ISSN XXXX XXXX © 2018 IJESC

Research Article Volume 8 Issue No.6

Engineering Geological Characteristics of limestone Types for Concrete Production in Jamshoro Sindh, Pakistan

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Abstract:
The production of concrete in PAKISTAN involves the use of several mineral aggregates such as gravel, granites, sand and limestones. The use of limestones for concrete, however, is well patronized especially by private low cost housing builders due to its low cost compared to other alternatives. Limestones are known to have strength characteristics which are not uniform and as such vary from low to high depending on their petrographic state. This research provides some Engineering Geological characteristics of limestone types used for concrete works in parts of Sindh and offers a classification of limestones for easy field identification by Construction Engineers. The results of strength tests and petrologic examination confirm that there are different types of limestones with strengths that correlate positively with their level of geologic state. In addition, the most compacted limestone was found to be resistant to weathering and useful for producing concrete for construction work.

Keywords: Limestone types, aggregate strength, Geological Characteristics, concrete

1. INTRODUCTION

Concrete production for construction purposes is an activity which goes on in almost every country. Concrete is a mixture of fine and coarse aggregates, an appropriate binder and water in specified ratios and is used for constructing foundation walls, floor slabs, columns and many other elements of buildings. The strength of concrete depends on several factors including aggregate characteristics such as aggregate size, aggregate type and aggregate strength. The size of aggregate used for concrete production is known to have some effect on the strength of the concrete. Zaidi, (2008) has indicated that when large size coarse aggregates are used in concrete the strength of the concrete is reduced due to weak bonds caused by greater heterogeneity, internal bleeding and the development of micro cracks. In another research, Aquinoi et al. (2010) confirmed that the coarse aggregate with the smallest comparative size gave the maximum compressive strength of concrete and that concrete strength reduces after a critical maximum aggregate size is attained. They further observed that as the heterogeneity of aggregates increases the compressive strength of concrete reduces. In Jamshoro Sindh, several rock types for producing aggregates are available but the rocks which form the bulk of mineral aggregates used for construction include shale, limestone (. Ahlrich, R., 1996). The type of construction aggregate used in a particular locality in Jamshoro depends on the requirements of the project involved and also proximity of the source of the aggregate to the project site. In the middle and northern sectors of the SINDH sandstone and limestone are extensively used.. Limestone and sandstone, which are converted to aggregates by crushing mechanically, are also exported for use in other regions of Sindh especially in the road sector. Due to the high cost of aggregates made from other igneous rocks, low cost housing construction works by indigenes are undertaken using limestone which is comparatively cheaper. The limestone rock aggregates are usually produced by family groups who hand crush the limestone rock from an outcrop using hammer and chisel. The Limestone is crushed manually in some places by local villagers because they do not have the modern mechanical tools or machinery, sometimes crushing is of different sizes because of its strength, degree of weathering, compactness, hardness etc. Field evidence has shown that different types of limestone occur in the Petaro Structural Unit. The different limestone types have not been clearly identified and categorized in terms of strength and geological features for concrete production. The lack of proper categorization of the limestone has resulted in a situation where producers of limestone rock aggregates mix up the various types before being offered for sale. The outcome of this mixing is that the strength of the resulting limestone rock aggregates is compromised and may be unpredictable. The aim of this research, therefore, is to identify and classify the different types of limestone used in some parts of Sindh and to test for their strength properties so as to determine their suitability for use in construction activities.

2. MATERIALS AND METHODS

Materials

Different types of limestones were selected from rock outcrops of the Jamshoro

25.3349° N, 68.2143° E BHOLARI
25.3541° N, 68.2683° E KOTRI
25.5167° N, 68.3000° E PETARO
25.4169° N, 68.2743° E JAMSHORO
25.3850° N, 68.3649° E S U CAMPUS

The different limestone types are readily accessible to the communities along the formation.

Methods

Tests performed on the aggregates include aggregate impact

value, aggregate abrasion value, 10% fines value, aggregate crushing value, water absorption test and petrologic examination of limestone samples.

Aggregate Impact Value Test

The material used for the Aggregate Impact Value (AIV) is aggregate passing a 12.70 mm sieve and retained on a 9.52 mm sieve. The test samples were placed in the steel mould and compacted by a single tamping of 25 strokes of the tamping rod and subjected to 15 blows of the hammer dropping through a height of 381 mm (BS 812-112). The crushed aggregate was sieved over a 2.36 mm sieve and the fraction passing 2.36 mm was weighed. The fraction retained on the sieve was also weighed and the aggregate impact value determined.

Aggregate Abrasion Value Test

The test sample weighing 5000g was placed in the Aggregate Abrasion Value (AAV) testing machine and steel balls were added for the crushing as outlined in ASTM C131. The drum of the machine was rotated for 500 revolutions at a speed of 30 to 33 revolutions per minute and the crushed aggregate was discharged and sieved through a 1.70mm sieve and then weighed. The abrasion value of the coarse aggregates was then determined.

Ten Percent Fine Value Test

Ten percent fines value is an indication of the resistance of aggregate to crushing when subjected to loading. The test which was carried out in line with BS 812-111, determined the forces required to produce 10% of fine values.

Aggregate Crushing Value Test

The Aggregate Crushing Value (ACV) is a measure of the resistance of an aggregate crushing under gradually applied compressive load. In this test the aggregate passing through 12.5mm and retained on sieve size 10mm is placed in 3 layers into the cylindricalmould, each layer is tamped with 25 strokes. The aggregate in the mould is then weighed, its surface leveled and the plunger inserted. The whole assembly is put into the compression testing machine, the load is started at an equal ratio, when the process is completed the sieving of sample is done in 2.36 mm sieve, the particles retained and passed is measured and ACV is then calculated.

Water Absorption Test

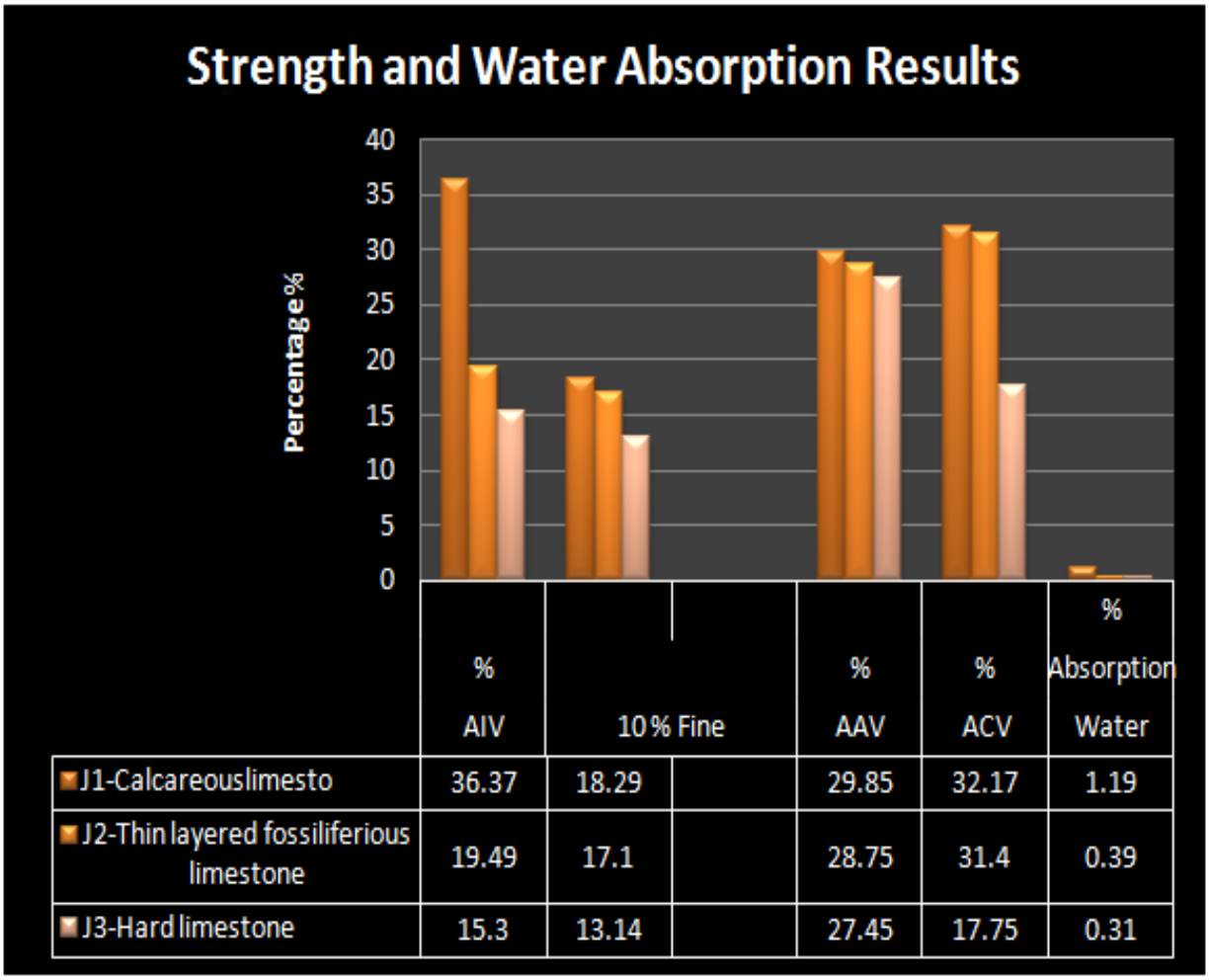
Limestone aggregates that are retained on the 10mm sieve size were collected into a perforated plate and thoroughly washed to remove dust, and then oven dried at a temperature of about 105^{o}C for a day and weighed. The aggregates were soaked for a day in water after which they were reweighed. The difference in weight, expressed as a percentage, is the absorption (ASTM C127).

Procedure for classification of limestones

Different types of limestones were identified in the Laki limestone Unit formation, which is the main source of limestone rock aggregates in Jamshoro area. The limestones were subjected to petrologic examination for various geologic characteristics such as structure, thickness, friability, fracture pattern, flakiness, lustre and colour. Petrographic analysis of some samples of the limestone rock..

3. RESULTS

The results below are the outcome of the field inspections of rock outcrops within the Lakilimestonel Unit and various strength tests conducted in the Laboratories in Jamshoro on the limestone samples.



	% AIV	10% Fine		% AAV	% ACV	% Absorption Water
J1-Calcareouslimesto	36.37	18.29		29.85	32.17	1.19
J2-Thin layered fossiliferious limestone	19.49	17.1		28.75	31.4	0.39
J3-Hard limestone	15.3	13.14		27.45	17.75	0.31

Table.1.Showing strength tests results and water absorption of limestone types in Laki Limestone Jamshoro.

Sample	AIV %	10 % Fine	Force/KN	AAV %	ACV %	Force/ KN	Water Absorption %
J1	36.37	18.29	110	29.85	32.17	400	1.19
J2	19.49	17.1	200	28.75	31.4	400	0.39
J3	15.30	13.14	260	27.45	17.75	400	0.31

J1- Calcareouslimestone; J2- Thin layered Fossiliferous limestone; J3- Hard limestone

Table .2. A Geological Lithofacies of limestone types found in the Jamshoro area Sindh., Pakistan.

Limestone Type	Description					
	Structure	**Fracture**	**Thickness**	**Flakiness**	**Lustre**	**Colour**
J1 Calcareous limestone	Hard compacted limestone with micro fossils	No Fractures	Variable	Very hard, limestone, breakes with hammer gives sone echo sound when hit	Earthy	Variable colours Different varieties of brown, Dark yellow brown and cream.
J2 Thin layered Limestone	Moderately thick layers Individual grains of the source rock in some layers are visible only with the aid of hand lens. May be schistose.	Fractures between and across grains	Thinly layered 10-200mm	Flaky Layers cannot be broken with the hand due their thickness; Gives moderate amount of dust when crushed	Greasy	Variable Different varieties of brown, dark brown and cream.
J3 Aranaceous Limestone	Massive Individual grains of the source rock are not visible even with hand lens. All sedimentary structures have been erased. May be jointed.	Fractures through grains	Massive layers > 200mm	Gives very low amount of dust when crushed	Glassy	Variable Different varieties of brown, dark brown and cream.

4. DISCUSSION

The results of the water absorption tests (Table 1) conducted on the three varieties of limestones vary due to the fact that J1 absorbs less water than J2 and J3 absorbs the least amount of water. This indicates that J3 is the most porous of the three samples and therefore may be the weakest in terms of strength.. Qureshi, M.A.,et al., 2015 Other results in Table 1, which include the aggregate impact value, aggregate crushing value and aggregate abrasion value for the limestone, are presented in Fig. 1. The high aggregate impact value for J1 limestone of 37% implies that J1 is too strong to be used for road surfacing and may affect the compressive strength of concrete positively. The low strength of J1 limestone Is corroborated by its high 10% Fine value of 18.%, the high aggregate abrasion value of 28% and the high aggregate crushing value of 32.% compared to the values for J2 and J3. The J3 limestone has the highest strength and resistance to crushing as indicated by the aggregate impact value of 15.50%, low 10% Fine of 11., low aggregate abrasion value of 26.50% and low aggregate crushing value of 18.65%. It is, therefore, good coarse aggregate for all types of construction works including road works, blinding and all reinforced concrete works as well as M_{25}, and M_{20} concrete. Table 2 contains the

different categorization of limestone types found in parts of Jamshoro which can be used for easy field identification. The three types of limestones may occur together in an outcrop in which case they may be accidentally or ignorantly mixed after crushing before being offered for sale or construction, but careful inspection using the characteristics in Table 2 may serve as useful tool for categorization. The J1 limestone (Table 2) has preserved a number of sedimentary features such as the nodular appearance, hard strong heavy to handle as a hand specimen. Gondal, M.M.I et al,., 2009, somewhat earthy. It is therefore, most susceptible to weathering. In terms of luster the J1 limestone can be described as being earthy. The J3 limestone is the most FOSSILIFEROUS. Ghaffar, A., et al., 2016.andas a result, has completely Clear all traces of the original grains and sedimentary features. It is the resistant limestone type to weathering. The J3 limestone usually occurs as massive outcrops with glassy lustre and may be jointed. The jointed J3 limestone is likely to be weaker than those which are not jointed. When crushed J3 limestone fractures through grains and gives very low amount of dust compared to J2 and J1 types of limestone. The J2 limestone however, is flaky, feels greasy and fractures between and across grains. They are often layered, and individual grains of the source rock are visible in some layers with the aid of hand lens. It is also susceptible to weathering, which may start in between layers as they represent weak zones.(Gondal, M.M.I., 2008) The flakiness of J2 limestone is likely to lower the workability of a concrete mix and therefore affect its long term durability. Flaky aggregates could affect bituminous mixtures by causing crack development and possible break up during compaction and rolling.(Yaqub, M. and Bukhari, I., 2006) The different samples of limestone types exhibited varieties of colours which are due to iron oxide (. Ahmed, S.et al 2015) and other impurities being incorporated during the metamorphic process. According to Gondal, et al. 2008) the quartz, which is the dominant mineral in the limestone,

Figure.1. J1

Figure.2. J2

Figure.3. J3

In view of its resistance to weathering J3 limestone may be valuable for highway construction and as a**base material for buildings. The glassy luster of J3 limestone however, may cause weak bonding between the aggregate and cement mortar due to its smooth surface. The J3 limestone rock aggregate have angular shapes and could form good interlocking network which makes it superior aggregate over rounded aggregates in terms of strength.**Zaidi, S.M., et al., 2008 **Three different varieties of laki limestone Jamshoro area Sindh, Pakistan.**

Figure.4. Photograph showing crusher plant (25.4169° N, 68.2743° E JAMSHORO SINDH PAK.

Figure.5. Photograph showing crusher plant (25.5167° N, 68.3000° E PETARO SINDH PAK

5. CONCLUSION

Three different types of limestone have been identified as the source of construction aggregates for concrete production in parts of Jamshoro area. They include quartzitic sandstones, thin layered limestone and met limestone and have been classified as J1, J2 and J3 limestone types. The limestone types have presented different strength values which correspond to their degrees of strenghth. The J3 limestone has the highest strength and may be most useful for concrete suitable for

structural work. The J1 limestone is the least weathered as indicated by the presence of some sedimentary features.

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