	8.50	2.40	0.52	1.55	0.25
L4	43.5	38.7	2.50	10.30	3.50	ND	1.29	0.26
L5	53.8	28.7	2.03	10.68	2.36	0.48	1.60	0.23
A	51.8	32.4	2.1	9.1	2.4	0.4	1.6	0.2
M1	65.4	23.0	2.5	5.15	1.20	0.62	1.30	0.84
M2	62.2	23.3	2.49	6.37	1.05	ND	1.67	0.94
M3	65.4	23.0	2.50	5.15	1.20	0.62	1.30	0.84
M4	58.7	31.4	2.15	3.99	1.36	0.68	0.83	0.89
M5	60.4	25.3	3.37	6.45	1.38	ND	1.39	0.86
A	62.4	25.2	2.6	5.4	1.2	0.4	1.3	0.87

Table 5. Chemical composition of the cement using XRF.

Oxides	Percentage composition (%)
SiO_2	28.88
Al_2O_3	4.87
CaO	58.41
Fe_2O_3	2.79
MgO	1.51
Na_2O	0.12
K_2O	0.25
SO_3	2.31
TiO_2	0.31

2.7. Correlations between the limestone and marlstone properties

Aggregate quality is a major consideration when using them in concrete buildings. As a result, the current study demonstrates the link between the different mechanical and physical characteristics of aggregates made of limestone and marlstone. In order to forecast how well these aggregates will function in various building applications, regression analysis was utilized to identify the high correlation between these characteristics and prediction models. Regression is used to identify the line that best fits the data in order to derive the equation for the linear connection. Drawing the line between the points is the procedure used to minimize the squared deviations of the measured points from the line. The applicable equation defines the line, and the value of the coefficient of determination or R-square is calculated. It also displays the number of samples (n) utilized in the regression analysis (Figure 7).

3. Analysis and discussion results

3.1. Analyses of physical and mechanical properties

[33] show that the qualities of the source rock have a direct impact on the quality of an aggregate.

Table 6. Test results of compressive strength for 28 days.

Limestone (%)	Cement (g)	Fine sand aggregate (g)	Fine limestone aggregate (g)	Coarse aggregate (g)	Water (g)	compressive strength (MPa)
0 %	1000	2000	0	4000	500	36.19
25 %	1000	1500	500	4000	500	35.20
50 %	1000	1000	1000	4000	500	31.82
75 %	1000	500	1500	4000	500	29.85
100 %	1000	0	2000	4000	500	29.03
Marlstone (%)	Cement (g)	Fine sand aggregate (g)	Fine Marlstone aggregate(g)	Coarse aggregate (g)	Water (g)	compressive strength (MPa)
0 %	1000	2000	0	4000	500	36.19
25 %	1000	1500	500	4000	500	18.59
50 %	1000	1000	1000	4000	500	16.14
75 %	1000	500	1500	4000	500	13.63
100 %	1000	0	2000	4000	500	4.67

Several physicomechanical tests are available to assess the quality of rock aggregates. A single test, however, cannot provide a clear assessment of the rock aggregate. In this scenario, various tests are suggested to civil engineers and geoscientists, and using a combination of the results of these tests. These analyses' results are condensed in (Table 7).

When the water in concrete comes into touch with the cement, a chemical reaction occurs that hardens the paste. However, when the water escapes, the concrete contracts. In order to calculate the drying shrinkage, it is crucial to know the water absorption value (WAV) and how much of it is retained in the hardened concrete according to [11]. The WAV of the limestone and marlstone aggregates with an average value of 4.4 % and3.25 % respectively. For overall construction manufacturing uses of aggregates, WAV should be<5 %, according to [34] specifications. [35] proved that the porosity is regarded as the most significant aggregate feature since it affects both directly and indirectly the majority of the physical characteristics of rocks (durability, mechanical strength, etc.). Porosity increases have a negative impact on the weathering properties. In addition, Carlos et al.(2010)reported that the possibility of the water remaining trapped in the pores for a long period of time and eventually evaporating, this could cause the paste to shrink. The results of the analyses revealed that the porosity with mean values of 10.46 % and 7.97 % for limestone and marlstone respectively. This demonstrates the samples' low effective porosity. When determining the ideal water-to-cementitious material ratio, the moisture content of an aggregate is one of the most crucial elements and a powerful mechanism for influencing the engineering properties of the aggregate on its physical and mechanical properties. Most of the engineering properties of rocks are significantly altered as a result, especially in terms of strength according to [36]. In the present study, the average value of 0.71 % and 0.65 % for limestone and marlstone respectively. This proved that the influence of moisture content on aggregate strength and deformational characteristics (weathering) was quite minimal. One of an aggregate's fundamental characteristics is dry density. [37] discovered that the density of the minerals, their composition, and the amount of void space in the aggregate primarily affect it. In the investigated samples, the dry density displayed little variation with a mean value of 2.38 g/cm^3 and 2.45 g/cm^3 for limestone and marlstone respectively. The

Figure 6. Concrete cubes measuring 10 × 10 × 10 cm with limestone and marl aggregate mix.

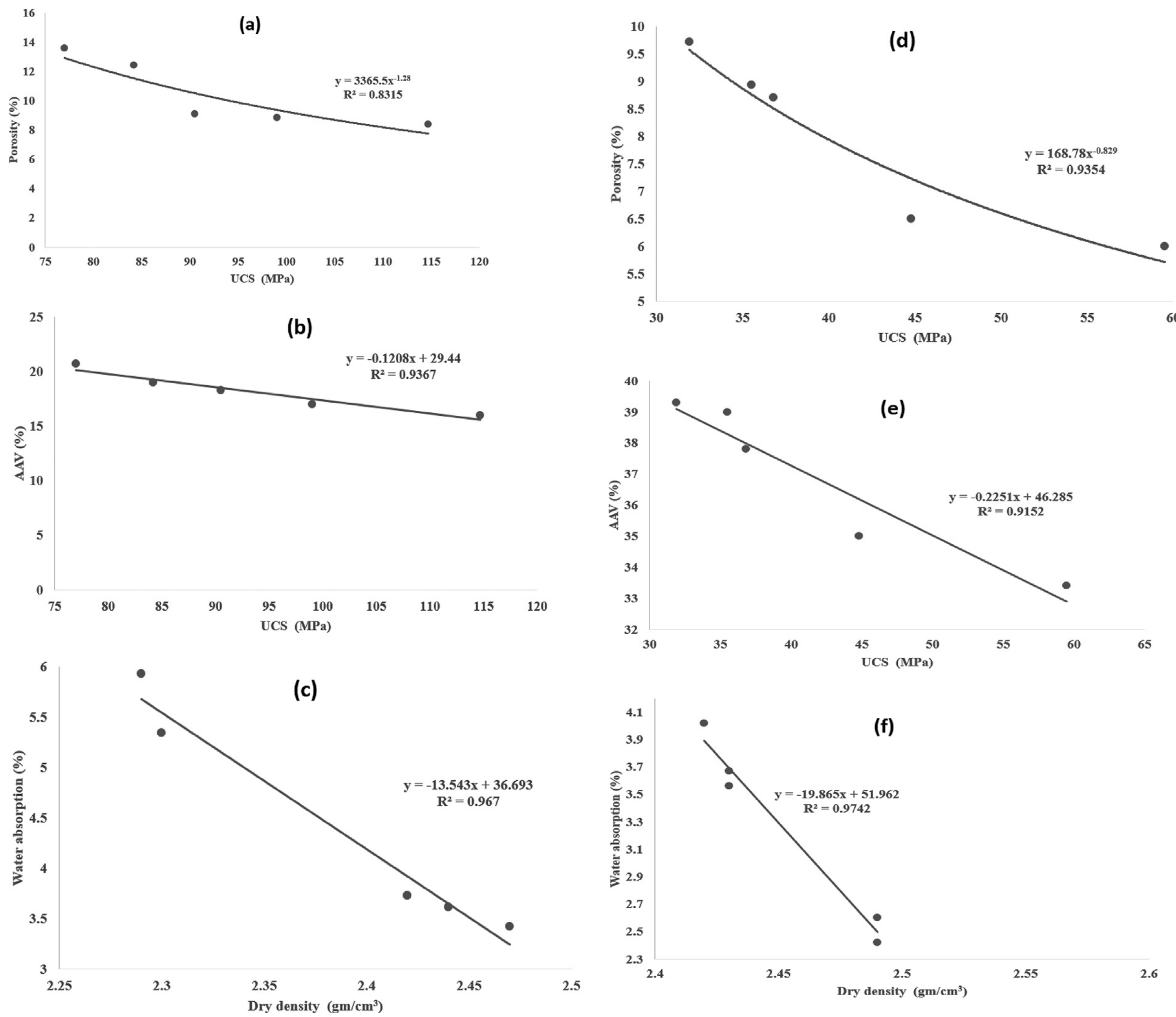

Figure 7. (a, d) porosity plotted against the UCS, (b, e) aggregate abrasion value AAV plotted against the UCS, and (c, f) water absorption against the dry density for limestone and marlstone respectively.

evaluated samples in this range fell under the aggregates' normal density category [38]. The medium-weight aggregate, which is better suited for aggregate, has a density between 2 and 3 g/cm^3 defined by [39]. Hard and dense aggregates reduce shrinkage in concrete, according to [40]. Uniaxial compressive strength (UCS) and point load index (PLI) of construction materials is regarded as the

Table 7. Physical and mechanical characteristic of limestone and marlstone aggregates.

Loc.No	Moisture content (%)	Porosity (%)	Water absorption (%)	Dry density gm/cm^3	Index ($Is_{(50)}$) (MPa)	UCS (MPa)	AAV (%)
L1	0.74	13.6	5.93	2.29	3.42	77.0	20.7 %
L2	0.59	12.4	5.34	2.30	3.74	84.2	19 %
L3	0.53	9.10	3.73	2.42	4.02	90.5	18.3 %
L4	0.62	8.83	3.61	2.44	4.40	99.0	17 %
L5	1.08	8.40	3.42	2.47	5.10	114.7	16 %
A	0.71	10.46	4.4	2.38	4.14	93.1	18.2 %
M1	0.73	9.72	4.02	2.42	1.42	31.9	39.3 %
M2	0.83	8.93	3.67	2.43	1.5	35.5	39 %
M3	0.68	8.70	3.56	2.43	1.64	36.8	37.8 %
M4	0.48	6.50	2.60	2.49	1.99	44.8	35 %
M5	0.56	6.0	2.42	2.49	2.64	59.5	33.4 %
A	0.65	7.97	3.25	2.45	1.84	41.7	36.9 %

characteristic material values for the classification of concrete and are most likely the most significant index properties for the evaluation of the mechanical behavior of rocks according to [41,42] show that UCS offers a clear understanding of the material selection for suitable civil structures. In the current research. A suggested procedure by [18] was used to conduct the UCS and PLI tests, and an average value of (93.1,41.7) MPa and (4.14,1.84) MPa for limestone and marlstone respectively. This value confirms that the limestone has strong strength while the marlstone has moderate strength. Therefore, these results seem to be somewhat unaffected by highly weathering agents and strong enough to withstand chemical reactions.

3.2. Analysis of aggregate degradation

In comparison to other types of rocks, limestone and marlstone aggregates are the most frequently used. This is due to their strength and density. Because of its mechanical quality, aggregates can withstand abrasion while remaining stable. AAV is an indicator test for abrasion resistance and an estimation of the surface wear of road surface aggregate. Aggregates experience significant wear during the course of their lifetime. Durable materials have a lower AAV defined by [43,44]. The mechanical properties of these aggregates were summarized as shown in Table 7. The AAV for the limestone and marlstone aggregates with an average value of 18.2 %, and 36.9 % respectively, less than 40 %, which indicates that these aggregates have good hardness and can be used in road paving (Asphaltic pavement to the base course and subbase course), as specified by ASTM (C131); [45,46].

3.3. Analyses of chemical properties of aggregates

Regarding chemical compatibility and stability between the elements of aggregates, the chemical characteristics and resistance of aggregates are crucial (Table 4).The results show that the major chemical components in the limestone and marlstone are CaO with an average value about (51.8 %,62.4 %) and SiO_2 (32.4 %,25.2 %)respectively. Calcite, the primary component of $CaCO_3$, is where the CaO is obtained from, whereas quartz and clay minerals are where the Silica SiO_2 is derived from, defined by [47]. [48] proved that the CaO contributes significantly to the strength of the rock since aggregates with a CaO concentration of more than 10 % often have high strength and good weathering resistance. The concentration of SiO_2 is much higher than that of the other constituents. Therefore, silicate mineral cementation is primarily responsible for the aggregates' strength. The concentration of Fe_2O_3 with an average of (2.1 %, 2.6 %) and Al_2O_3 (9.1 %, 5.4 %) respectively. Therefore, all of the previous oxide percentages have a significant part in acting as cementing elements, which increases the aggregate's compressive strength. The small amounts concentration of MgO in limestone and marlstone with an average of (2.4%, and 1.2%) respectively. A concrete's excessive MgO content causes its soundness (expansion) and subsequent loss of strength reported by [49]. [50] concluded that, it derives from the mineral dolomite $CaMg(CO_3)_2$. The alkali content ($K_2O + Na_2O$) typically ranges from 0.3 % to 1.5 %. The most common hazardous occurrence in concrete is the alkali−silica reaction (ASR), and the alkalis undergo a chemical reaction known as the ASR. The high concentration of these oxides degrades the quality of the raw materials, leading to ASR, and creates a swelling gel that can cause the aggregate to compress, expand, and crack. This gel also has a disruptive effect on the concrete proved by [51]. In limestone and marlstone, respectively, Na_2O has an average concentration of 0.4 % and 0.4 %, while K_2O has an average concentration of 1.6 % and 1.3 %. These percentages of Na_2O and K_2O in the study aggregates are in lower acceptable limits will reduce the operational problems and production loss in the concrete structure. The sulfate content in raw materials as (SO_3), generally, ranges from 0.1 % to 3 % defined by [52]. The concentration of SO_3 with an average value is 0.2 % in limestone and 0.87 % in marlstone. Thus, the results showed that all of these average percentages of CaO, SiO_2, Al_2O_3, Fe_2O_3, MgO, $K_2O + Na_2O$, and SO_3 are suitable levels and highly suitable for building and road construction industries compared to findings that fall within the range of accepted international standards.

3.4. Result of concrete compressive strength test

[42] assert that the cement-to-water ratio, degree of compaction, cement-to-aggregate ratio, mortar-to-aggregate binding, and the aggregate's grading, shape, strength, and size all have an impact on the compressive strength of concrete [21] indicated that the use of limestone either as a substitute for fine and coarse aggregate in a concrete mixture is still lacking [53] show that the compressive strength of different grades of nominal mix concrete varies significantly depending on the source of the coarse aggregate (geological, physical, mechanical, and chemical composition). Variations in aggregate qualities impact the strength, workability, and durability of

both fresh and hardened concrete concluded by [54,55]. Presently, Figure 8 shows the average compressive strength of concretes constructed using limestone and marlstone aggregates at 28 days. The compressive strength of two aggregate types with varying percentages (0, 25, 50, 75, 100) as a partial river sand substitution after 28 days of moist curing is used for better comparative purposes. The results showed that 100 % limestone and marlstone concrete's compressive strength decreased from 36.19 MPa for control concrete to 29.03 MPa and 4.67 MPa, respectively. When compared to control concrete, the compressive strength decreased by 2.73 %, 12.07 %,17.51 %,19.78 %, and 48.63 %,55.40 %,62.33 %, 87.09 % for the 25 %, 50 %,75 %, and 100 % limestone and marlstone concentrations, respectively. Due to the low SiO_2 concentration (32.44 %,25.2 %) of the limestone and marlstone aggregates, respectively, in comparison to the chemical composition of river sand (86%−93 % SiO_2), the parameters of compressive strength are decreased when both aggregates are used as a partial replacement of river sand proved by [56,57]. Also, as the replacement amount and the mixing ratio of the CaO expansion agent of both aggregates increases, its porosity then increases, compressive strength gradually decreases and the frost resistance of the concrete is reduced discovered by [58]. On the other hand, limestone aggregate has a stronger uniaxial compressive strength and a lower clay content than marlstone aggregate, which causes a drastic fall in the compressive strengths of marlstone concrete more than limestone concrete. As a result, the surface of limestone concrete is rough and it has greater strength than marlstone concrete. Because of this, marlstone aggregate has discovered that no research has been done to utilize its aggregates as heavy building materials in concrete, its water sensitivity, increasing clay minerals content, and low to moderate strength. In contrast, the full potential of limestone aggregate with appropriate higher strength and abrasion resistance has to be used as a structural application in the building materials of concrete.

3.5. Regression aanalysis

To determine the reciprocal relationships between the physical and mechanical characteristics of these aggregates, a simple regression analysis was conducted. The strength of a material is inversely correlated with the porosity of the aggregate. Due to stress concentration in and around the voids, the presence of voids reduces an aggregate's strength concluded by [59]. A significant negative correlation (R^2 = 0,83,0.93) is observed between the porosity and UCS of limestone and marlstone respectively (Figure 7a, d), which reveals that relatively less porous aggregate leads to higher compressive strength to the material. In these aggregates, there is a significant negative correlation (R^2 = 0.93, 0.91) between AAV and UCS, demonstrating that the AAV decreases as UCS increases (Figure 7b, e),. An inverse relationship (R^2 = 0.96,0.97) has been observed between water absorption with dry density (Figure 7c,f) depicting lower water absorption and higher dry density value. Our analysis, which depended on simple and direct statistical regressions, showed that the aggregates' values for all of their mechanical and physical properties fell within the acceptable range of values, making them suitable for use as an aggregate source for engineering projects.

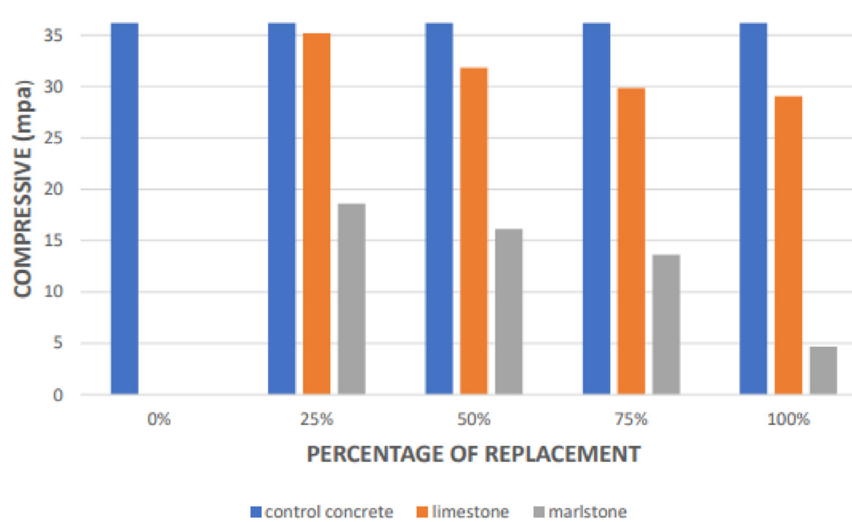

Figure 8. Compressive strength of all% of limestone and marlstone concretes at 28 days curing period.

4. Conclusions

The following conclusions can be derived from the study's results, within the limits of the test parameters:

4.1 Because of their low porosity, low water absorption, low moisture content, medium-specific gravity, strong to moderately strong compressive strength, low abrasion value, and the reduction in drying shrinkage in concrete, aggregate made from limestone and marlstone has the necessary properties for use, particularly in construction materials and environmentally friendly road pavement construction.

4.2 Most of the rocks have weathering behavior fall in grade II and III (slightly to moderately weathered).

4.3 Natural aggregates, which primarily contains relatively small levels of alkalis ($Na_2O + K_2O$) to be used as an aggregate source for engineering purposes, has not yet undergone the alkali−silica reaction (ASR).

4.4 As compressive strength was the primary factor influencing abrasion resistance, limestone aggregate samples demonstrated the highest compressive strength and had greater abrasion resistance than marlstone aggregate, As a result, limestone aggregate was frequently utilized aggregate in heavy building materials, base courses in the construction of roads and as a concrete mix's aggregate. On the other hand, the marlstone aggregates showed moderate strength and are appropriate for use as sub base courses in roads and non-structural concrete applications such as concretes for sidewalks and filling.

4.5 The development of concrete durability was further enriched by the use of the correlation analysis method to establish a quantitative characterization relationship between an aggregate's physical and mechanical properties.

4.6 Knowing and interpreting the geological characteristics, rock mass classification and rock strength of limestone and marl are essential components of safe geotechnical design and site selection. So, all of these parameters are an amazingly effective strategy that helps miners decide quickly and provides convincing evidence for their use as raw material for construction materials.

Conflict of interest

There is no conflict of interest associated with this research.

Acknowledgement

I would like to extend my sincere gratitude to the Koya University Faculty of Engineering and Civil/ Geotechnical Departments for allowing me to use their workshop and laboratory facilities for samples preparation. I particularly valued their assistance during fieldwork and their computer resources.

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