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Comparative Study of the Compressive Strengths of Concrete Produced fromTap and Well water in Sokoto Metropolis; Sokoto State Nigeria

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ABSTRACT

The study focus on the effect of different qualities of water on concrete compressive strength. The concrete mix of M20 grade with water cement ratio of 0.5 were investigated. Water samples, such as tap water and well water were collected from various sources at Ruggarworo, kanwuri area sokoto, GangarentasharIllela area, Tshowarkasuwa area Mabera area, Tudunwada area, Arkilla area Runbukawa area. The concrete was produced with different types of water forthe compressive strength of the concrete. The concrete was produced with tap and well water in nine (9) cubes each using moulds sizes of 150mm x 150mm with water source from Sokoto metropolis. The batching used was by volume using a mix ratio of 1:2:4-19mm aggregates. The concrete was cured and the compressive strength was determined for a hydration period of 14, 21 and 28 days. The outcome of the research shows that concrete cast with tap water has higher compressive strength than well water concrete but yet at 21 days' hydration period, well water has a compressive strength of 22N/mm^2 which is still adequate for its to be used in concrete productionu because it fails within the range of BS 8110 which 20N/mm^3-40N/mm^3. Therefore, the rural dwellers in the study area can embrace the use of well water for concreting as they access well water more easily than tap water.

Keywords: Compressive, Strength, Concrete, Tap Water, Well water, Cement.

I. INTRODUCTION

Majority of cities in Nigeria are fast becoming homes of majority of people due to rural-urban migration, rapid-growing population and rapid urbanization, among other factors (Onibokun and Faniran, 2015). Consequently, there has been an astronomical increase in the demand for houses in all urban areas including Sokoto metropolis. The World Bank (World Bank, 2018) demonstrates that Nigeria requires about 700,000 housing units annually, spanning through a 20-year period to accommodate her rising population. This is highly unattainable with current indices, coupled with the sluggish growth of housing sector in Nigeria. With a population of approximately 197 million (World Bank, 2019), coupled with high demand in housing units, both in quantity and quality as well as other municipal infrastructure. Nigeria is facing a critical housing crisis with sub-standard and unsafe houses spring up every in the urban areas just as severe shortages of other municipal infrastructure. Sokoto metropolis is among the locales bedevilled with very acute housing shortage due to what Onibokun and Faniran (2015) have listed.

To expatiate this point, the Techno-Economic Survey (1981) of Sokoto State (conducted to form the basis of Economic Development of the state) demonstrated the population of the Sokoto metropolis to be 206,000 in 1980; 263,000 in 1985; 336,000 in 1990 while the latest figures (National Population Commission of Nigeria/National Bureau of Statistics website-https://www.citypopulation.de/) indicates that Sokoto metropolis had 563,861 residents in 2017. Indicatively, Sokoto metropolis requires several units of standard houses to serve the populace therein. Furthermore, the Techno-Economic Survey of Sokoto State (1981) projected that while the demand was 207 Million Litres per Day (MLD) in 1980, it will rose to 286.3 MLD by 1985, further rose again to 394.7 MLD in 1990 and should be expected to have risen to 697.7 MLD by 2000. The twin problems (housing and water shortages) usually tied to rapid urbanization motivated the authors to conduct the study the 'Compressive Strengths of Concrete Produced from Tap and Well water in Sokoto Metropolis. Undeniably, the construction of standard houses involves the use of concrete which could be sub-standard or otherwise depending on the compressive strength.

Cement concrete is a mixture of cement, sand, pebbles or crushed rock and water, which when placed in the skeleton of formworkand allowed to cure, becomes hard like a stone. Consequently, aggregates are the important constituents in concrete production because they give structure to the concrete, reduce shrinkage and effect economy. Earlier in building construction, aggregates were considered as chemically inert materials but now it has been recognized that some of the aggregates are chemically active. Moreover, certain aggregates exhibit chemical bond at the interface of the aggregate and paste. The mere fact that aggregates may occupysome 70-80% of the volume of concrete, strongly suggests that their impact on the various characteristics and properties of concrete is undoubtedly considerable. Thus, since aggregates constitute major volume in concrete, a discussion on concreteproduction is incompletewithout the examination of aggregates in depth and range.

Categorically, cement constitutes the only factor that has become a standard component in concrete production in Nigeria. Other ingredients especially water and other aggregates are natural materials and vary in their properties. In view of this fact, lin-depth studies conducted in respect of aggregates so that their widely varying effects and influence on the properties of concrete cannot be underrated. Cement is an extremely ground material having adhesive and cohesive properties which provide a binding medium for the discrete ingredients. Categorically, in all parts of Sokoto State, there is inadequate production and supply of tap/ (potable)water forhuman consumption (Bala, 2021) and in consequence for concrete production.Admittedly, concrete is one of the most widely used construction materials worldwide including Sokoto State of interest the reasons being: its versatility, strength, durability and the fact that it is easy to be used to produce any form and shape. Moreover, GIRMAY (2019) demonstrates that concrete is made up cement, aggregates, water and sometimes admixtures.Corroboratively, Usman, GyangandBamidele(2020) opine that concrete in Nigeria is commonly made by mixing Portland cement with sand, crushed rock and water. It must be noted that a concrete mix may either be classified as designed or prescribed. A designed concrete mix is where the contractor is responsible for the selection of mix proportions/ (aggregates) to achieve the required strength and workability whereas for a prescribed concrete mix, the producer specifies the mix proportions (aggregates) and the contractor is responsible only for providing proportions.

Ileana,Palobo, Francesca (2020) have elucidated that the strength of concreteis commonly considered mostly based on its valuable properties although in many practical cases, other characteristics such as durability, impermeability and volume stability may be more important. Nevertheless, strength usually gives an overall picture of the quality of concrete because it is directly related to the structure of cement paste. However, Riyad, Ferreira, Indraratna and TNO (2021) argue that strength, durabilityas well as volume changes of hardened cement paste depends not so much on the chemical composition as on the physical structure of the product of hydration of cement, and also on their relative volumetric proportions in particular; thus, it is the presence of flows, discontinuities and pose which are of significance.So, to understand their influence and strength, it is pertinent to consider the mechanics of fractures of concrete under stress.Kiambigi (2021) explains that concrete is the name given to mixture of particles of stone bond together with cement since the major part of concrete is of particles of broken stone and sand and is termed as aggregate.

HabertandPittau (2020) assert that concreting constitutes 50% to70% of the total building, while(Sharma2021) postulates that as at 2005, about six billion cubic meters of concrete are made every yearglobally which is equal to one cubic meters (m^3) for every one person on the earth. In the same vein, Siddiqi (2020) posits that in building industry, concrete is mainly used for structural components such as foundations, beams, columns, slabs, staircases, lintels, water storagesand etc. Concrete is considered to be a universal construction material because of its resistance to water, ease with which structural concrete elements can be formed into a variety of shapes and sizes. Hence, this research aimed at investigating the compressive strength development of concrete made from tap (potable) and well water as a building material in Sokoto a burgeoning metropolis in north-western Nigeria. Specifically, the research will address different kinds of water used in concreting, workability and setting of concrete mixing as well as determining the compressive strengthof concrete made with different qualities of water found in the locale.

Statement of Research Problem

It has been outlined that housing demand outstrips housing supply in Sokoto metropolis on account of the city's rapid rate of urbanization. Thus, private developers have resorted to building houses to meet demand. Muhammad (2021) elucidates that in all parts of Sokoto metropolis, there is inadequate production and supply of tap/ (potable) water for human consumption and other uses; this fact clearly indicates that there is acute supply of tap water in the metropolis resulting in several residents' use. Thus, other sources of water supply especially wells have become the main source of water supply consumption and other activities. It is therefore reasonable to say that there is the probability that builders are not using tap water to produce concrete needed to construct houses. Indeed, concrete constitutes the major component in the structure of buildings. Although,several researches have been conducted on the compressive strength of concrete with partial replacement of cement or sand (either mass or reinforced concrete in the study area, virtually none of them focused on the use of different sources of water (especially that from hand-dug shallow or deep wells) in the production of concrete in Sokoto metropolis where concrete is commonly used in building construction. This is the reason why the researchershave focused attention on examining partial replacement and use of admixtures. So thefocus of the study is to assess the compressive strength of concrete produced from waterfrom wells (of all categories) to determine if is such concrete is in conformity with building regulation standards and that water from wells canstand as an alternative to conventional concrete produced from tap (potable)water being used presently in the area thereby reducing the cost of producing concrete.

Objectives of the Study

To reiterate,Sokotometropolis comprises: Sokoto North, Sokoto South, part ofWamakko, a portion of Dange-Shuni, part of Bodinga and Kware Local Government Areas. The studypurposively chosethe following locationsRuggarWoro,Kanwuriarea of inner Sokoto, Gangaren-Illela area, TshowarKasuwaarea Mabera area, Tudun Wada area, Arkilla areaand Runbukawa area as study sites. The objective the study are as follows: -

1. To identify different types of water used in concrete production sokoto metropolis.
2. To identify the setting time of a concrete mixed with different types of water in the study area.
3. To determine the compressive strength of concrete produced with different types of water in the study area.

Sokoto metropolis lies between latitude 12^o $55^{'}$and 13^o $10^{'}$ N and longitude 5^o $09^{'}$ E and $5^o17^{'}$ E (Sokoto Master Plan, 19xx). Specifically, Sokoto metropolis covers the entire Sokoto North and Sokoto South Local Government Areas (LGAs) as well as the Army Barracks, and Danbuwa neighbourhoods of Dange-Shuni LGA; the Arkilla, RuggarWaru, Bado, Gwiwa, Nufawa, Gidan Fulani and Kalambaina districts of Wamakko LGA) and the More district and the permanent site of Usman Danfodiyo University all in Kware LGA.

II. LITERATURE REVIEW

2.1 Introduction

It must be emphasized that the purpose of the study is to assess the compressive strength of concrete produced from well water in the bid to determine if is such concrete is in conformity with building regulation standards in Nigeria so that well water can stand as an alternative to tap (potable) water which is used in producing conventional. Several technical terms need to be well-explained to allow non-professional readers to appreciate subsequent discussions. The sub-sections below have been devoted to highlighting concepts that are akin to concrete production and usage.

2.2 Definition and Types of Concretes

Sharma (2021) elucidates that the most commonly and widely used material in the construction is concrete; he opines that concrete is a heterogeneous manufactured stone composed of graded granular inert material held together by the action of cement, water and inner materials. Earlier, Qian et al (2014) have explained that concrete consists basically of gravels or large particles of crushed stones and sand called aggregates. The authors (ibid) report thatthe fact that aggregate constitute about three quarter the volume of concrete is of tremendous importance. Concrete may either be classified as designed or prescribed; a designed concrete mix is one in which the contractor is responsible for selecting the mix proportions to achieve the required strength and workability whereas for prescribed mix proportion, the engineer specifies the mix proportions and the contractor is responsible only for providing the proportion.

2.3 Cement

Narcloch, Paschuk, Correa (2019) as well as Panda (2016) have demonstrated that cement is a composite produced from clay and limestone. In general, most concrete is made with ordinary or rapid hardening Portland cement both types being manufactured to the recommendation BS 1976-1.

Narcloch, Paschuk, Correa (2019) had outlined that various types of cement are available on the market depending on the consultant and process of manufacturing. The most common type is ordinary Portland cement which is manufactured by burning specific proportions of various compounds of calcium to form clinker. The clinker is the crushed into a powder-like form that is known ordinarily as Portland cement and used for general contractor works where no specific proportions;the are other type of cement available for faster removal of form work is sulphate-resistant cement.

2.4 Aggregates

Commonly, the term aggregate refers to a collection of things used for a specific purpose. Panda (2016) observes that sand is generally the fine aggregate used for concrete while coarse aggregate is usually either gravel or crushed stone. Furthermore, Roy et al (1999) describe aggregate as any material that has sharp, surface texture and grinding (distribution of particles sizes) characteristics which influence the workability and strength of a concrete. A coarse aggregate has been described as stones larger than 4.76mm in size (B.S 410 which are products of solid crush of rocks. The mode of formation of these rocks accounts for the variability in coarse aggregates. Metamorphic reported classification of rock in the basis of their formation and sedimentary rocks. Use of laterite as fine aggregate preliminary result indicates that a relative smaller amount of cement is required.

2.5 Fine aggregates

Fine aggregates concrete consists of a mixture of Portland cement, fine aggregate (sand) and water, so proportioned mixed as to provide a punipable fine aggregate concrete. Fine aggregate concrete has a typical mix ratio of 0.65 to 075 (wekipidyclopia,2009). The nominal size of fine aggregate is less than 4.76mm which are form sharp river sand or red sand. The pumping of fine aggregate into the fabric forms causes a reduction in the water content by filtering excess mixing water through the permeable fabric. The reduction mixing water substantially improves the water/cement ratio of in place of fine aggregate concrete thereby increasing its strength and durability with a typical loss of approximate 15% of the total mixing water, 27 cubic feet or (1.0 cubic meter) of hundred concrete.

2.5.1 Mechanical propertiesfine aggregate

1. Bond strength of concrete. The resistance develops to shear particles from the hardened cement paste3 is called bond strength of aggregate. Bond is partly due to the interlocking of the aggregate and the paste owing to the roughness of the surface of the aggregate particles.
2. Crushing strength of aggregate. The compressive strength of concrete cannot exceed that of the aggregate used. There in usually aggregate is considered ten times stronger than the crushing strength of concrete but some particles break also and influence its strength.

2.5.2 Physical properties of fine aggregate

1. Specific gravity. Specific gravity is defined as the ratio of mass (or weight in air) of a unit volume of materials to the mass of some volume of water at the stated temperatures in producing concrete aggregate. Generally, contains pores both permeable and impermeable. The specific gravity of most aggregate varies between 2.6 and 2.8
2. Bulk density. The weight of aggregate that would fill a container of a unit volume is known as bulk density of aggregate. Bulk density depends on how densely the aggregate is packed and consequently on the size distribution of the particles
3. Porosity and absorption of water by aggregate. The porosity, permeability and absorption of aggregate influence the resistance of concrete to freezing and thawing, bond strength between aggregate and cement paste, resistance to abrasion of concrete.

2.6 Coarse aggregates

They are aggregates larger than 4.76mm in size and they product of solid crush of the earth (rock) which form as a result of formation of the movement of molten magma beneath earth crust, maple of coarse aggregate is granite, limestone, basalt etc. similarly, according to Engidasew(2014) in normal or conventional concrete, coarse aggregate is made from rock fragment characterized by high strength on their part. Bashir, Almusalam and Maslehuddin (2003) stated that the strength of concrete at an interfacial zone as an essential dependent on the integrity of the cement paste as well as the nature of the coarse aggregates used.

Properties of Coarse Aggregate

Aggregate is one of the principles of concrete mix design is to use as much aggregate as possible (up to 75% or more). Aggregate is much cheaper than cement and is more satisfactory structural material than cement paste, (Robalo,et al 2021). To assess the quality of an aggregate, its

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properties must be determined as described in the relevant standard e.g. the BS 882: (Jaskulski, et al2019). Apart from the amount of aggregate in concrete, another very important factor to be considered is that the aggregate must be of good quality, (Nwakaire,et al 2020).

2.7 Water

Roy et al (1999) are of the opinion that, water must be clean and free from impurities which are likely to affect the quality or strength of the resultant concrete such as pond, river, canal, sea, and well should not use and only water which is fit for drinking should be specified. The cement/water ratio is a most important factor in concrete quality. It should be kept as low as possible constituent with sufficient workability secured fully compacted concrete with the equipment available on the site. The higher the proportion of water, the weaker with the concrete water/cement ratio usually in the range of 0.40 to 0.60 weight of water divided by weight of cement, allowance has to be made for observation by dry and porous aggregate and the surface proportional aggregate require an excessive amount of water to give adequate workability and this result in low strength and poor durability

2.8 Compressive Strength

According to Siddiqi (1998), compressive strength with given proportions of aggregates depends on cement and cement/water ratio, an increase in any of this factors produces increase in strength. Compressive strength varies from less than 10N/mm^2 or 1500Ib/mm^2 for lean concrete to more than 10N/mm^2 or 1500Ib/m for special concrete. The minimum characteristics strength to BS 110 is 10N/mm^2, for concrete with light aggregate (except for plain walls) it is 20N/mm^2 (about 3600Ib/m^2).

III. MATERIALS AND METHODS

3.1Methods

In each of the local Government selected for the research, fifteen (15) cubes from each local Government were produced. Therefore, for the three senatorial areas, a total of 90 cubes were casted. After 24 hours of production, the sample was immersed in water inside curing tank for 28 days. The same water/cement ratio (w/c ratio) was adopted for all the mixes. Absolute method of batching was by weight and the concrete of nominal mix ratio of 1:2:4 was used. After 28 days of curing, the concrete sample was removed from curing tank and subjected to compressive strength test. The compressive strength of sample from the three senatorial districts was recorded after crushing. However, the results were also compared with the stipulated value(s) of compressive strength of concrete sample in the recognized standard code of practice of BS 8110.

3.2 Sample Collection

The sample of tap and well water used for this study work was collected from two LGAs which are:Sokoto North and Sokoto South LGAs

3.3 Material

a. Cement: Ordinary Portland cement was obtained from Sokoto Cement Company
b. Sharp sand was obtained from Sokoto North and Sokoto South LGAs
c. Gravel/Coarse aggregate was obtained in Kalambaina of Wamakko LGA
d. Tap Water was obtained in TasharIllela in SokotoNorth LGA
e. Well water was obtained in RuggarWoroof Wamakko LGA.

3.4Apparatus

The sets of apparatus used were in the study were; **(i)** Trowel; **(ii)** Iron tamping rod; **(ii)** Head pan; **(iv)** Brush; **(v)** Cube moulds of size 150mm x 150mm; **(vi)** Bucket.

3.5Experimental Procedure

The preparation of concrete was initiated through the mix and cast in the workshop, with the mix ratio of 1:2:4. The concrete materials were batched in volume and mixing was done using shovel and trowel. The specimen was cast in 150mm x150mm cube moulds, the moulds were thoroughly clean and a light coat of oil was applied on the moulds. The moulds were placed on a smooth horizontal and rigid surface. The moulds are then filled with concrete in four layers with each layer been tamped 25 times with a tamping rod, the top layer was robbed and then stroked off level with trowel and the specimen were allowed for 24hrs before demoulding. The concrete specimen was cured in a moisture environment for 14, 21 and 28 days, at end of curing period of 14, 21 and 28 days respectively, 3 cubes from each of the local government area concrete specimens were randomly selected, they were then allowed on air to dry in laboratory for 24hrs, they were then tested in a compressive testing machine and the average crushing load of each of the 3 specimen were then recorded.

IV. RESULTS AND DISCUSSION

4.1Results

Table 1: Compressive strength of concrete produced using Tap water in sokoto metropolis

Curing days	[g] Averageweight	[g/cm] Averagedensity	[cm] averagevolume	[KN] averageload	[N/mm] average compressive strength
14	7891	234	3375	405	18.0
21	8029	384	3375	510	22.6
28	7813	233	3375	609	27.1

Source, [laboratory test2021]

Table 2: Compressive strength of concrete produced using well water in sokoto metropolis

Curing days	[g] Averageweight	[g/cm] Averagedensity	[cm] averagevolume	[KN] averageload	[N/mm] average compressive strength
14	7874	233	3375	356	15.8
21	8041	238	3375	451	20.0
28	7813	233	3375	531	23.6

Source,[laboratory test 2021]

4.2.2Discussion

4.2 Effects of Tap water on Strength of Concrete

InTable 1 , the hydration period of tap water [concrete] shows that beside 14 days of hydration, 21 and 28 days has already gain the required compressive strength in BS needed which was within the range of 20 – 27N/mm. minimum compressive strength of a concrete in 28 days was within 20 – 40 N/mm. BS 8110 [1995] and the crushing load range from 400 – 600 KN,thus the reason why tap water [concrete] has higher compressive strength than well water was as a result of tap water been treated very well from source (Water treatment plant) that prevent chemical reaction with the cement and thereby not inhibiting concrete quality or strength.

4.3 Effects of Well water on Strength of Concrete

Based on the result of the test carried out as shown in table 2, it was observed that well water concrete is also useable in concrete production because 21 and 28 days' hydration compressive strength falls within the range of 20 – 27N/mm and 20 – 40 N/mm and has a crushing of 451 – 531Kn as stipulated by BS 8110.

V. CONCLUSION

Based on the research and laboratory test carried out it has been realized that the tap water concrete has much crushing load than the well water concrete. Also the tap water was more preferred for making concrete due to its high compressive strength than the well water concrete. However, as the hydration compressive strength of concrete made from well water falls within the acceptable standard of building code $2N/mm^3$-$40N/mm^3$ after 28 days of hydration (BS 8110) could therefore be used for building in the study area.

VI. RECOMMENDATIONS

i. Therefore, the well water in the study can be used in concrete production after 21 days of hydration.
ii. well water can be serve as alternative to tap water.
iii. The rural dwellers in the study area can embrace the use of well water for concreting as they access well water more easily than tap water

REFERENCE

[1]. Muhammad, B. (2021). An Assessment of the Challenges of Potable Water Supply in Sokoto Metropolis, Sokoto State Nigeria. An MscGeography Thesis, Department of Geography, Usman Danfodiyo University Sokoto

[2]. Riyad, A. S. M; Ferreira, F. B; Indraratna, B; TNO (2021). Critical Review on the Performance ofPile supported Rail Embankment under cyclic loading: Numerical modelling approach. Transport research centre, School of Civil Engineering

and Environmentalngineering, University of Technology Sydney (UTS) Sydney, NSW 2007, Austrailia. http//doi,org/10.3390/543052509 (Accessed on 15th May, 2021)

[3]. Engidasew, T. A. (2014) Engineering geological characterization of volcanic rocks of Ethiopianand high land to be used as construction material. http//veprint.unica, it/959/

[4]. Girmay, M.K. (2019), A study mechanical properties of concrete using waste bottle caps partial replacement for coarse aggregates. A master thesis, Department of Civil Engineering Addis Ababa science and Technology University.

[5]. Jaskulski, R., Glinicki, M. A., Kubissa, W., &Dąbrowski, M. (2019). Application of a non

[6]. -stationary method in determination of the thermal properties of radiation shielding concrete with heavy and hydrous aggregate. International Journal of Heat and Mass Transfer, 130, 882-892.

[7]. Kiambigi, J.M (2021), Modelling of concrete performance based on quality attributes of different fine aggregates. http//local/host/xmlui/handle//123456789/5526 (Accessed on15th May, 2021)

[8]. Ileana, O. Jelescu, Marco.P., Francesca.B.Kurt.G. S. (2020).Changes for biophysical Modelling of Microstructure. Journal of Neuroscience method. http//doi,org/10.1016/j.jneumeth,2020.108861 (Accessed on 15th May, 2021)

[9]. Mosley, W, et al. (1999), Reinforced concrete Design, Pal gave, Pp.1, 3, 19

[10]. Narcloch, .D.C., Paschuk.S.A., Correa.J.N. (2019) Elementary characteristics of samples of Portland cement, Natural gypsum and Phosphogypsum mortar from Brazil. Brazilian Journal of Radiation Sciences.

[11]. Nwakaire, C. M., Yap, S. P., Onn, C. C., Yuen, C. W., & Ibrahim, H. A. (2020). Utilisation of recycled concrete aggregates for sustainable highway pavement applications; a review. Construction and Building Materials, 235, 117444.

[12]. Panda, H., (2016), Cement manufacturing, asbestos cement production method, asbestos cement manufacturing. Complete Technology Book on Asbestos, Cement, Ceramic andLimestone.

[13]. Qain .Z, Garbizi, E.J. Ye, G., Schlange.E. (2014), A Geometrical Model for Composite Structure of Mortar and Concrete using real Shape.Matarstruct 49, 149-158 http//doi,ng/10.1617/s11527-014-0482-5 (Accessed on 15th May, 2021)

[14]. Onibokun A, Faniran A (2015). Urbanization and Urban Problems in Nigeria. Urban Research in Nigeria. Available from: http://www.books.openedition.org/ifra.

[15]. Usman, A. Dahiru, B. and Samson, K. (2010).Concrete Technology, Longman Publisher London Pp 87

[16]. Usman, N; Gyang, J. B;Bamidele, B.O. (2020).Determination of Compressive Strength of Concretefrom different Brands of Ordinary Portland Cement, Journal of Building andEnvironmental Engineering 1 (1),34-44 retrieved from http//journal.scienceca.org /index,php/jbee/view/129.(Accessed on 15th May, 2021)

[17]. Robalo, K., Soldado, E., Costa, H., do Carmo, R., Alves, H., &Júlio, E. (2021). Efficiency of

[18]. cement content and of compactness on mechanical performance of low cement concrete designed with packing optimization. Construction and Building materials, 266, 121077.

[19]. Siddiqi, Z.A. (2020.) Concrete Structures, Part 1 4th Edition Longman Publishers London Pp32.

[20]. Sharma, C.B. (2021) Applied Environmental Sciences and Engineering,BFC publication Vol. 9 No1 Pp 55-56.

[21]. Wikipedia Encyclopaedia (2009), Detail on Alluvial (online) Available from http/www.google.com (accessed 10th August, 2019).