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A Study on the Suitability of Crushed Sandstone around Adigrat (Ethiopia) for Hollow Concrete Block Production

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Abstract

This study targets to assess the feasibility of using crushed sandstone in and around Adigrat as a sand replacement material in hollow concrete block. The study was conducted by taking samples from three types of sandstone, categorized based on their colour as white, red and light red. The physical and chemical properties of the sandstone were studied. The sandstone was then used to prepare sample blocks which were then tested for density and compressive strength. The test results on the blocks showed that the blocks manufactured using sandstone as a replacement of construction sand, have all the strength and density requirements specified in ES 596:2001, at least as a non-load bearing wall making material. From the three sandstone categories, the white sandstone has produced the best results with relatively higher compressive strength and density. It can be concluded from the study that the crushed sandstone around Adigrat can be readily used as a replacement for sand in hollow concrete block, as far as the production procedures in this study are followed. The sandstone may also serve as a sand replacement in concrete production with further study on it. Commercial sand production from the sandstone could also be taken as a potential solution for sand shortage with further study on cost feasibility.

Keywords: Crushed sandstone, Hollow concrete blocks, Compressive strength, Density.

Introduction

Society has been blessed with fairly plentiful natural resources. Mankind has to face the scarcity of natural resources, if they are over exploited. Abundant mining operation on extracting of natural resources will adversely impacts the environment in several ways. It is also essential to keep rapidity with the growth in construction. One of the alternatives to Sand is crushed sand stone. It possesses properties similar to that of river sand and is a more suitable construction material. One of the major challenges in the construction industry in Ethiopia is provision of construction materials. Different construction materials are used in a construction project which can be either manufactured products or natural materials, including cement, sand, coarse aggregate, masonry, timber, steel, glass, aluminum, tiles, plastic products and many others. Sand is one of the extensively used construction material. It is used in the preparation of blocks, concrete, mortar and other products. Requirement of large amount of sand with acceptable cost is one of the challenges in the construction around river areas and other relatively far sites. Investigation of alternative option for the source of such sand will have great import for the current construction activities in the country. The chemical and physical properties of quarry dust were investigated with respect to requirements of codal provision which are satisfied. The 100% replacement of sand with quarry dust gives improved results in terms of compressive strength which lead to investigate on crushed sand stone as a fine aggregate in concrete block production [4]

It is a conventional fact that the physical and mechanical properties of aggregates are innate from parent materials, while the properties of the parent material innate on its geological formation. Geologically rocks are classified into three major divisions based on their source, namely Igneous, Sedimentary and Metamorphic. Igneous rocks are rocks produced from the solidification of molten material (magma) either at or below the earth's surface (e.g. granite, diorite, gabro, felsites, basalt, etc). Sedimentary rocks are shaped as strata as a result of sedimentation from disintegrated products. They are stratified rocks usually laid down under water even though they can also be formed due to wind and glacial action. (Sand stone, limestone, and shale etc). Metamorphic rocks are formed using pre-existing igneous, sedimentary or metamorphic rocks by the reasons of heat or pressure or both. The change may

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be textural, structural or mineralogical gone with changes in chemical composition. (Marble, meta-quartzite, and slate etc). [1]

Sandstone is a classic sedimentary rock comprising an aggregate of fragments of minerals, rocks or fossils held together by mineral cement. Actually, sandstone forms when sand is buried under successive layers of sediment. During burial the sand is compacted and a binding agent such as quartz, calcite or iron oxide is precipitated from ground water which moves through passageways between grains to create Sandstone. Sandstone is an abundant material in and around Adigrat. It is made up of mainly sand particles with fewer amounts of fine cementing particles. This stone has comprised the bed rock of Adigrat town and its surroundings and can be accessed at a very shallow depth. In addition, it is a stone which can be easily crushed into constituting smaller particles. It can be seen that, when excavation work is done for different projects in the town most of the material is this crushed sandstone and it is mostly carted away as a waste material, while some people are trying to use it in place of sand mainly in hollow concrete block production.

This research attempts to scientifically study the significance of this crushed sandstone around Adigrat town as a sand replacement material for hollow concrete block production and to propose a standard application procedure. The result of this study will also have significance to further study the feasibility of producing sand from sandstone on a commercial level.

Necessity

Currently the construction industry of Ethiopia is under huge shortage of quality construction sand. Providing efficient and cost effective alternative sources for construction sand will have a huge importance for the industry. Studying the properties of crushed sandstone, which is abundantly and easily assessed in different parts of the country, as an alternative sand replacement material will provide a huge potential to supply especially the northern part of the country with a cost effective, quality and easily accessible construction sand.

Objectives

The objectives of this research are:

1. Studying the physical and chemical properties of sandstone around Adigrat town with emphasis on its use as a sand replacement material.
2. Study on the best proportion of ingredients in the production of hollow concrete block using crushed sandstone.
3. Preparation of standard procedure in the use of sandstone as a sand replacement material.

Methodology

The research was conducted with two basic steps. First, the physical and chemical properties of the crushed sandstone are studied. Then hollow concrete (HCB) blocks were produced using different types of crushed sand stones and tested. The sandstone was classified into three categories based on its colour as natural sand, white, red and light red, for sampling purpose. Chemical and physical tests were conducted on three samples taken from each category of as natural sand, white, red and light red. Initially white, red and light red sand stones were crushed and sieved as per the codal provisions [6, 7].

The chemical test conducted was a complete silicate analysis test which is used to determine the mineralogical content of the sandstone. The test was performed at the Geochemical Laboratory of the Geological Survey of Ethiopia, Addis Ababa. The test was conducted on three samples taken from each of the three categories described above. A physical test, grain size analysis, was conducted in the soil laboratory of Adigrat University on three samples taken from each category, to determine the fine content (silt and clay content) of the sandstone. The wet sieve procedure was used here, in order to obtain a more accurate result. A total of twelve blocks are manufactured using sandstone, by varying proportion and color. In that blocks were prepared using the standard procedure and the details about the type and proportion of ingredients were given in table 1.

Table 1
Type and amount of ingredients used for block production

Type of sandstone	Number of Samples (each)	Amount of ingredients used for the production of blocks			
		Cement (kg)	01* Aggregate (m^3)	00* Aggregate (m^3)	Sandstone (m^3)
Red Light red White Natural sand	3	2.75	0.017	0.002	0.004

* 01 Aggregate is a local common naming for aggregates with a maximum aggregate size of 10 mm, while 00 is again a local naming for the finest particles obtained during the crushing process for aggregate production [1].

Results and Discussion

This chapter presents the results obtained from the study. Two parameters of the hollow concrete blocks were measured in the study; the density and the compressive strength of the blocks. These values are then compared with the standard ranges of recommended values and with the characteristics of the conventional local block samples.

Physical and Chemical Properties of Crushed Sandstone

Chemical and physical tests were conducted on the natural sand, white, red and light red crushed sandstone samples.

The natural cementing material which binds the sand together as rock is usually composed of silica, calcium carbonate, or iron oxide. The percentage constitution of each constituent varies between certain limit, the results of these tests are given in tables 2 and 3. A physical test was conducted in the soil laboratory of Adigrat University on three samples taken from each category of natural sand, white, red and light red, to determine the silt and clay content of the sandstone. The wet sieve procedure was used here, for more accurate result.

Table 2
Complete silicate analysis results on the three samples

Type of sandstone	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Na_2O	K_2O	MnO	P_2O_5	TiO_2	H_2O	LOI
Red	87.5	4.45	1.22	1.56	1.18	1.54	0.01	0.01	0.07	0.43	0.19	1.42
White	90.5	4.43	0.34	1.04	1.06	0.54	0.01	0.01	0.1	0.36	0.14	0.88
Light red	86.3	5.74	0.86	1.4	1.48	0.54	0.46	0.01	0.14	0.4	0.22	1.95
Natural sand	86.1	5.64	0.54	1.36	1.45	0.52	0.45	0.01	0.13	0.38	0.2	1.97

Table 3
Wet sieve analysis results on the three samples

Type of sandstone	Sand content (%)	Fine content (%)
Light red	85.4	14.6
White	90.0	10.0
Red	86.0	14.0
Natural sand	84.8	15.2

Density of HCB blocks

They are three classes of aggregates were known depending on their weight: i. light weight, ii.normal weight and iii.heavy weight. Lightweight aggregates are aggregates whose maximum dry loose bulk density is about 880kg/m3 for aggregates and 1040Kg/m3 for all-in aggregates. Lightweight aggregates are classified as natural and artificial depending on how they are sheltered. The main natural lightweight aggregates are diatomite, pumice, scoria, volcanic cinder, and tuff. Except for diatomite, all are volcanic in origin. Pumice and scoria are more widely used for hollow and solid concrete block production in Ethiopia. [2]. The weight of a hollow concrete block should not be generally high; otherwise it will impose high dead load pressure on the structural members of the building or any other work. According to ES 596:2001, class A, B and C blocks are recommended to have a density ranging from 900 kg/m^3 to 1200 kg/m^3. The measured density of the prepared sample blocks is given in table 5.3.

As can be seen from the result, the densities of all the blocks are up to the required range for class A, B, and C blocks according to ES596:2001. According to IS: 2185 (Part I) – 1979, the blocks made using the red and light red sandstone are slightly below than the other type of stones. But, the researcher believes that the density requirement will not be very significant as far as the blocks can fulfill the strength criterion. In addition, lower weight will also have its advantage in reducing the total dead load the structural members of a building are expected to carry. Then these blocks were tested in the construction materials laboratory of Adigrat University. The compressive strength test was performed using a digital “Impact” compressive strength testing machine.

Table 4
Density of the prepared sample blocks

Type of Sandstone	Density of the Samples (kg/m^3)			
	Sample 1	Sample 2	Sample 3	Average
Red	998.5	1000.5	1010.5	1003.2
Light red	975.5	967.5	982.4	975.1
White	1044.7	1053.06	1055.06	1051
Conventional Block	1027.2	1010.06	1020.06	1019

Table 5
Compressive Strength of the Produced Blocks (After 28 Days)

Type of Sandstone	Compressive strength of the Samples (MPa or N/mm^2)				Class [ES 596:2001]			Class [IS: 2185-1979]		
	Sample 1	Sample 2	Sample 3	Average	Sample 1	Sample 2	Sample 3	Sample 1	Sample 2	Sample 3
Red	3.66	3.65	3.68	3.66	C	C	C	B*	B*	B*
Light red	2.55	2.45	2.65	2.55	D	D	D	B*	B*	B*
White	4.21	4.36	4.37	4.31	B	B	B	B*	B*	B*
Conventional Block	3.21	2.81	2.84	2.95	C	D	D	B*	B*	B*

* The classification is made even if the blocks have a density slightly lower than the required limit.

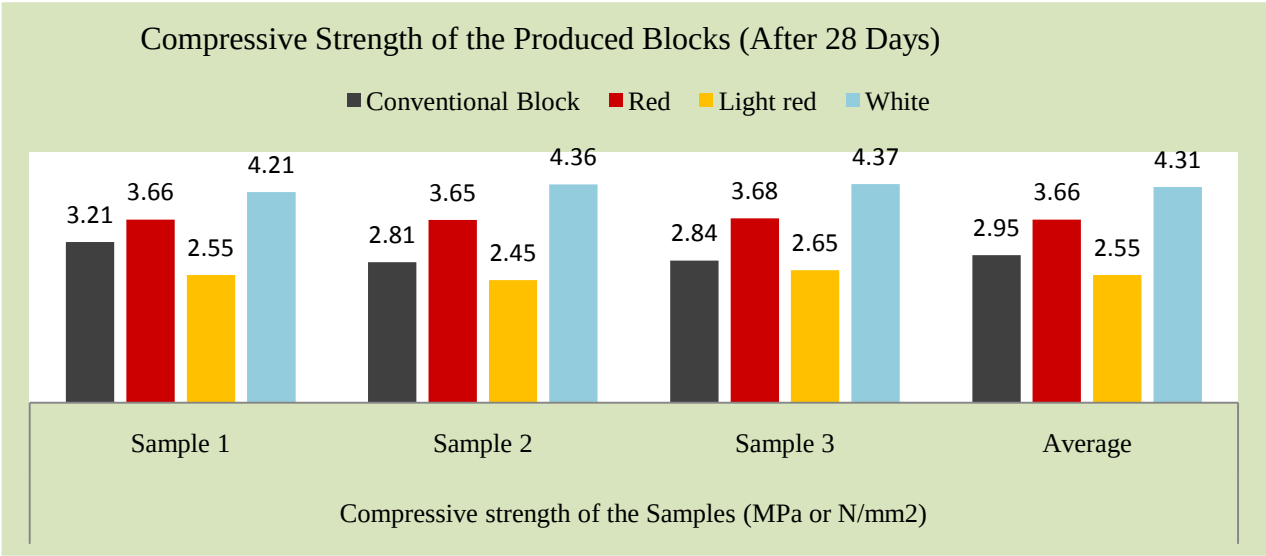

Figure I
Compressive Strength of the Produced Blocks (After 28 Days)

Figure II
Prepared sample hollow blocks

Figure III
Prepared sample hollow concrete blocks during test

Conclusion and Recommendations

1. The concept of replacement of natural fine aggregate by crushed Sand stone thus reducing the need of land fill area and conserving the scarcely available natural sand sustainable development. Strength of the concrete block is mainly dependent on bonding of the fine aggregates which fills the voids between the coarse aggregates.
2. From the experimental study, it is concluded that white sand stones and red sand stones can be used as a replacement for fine aggregate (natural sand). It is found that crushed white sand stones and red sand stones given maximum result in strength compared to other type of sand stones and natural river sand. The results proved that crushed white sand stones and red sand stones were produced increase in percentage of characteristic compressive strength of 46% and 24% but light red sand was produced decrease in percentage of characteristic compressive strength of 13%.

And the following points are recommended based on the study

1. The general quality of Adigrat Sand stone for fine aggregate production is very good.
2. When using the crushed sandstone as a replacement for sand in hollow concrete block production, it the fine content should be checked first and should be compatible with the standard requirements. The producers should also be able to guarantee the quality of their products satisfying the required relevant standards.
3. The ratio of sandstone to be used should be decided based on the better strength and density obtained using different ratios in this study.
4. It will be better to use a sand stone with a white colour and red colour for fine aggregate production intended for better strength and results.
5. It is recommended to further study on the potential use of sandstone for use in concrete and feasibility of production of sand commercially by crushing it and also
6. It is suggested that future study on using different ratio of the red and white crushed sand stones as fine aggregate of Hollow Concrete Block Production.

References

1. Abebe D. 2005. *"The Need for Standardization of Aggregates for Concrete Production in Ethiopian Construction Industry"*, Addis Ababa University
2. Annual books of ASTM standards, 2002, volume 04.02 and Volume 04.03.
3. Mengistu, T. and Fentaw, H.M., Industrial Minerals and Rocks Resource.
4. R. Ilangovana, N. Mahendrana, and K. Nagamanib, *"Strength and durability properties of concrete containing quarry rock dust as fine aggregate,"* ARPN Journal of Engineering and Applied Sciences, vol. 3, no. 5, pp. 20–26, 2008.
5. Potential of Ethiopia, FDRE Ministry of Mines, Geological Survey of Ethiopia, March 2003.
6. Ethiopian standard (ES 596:2001); specification for concrete masonry units.
7. Indian standard IS: 2185 (Part I) – 1979, Specification for Concrete Masonry units.
8. Shewaferaw D. 2006. *"The Use of Manufactured Sand in Concrete Production: Test Results and Cost Comparison"*, A thesis submitted to the school of graduate studies of Addis Ababa University.