*International Journal of Women in Technical Education and Employment*
*ISSN: 2811-1567. Volume 5 – Issue 1. July 2024*
*https://fpiwitedjournal.federalpolyilaro.edu.ng*

INTERNATIONAL JOURNAL OF WOMEN IN TECHNICAL EDUCATION AND EMPLOYMENT (IJOWITED)

# Evaluation of the Outcome of the Variation of Constituent Ingredients on the Compressive Strength of Concrete

**S. S. Omopariola**
Department of Civil Engineering, School of Engineering, Federal Polytechnic, Ilaro, Nigeria.
samuel.omopariola@federalpolyilaro.edu.ng

## *Abstract*

*Concrete is a universal material of construction due to its versatility. It is made up of a combination of different constituent materials which are water cement, fine and coarse aggregates. These materials have diverse properties which are brought to bear on the overall properties of the product (concrete). The variation in the content of these various constituents will affect the different properties of concrete especially the compressive strength. This study is therefore geared towards evaluating the influence of such variations on the compressive strength of concrete. 27 trial mixes were produced and the 28 days compressive strength was determined. The results subsequently obtained from the trial mixes were analyzed to formulate a regression model for concrete mix proportion. The result of the predicted compressive strength was examined to evaluate the effect of the variation of the various constituent materials. The result shows that variation by weight of each of the constituent materials results in variation in the compressive strength of concrete.*

**ARTICLE HISTORY**
Received: June 8, 2024
Revised: June 19, 2024
Accepted: June 27, 2024

**Keywords:** Evaluation, Variation Constituents, Compressive Strength, Concrete.

**Citation**
Omopariola, S. S. (2024). Evaluation of the Outcome of the Variation of Constituent Ingredients on the Compressive Strength of Concrete. *International Journal of Women in Technical Education and Employment,* 5(1), 231 – 238.

## Introduction

Concrete has been described as an essential material of construction. Its economic, structural and mechanical versatility is responsible for its being referred to as the backbone of the construction industry (Simnani, 2017). Its use is universal and cuts across many aspects of infrastructural development such as building (residential, commercial and industrial), roads, bridges, docks, habours, dams, etc. Its function in the construction of structural members that serves as load bearing members implies that special attention should be paid to the different factors that contribute to the strength of such members. The compressive strength of concrete is defined as its capacity to resist loads coming upon it before the failure of the member. It is the most important test carried out on concrete because it provides a basis for the assessment of the characteristics of concrete (Ramadhansyah, 2020). The components of concrete are water, cement, fine and coarse aggregates. Each

The important role of cement in concrete cannot be overemphasized, it is the constituent material that binds other solid constituents (fine and coarse aggregate) together and is responsible for the gain in strength of concrete upon hardening (Civil Synergy, 2020). Additionally, it reacts with water for its hydration. LeBow (2018), attests to the significant role of cement in concrete, stating among others its influence on the compressive strength of concrete. It was opined that increasing the cement content of concrete causes the compressive strength to increase to an extent. Taylor et al. (2015), asserted that there is limitation to the linear relationship of cement and the compressive strength. It was further stated that there is effective minimum cement content requirement beyond which addition to the cement content will not cause any significant increase in the cement content.

Bamigboye et al. (2016), attested to the significant role of coarse aggregate in concrete materials. Engr.psu.edu (nd), asserted that the various properties of coarse aggregate such as specific gravity, moisture content, gradation etc. in conjunction with water cement ratio (w/c) is a determinant factor in the compressive strength of concrete. In like manner, water is a constituent of concrete in that it helps to form the gel or paste that binds both the fine and coarse aggregate together to form a solid mass (Shetty, 2005) . Furthermore, it is responsible for the hydration of cement through its chemical reaction with cement thus enhancing its hardening and development of strength (Baylynx.co.uk, nd).

According to Gagg (2014) variation in the mix of the various constituent materials used in the production of concrete enhances its diversity of usage in various ranges of applications. It therefore entails that this variation in the content of these various constituents will affect the different properties of concrete especially the compressive strength. This study is therefore geared towards evaluating the effect of such variations on the compressive strength of concrete.

## Materials and Methods

Water, cement, pit sand and granite were used in producing the concrete cubes for the study. The water used was portable water suitable for drinking obtained from the laboratory. Dangote cement of grade 42N conforming to BS EN 197 – 1:2011, was used. Pit sand and granite were used as fine and coarse aggregate respectively. All the materials were obtained from local dealers in Ilaro, Ogun State Nigeria.

**Experimental Mix Design:**

The minimum requirements stated in BS 5328 _ 1: 1997, was taking into consideration in the design of the experimental mix. Three different (w/c) were considered, they are 0.35, 0.4, and 0.45. Similarly, three different cement contents of 325Kg/m$^3$, 350 Kg/m$^3$ and 375 Kg/m$^3$ were used. While the coarse aggregate /total aggregate (CA/TA) ratios are 0.6, 0.65, and 0.7. The proportions of the various component used in the study is presented in Table 1 while the properties of the aggregates used are presented in Table 2.

Table 1 Proportion of Components Used in the Study

| Component | 1 | 2 | 3 | Level |
|---|---|---|---|---|
| W/C | 0.35 | 0.4 | 0.45 | 3 |
| CC (kg/m$^3$) | 325 | 350 | 375 | 3 |
| CA/TA ratio | 0.6 | 0.65 | 0.7 | 3 |

**Mixing of Constituent Materials:**

The different components were mixed manually because the quantity of materials used in each trail mix was small. The mixing process consist of measurement of the required quantity of cement and fine aggregate by weight after which they were thoroughly mixed until uniform colouration was attained. This was followed by the addition of measured amount of the required quantity of coarse aggregate. The required amount of measured quantity of water was added. The entire constituents were then mixed thoroughly before scooping into moistened 150mm x 150mm x 150mm cube moulds.

**Casting of Cubes:**

The cube moulds were filled in three equal layers, compaction of each of the three layers was done by applying 25 strokes of tamping rod to each layer. The cubes were demoulded after twenty four hours and the cubes were transferred to the curing tank leaving it to be cured for 28 days. A total of 81 cubes were cast for 27 trial mixes. After 28 days, the cubes removed from the curing tank. The cubes were then left on the floor for about 15 minutes to allow the water to dry from the surface after which they were conveyed to the compressive testing machine for crushing.

**Development of Mix Design Model:**

The results obtained from the experimental trial mixes were analyzed using SPSS to develop a regression model for which was used to predict the compressive strength of concrete with the use of the mix design parameters that was used in the trial mix design.

## Results and Discussion

### Results of Tests on the Material

The sieve analysis curve for the granite and pit sand used for this work is presented in Figures 1 and 2, while Table 2 presents the result of the coefficient of uniformity (Cu) and coefficient of curvature (Cc). The results indicates that (Cu) and (Cc) for pit sand are 2.66 and 0.98 respectively, while that of granite was 1.64 and 1.11 respectively. According to Ajagbe et al. (2018) and Kalore & Sivakurmar (2023), Cu value of value of fine aggregate must be greater than 6 and that of coarse aggregate must be greater than 4 for them to be considered as well graded. Otherwise, they are said to be poorly graded. Similarly the CC value must be between 1 and 3 for well graded aggregate. Since none of the two materials meet all of these criteria, both of them are poorly graded. From these results, the Cu of pit sand is less than 6 while that of granite is less than 4 it can be inferred that both pit sand and granite are poorly graded.

Table 2 The Properties of Aggregates used in the Study.

| Material | Pit Sand | Granite |
|---|---|---|
| Fineness Modulus | 2.7 | 5.17 |
| Specific Gravity | 2.65 | 2.67 |
| Water Absorption | 2.31 | 0.85 |
| CU | 2.66 | 1.64 |
| CC | 0.96 | 1.11 |

The fineness modulus (FM) of pit sand as presented in Table 2 is 2.7, with this value, the sample can be considered as of medium coarseness judging by the assertion of Team Civil (2020) that the range of the FM of medium sand is 2.6 – 2.9. The FM of 5.17 for granite used in this study falls below the range of 5.5 – 8.0 stated in (The Constructor, n d). The specific gravity of both the pit sand and granite are 2.65 and 2.67 respectively as presented in Table 2. These values are between the range of 2.6 and 2.8 stated in Shetty (2010). This implies that the specific gravity of both materials is okay for the study. The water absorption (WA) of both materials are 2.31% and 1.9% respectively, which are less than limiting value of 3% as contained in BS 8007: 1987.

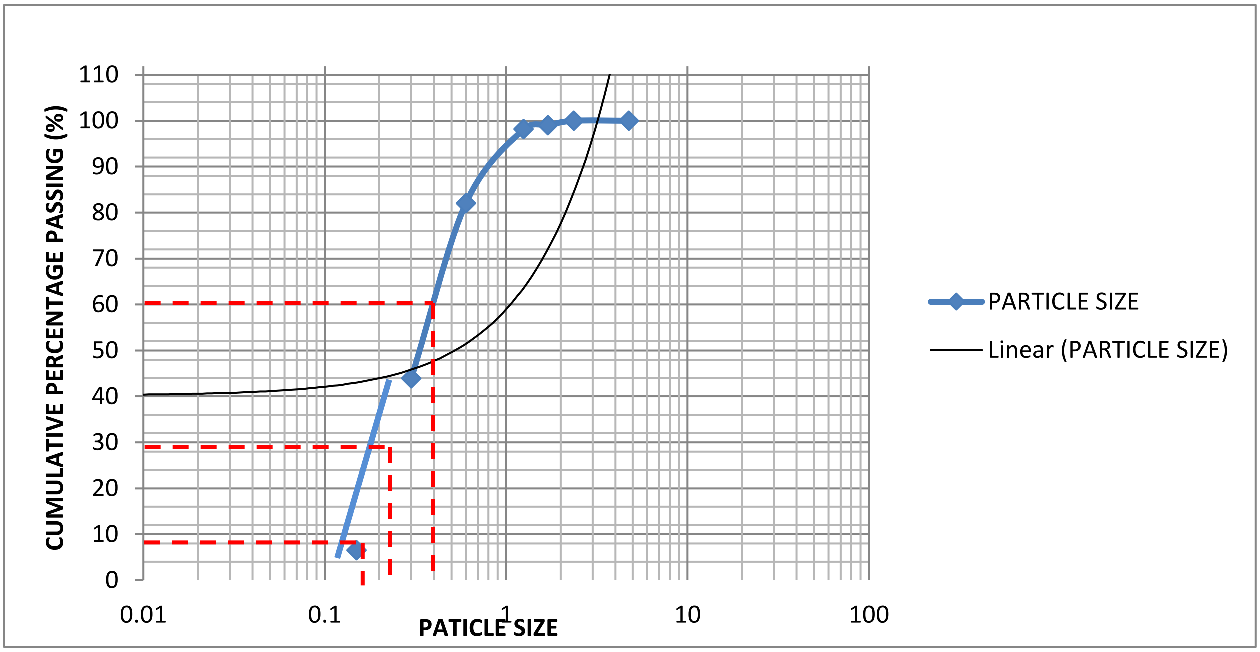


Figure 1 Particle Size distribution curve for Pit Sand

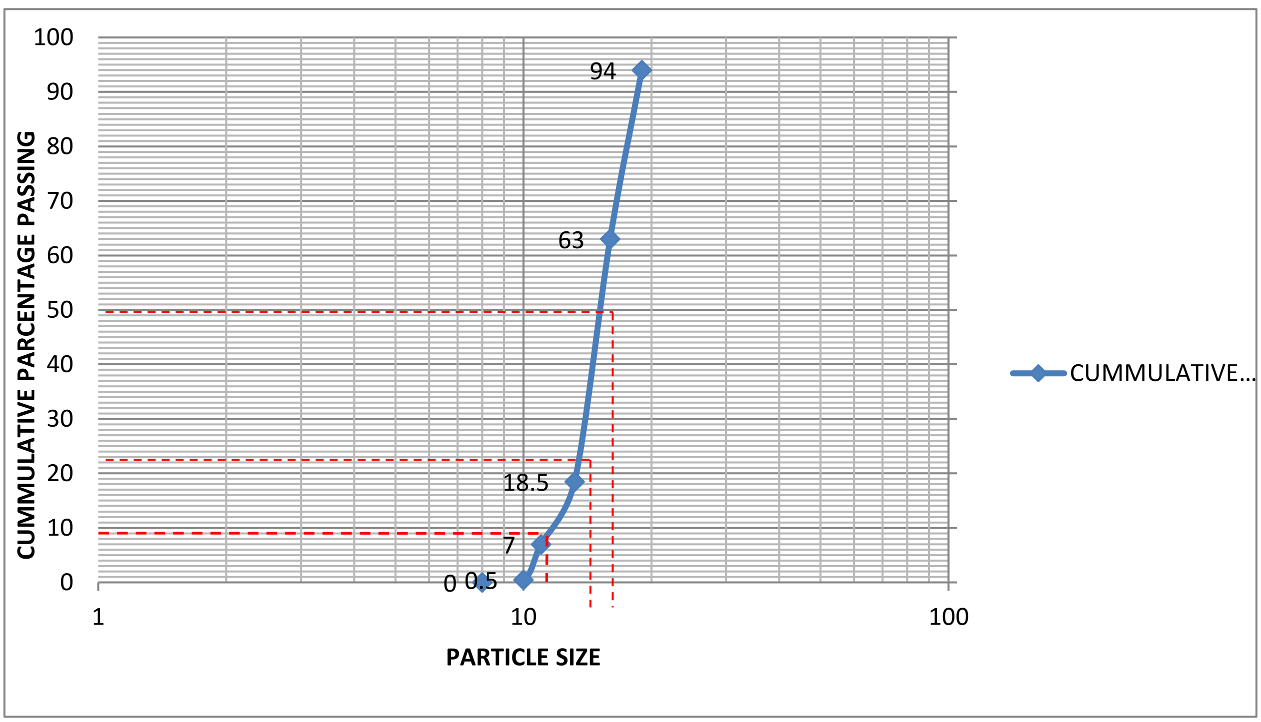


Figure 2 Particle Size Distribution Curve for Granite

**Effect of Variation of W/C Ratio and Cement Content on the Compressive Strength of Concrete made with Pit Sand**

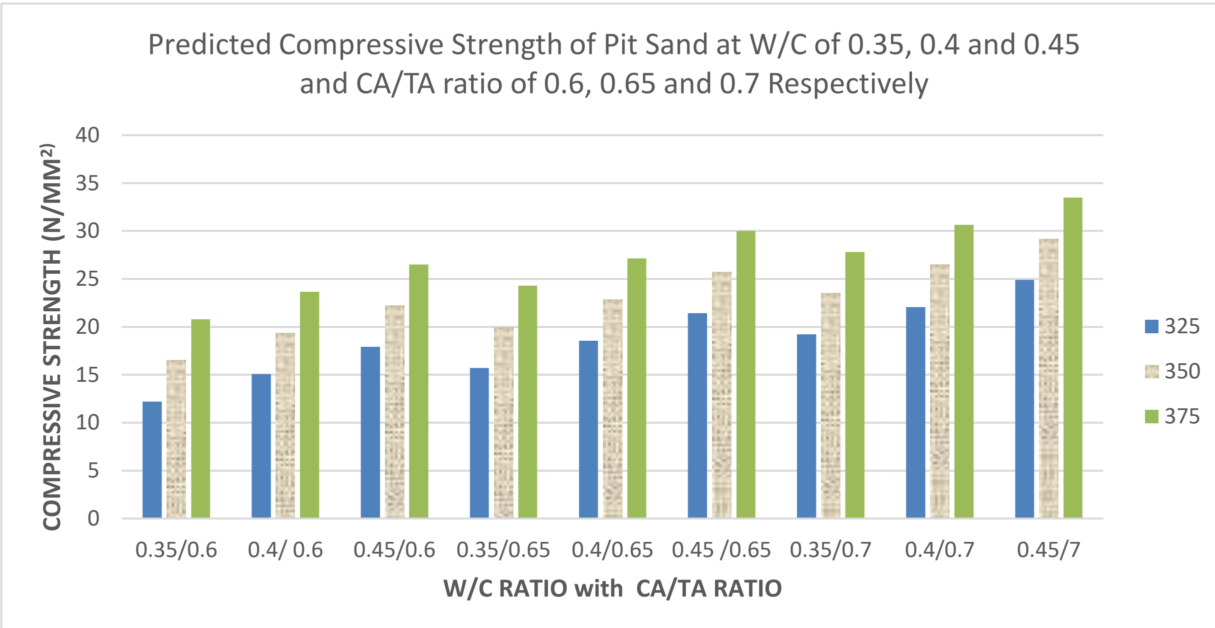


Figure 3: Chart of the Effect of Variation of W/C Ratio and Cement Content on the Compressive Strength of Concrete made with Pit Sand

In figure 3, the result of predicted compressive strength of pit sand at w/c ratio of 0.35, 0.4 and 0.45 is presented. The observation from the figure is that the compressive strength increases as both the cement content and w/c ratio increases.

**Effect of Variation of** CA/TA **Ratio and Cement Content on the Compressive Strength of Pit Sand Concrete**

Figure 4 presents the result of the predicted compressive strength of pit sand at CA/TA ratio of 0.6, 0.65 and 0.7 respectively. From the figure, it can be observed that the compressive strength increases with increase in the cement content for every case of the CA/TA ratio. On the other hand the compressive strength decreases with increase in CA/TA ratio for all cases of w/c.

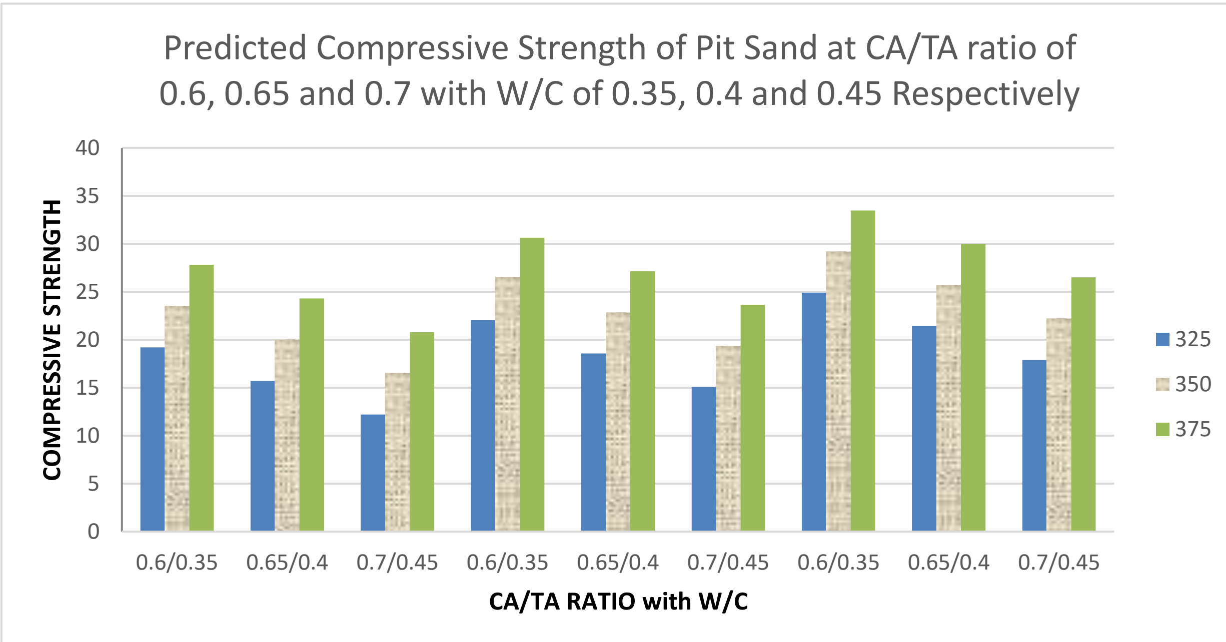


Figure 4 Chart of the Effect of Variation of CA/TA Ratio and Cement Content on the Compressive Strength of Concrete made with Pit Sand

**Effect of Variation of W/C Ratio and CA/TA Ratio on the Compressive Strength of Concrete made with Pit Sand**

The predicted compressive strength of pit sand at w/c ratio of 0.35, 0.4 and 0.45 is presented in Figure 5. The figure indicates that there is increase in the compressive strength when the w/c is increased, while it reduces when the CA/TA ratio was increased.

In summary, it can be established that the lowest value of the compressive strength is 12.21N/mm$^2$ which occurs at the CA/TA ratio of 0.7 and w/c of 0.35 and cement content of 325Kg/m$^3$, while the highest value of 33.49N/mm$^2$ occurred at CA/TA ratio of 0.6, w/c ratio of 0.45 and cement content of 375Kg/m$^3$.

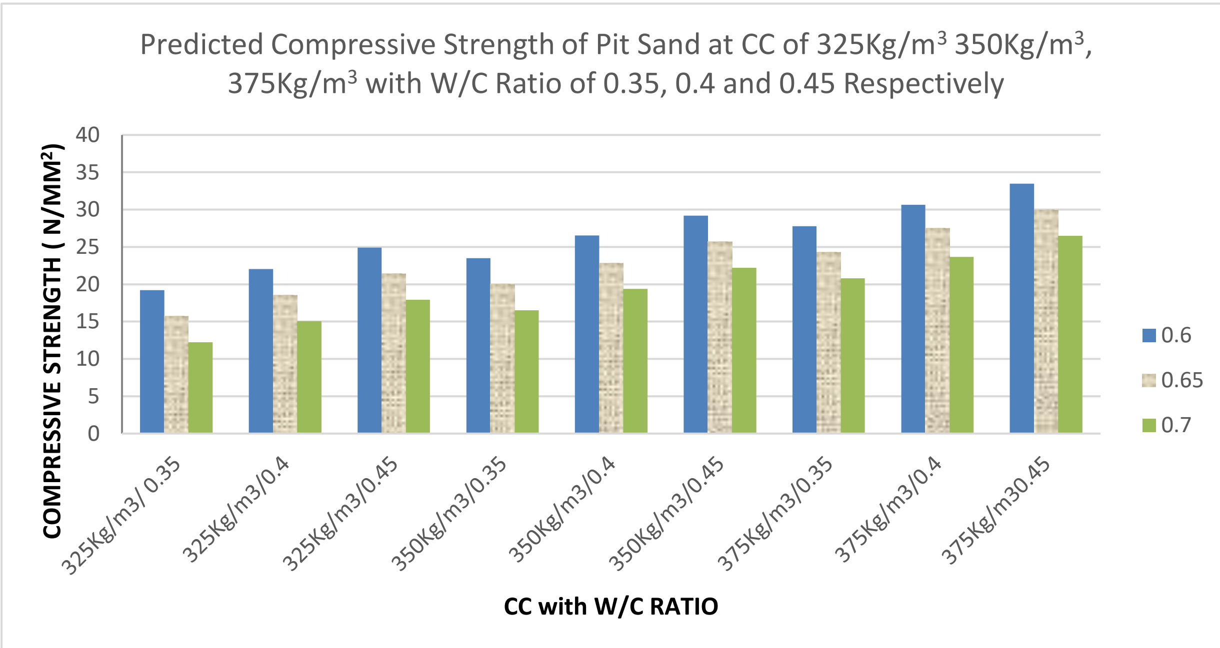


Figure 5 Chart of the Effect of Variation of w/c Ratio and CA/TA Ratio on the Compressive Strength of Concrete made with Pit Sand

## Conclusion

From the study, it is concluded that variation in the composition by weight of the constituent materials affects the compressive strength of concrete. The increase in both the w/c ratio from 0.35 to 0.45 and the cement content from 325Kg/m$^3$ to 375Kg/m$^3$ results in increase in compressive strength of concrete, while increase in CA/TA ratio from o.6 to 0.7 results in decrease in the compressive strength of concrete.

## References

Ajagbe, M. A., Tijuana, I. S., & Arohunfegbe, M. T. A. (2018). Assessment of Fine Aggregates from Different Sources in Ibadan and Environs for Concrete Production, Nigerian *Journal of Technological Development,* 15(1), 7 - 13

Bamigboye G. O., Ede A. N, Umana U. E., Odewumi T. O., & Olowu A. O., (2016). Assessment of Strength Characteristics of Concrete Made from Locally Sourced Gravel Aggregate from South-South Nigeria, *British Journal of Applied Science & Technology*, 12(5), 1-10.

BS 5328 Part 1 (1997). Concrete: Methods for specifying concrete, British Standards Institution London.

BS 8007:1987, *Code of Practice for the Design of concrete structures for retaining aqueous liquids,* BSI British Standards.

BS EN 197 – 1:2011 Cement Part 1 Composition, specifications and conformity criteria for common cements, BSI British Standards.

Civil Synergy (2020), https://civilsynergy.wordpress.com/2020/07/25/cement-and-its-importance-in-construction/ Accessed on 26/01/24.

Engr.psu.edu (nd), https://www.engr.psu.edu/ce/courses/ce584/concrete/library/materials/aggregate/aggregatesmain.htm Accessed on 28/01/24.

Kalore S. A. & Sivakumar B. G. L. (2023). Significance of Cu and Cc in Evaluating Internal Stability with Application to Design of Sub base Gradation in Pavements, Transportation Geotechnics, Volume 40.

LeBow, C. J. (2018). Effect of Cement Content on Concrete Performance. Graduate Theses and Dissertations Retrieved from https://scholarworks.uark.edu/etd/3000 Accessed on 26/01/24.

Ramadhansyah, P. J. (2020). 14 - Porous concrete
Taylor, P., Yurdakul, E., & Brink, M. (2015). Performance-Based Proportioning. *Concrete International*, 37(8), 41-46.

Team Civil (2022). https://www.civilengineeringforum.me/how-to-calculate-fineness-modulus-of-aggregates/ Accessed on 28/01/24.

pavement containing nanosilica from black rice husk ash, Editor(s): Pijush Samui, Dookie Kim, Nagesh R. Iyer, Sandeep Chaudhary.

Shetty M.S., (2005). Concrete Technology Theory and Practice, S. Chand & Company Ltd. Ram Nagar, New Delhi - 110 055.

Simnani S. I. (2017). Effect of Water-Cement Ratio on Compressive Strength of Concrete, Journal of Emerging *Technologies and Innovative Research (JETIR),* 4(10), 486 – 488.