DEVELOPMENT OF SELF-COMPACTING CONCRETE MIX DESIGN: IMPLEMENTING BAILEY AGGREGATE GRADATION TECHNIQUES

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ABSTRACT

To achieve the desired fluidity, resistance to segregation and sufficient strength in self-compacting concrete (SCC), it is crucial to choose and optimize the aggregate gradation. The Bailey aggregate gradation process, initially designed for hot mix asphalt, provides a systematic way to mixing aggregates for use in concrete mix designs. Bailey gradation was compared to more traditional methods in a series of experimental studies using varying aggregate quantities. Slump flow, compressive strength, segregation resistance, and L-box passage ratio were the key features that were examined. The results demonstrate that by controlling the particle distribution more precisely, the work ability and mechanical qualities of the SCC are improved when Bailey aggregate gradation is used. This method improves SCC's overall efficiency by refining the mix design, making it more suited for use in complicated and packed form work environments. Work ability, void content, and balanced particle packing density are all enhanced when SCC mix designs are optimized using the Bailey approach. With the use of the Bailey approach, this research aims to determine the optimal ratio of coarse to fine aggregates so that SCC may achieve its desired properties, such as good flow-ability, passing ability, and segregation resistance, all without sacrificing compressive strength.

Keywords: *self-compacting concrete (SCC), mixing aggregates, compressive strength, segregation resistance, mix designs, Bailey approach.*

INTRODUCTION

This is the best approach if you need to make a lot of predictions with a little amount of data. Changing the conditions of an independent variable, also called a predictor variable, allows one to anticipate the outcome of an event. Here we have the experiment in its most basic form. Alterations to the predictor have a corresponding effect on the dependent or outcome variable, the second of the two variables. Consequently, getting the desired outcomes relies heavily on selecting appropriate predictors. Energy pile foundations are a great alternative to traditional piles made of concrete or steel in modern technological engineering. They are not only supporting structures, but they also act as heat exchange components for geothermal energy systems. There has been a lot of talk and practice around energy piles in the realm of civil infrastructure engineering. Developing countries like India, which is the third-largest producer of cashew nut in the world, perform disposal of cashew nut-shell with an uncontrolled burning technique. Limited studies were executed and addressed towards the comparison of calcined and uncalcined agro-waste products on concrete applications. However, to date, no study is performed on the utilization of UCCNA in concrete paste appliances. In addition, oxide nature

variance of CCNA from source to source promotes the scope of research. Many developed nations accept the TRCA coarse as a major construction material. On antithesis, very few studies have been made regards TRCA fines, and many countries do not recommend utilizing it in actual construction practices. It may be due to the uncertain property behaviour of TRCA fines in composite concrete.

LITERATURE REVIEW

Azeokoli Fidelis Okechukwu (2022) Fixing old buildings' structural flaws as soon as possible will avert more problems. Houses in the Astonish metropolitan region of Anambra State, Nigeria, older than 30 years, were the target of this research, which aimed to assess the prevalence of flaws in concrete parts. Questions posed via interviews and questionnaires, as well as visual inspections and observations, historical documents, recordings, images, and non-destructive testing of concrete components in an existing building in the research region, all contribute to the evidence for the study. Licensed builders and preexisting buildings in the study region made up the study's population.

Nicolás Zaragoza (2022) and Jesus, Messiah Manufacturers of concrete utilize additives, which are chemical compounds, to change the material's characteristics. The principal role of the accelerator in modern concrete was to reduce the material's stress reactivity. Although calcium chloride accelerators have been around for quite some time, recent years have seen an uptick in the usage of chloride-free additives that extend the life of reinforced steel by preventing corrosion. This research sought to examine the performance of two kinds of accelerating admixtures in concrete using limestone aggregates in a warm sub-humid environment. Part of the process included measuring important concrete qualities in controlled laboratory settings both when the concrete was new and after it had hardened. The samples were made using both controls and accelerators.

Juliana de Toledo Viana (2020) Using non-renewable materials in building causes a lot of waste and energy consumption, which are two of the numerous harmful consequences on the environment. Therefore, in their pursuit of improved approaches, architects and builders are always looking for ways to use non-traditional and environmentally friendly materials. Bamboo has several benefits as a construction material, such as its low cost, rapid growth rate, exceptional physical and mechanical properties, and everlasting status. The compliance of bamboo to the Bernoulli-Kirchner bending theory has made it the object of several study as a possible steel-free beam substitute. Why? Because it's possible that these beams' design procedures are quite similar to those of reinforced concrete beams. Building four-point bent, rectangular-section bamboo reinforced concrete beams that meet.

Paul Louzolo-Kimbembe (2019) the goal of this research is to find the best way to blend sand from various quarries or extraction locations with other types of natural sands. If naturally existing sands include too-fine components, adding crushed sand may improve their physical properties. Sand from the Congo river, Djiri, Mfilou, and gravel were the four sources of sand that were used. The mechanical strength of concrete is increased by including reinforced sands in the mix. The usual composition of enhanced sands is 70% natural sand and

30% crushed sand. Crushed sand has a sand equivalent value below 70%, but when mixed with natural fine sands, it improves concrete's physio-mechanical qualities and makes it more manoeuvrable by about 50%. The findings of this study provide the Congolese construction industry with optimism for the future and provide evidence that their structures are resilient.

Azadeh Parvin (2019) Despite concrete's intrinsic fragility under stress, professionals have managed to make it harder by adding fibers such carbon, glass, polypropylene, and stainless steel (SSF). After GFRP, CFRP, and SSF fibers are added to concrete, either alone or in mixtures, their mechanical characteristics are studied. Substituting 10% fly ash for cement, specimens were cast in concrete cylinders and subjected to tension and compression testing. Using reinforcing rates of 1% and 1.5%, we investigated the mechanical characteristics of concrete with different kinds of fibers. A 1% fibre reinforcement ratio significantly increased the tensile strength across the board for the concrete cylinder tests, while having little effect on the compressive strength. When contrasted with the control specimen, the results showed a 26% increase in tensile strength and an 11% increase in compressive strength. Extremely disparities existed in the concrete's compressive and tensile strengths.

Design mix

Engineers find the best design mix ratios by researching component attributes. In contrast to the second example, which employs a "nominal mix" of 1 part cement, 2 parts sand, and 4 parts aggregate, a civil engineer would tailor a concrete mixture according to the specific needs of the site and environmental factors. To maximize the mix's efficacy and practicality, precise component measurements are required, therefore admixture packages are often developed. Including the engineer in the process usually drives up the price of the concrete mix, even if cheaper nominal mixes can't meet the very general requirements of design-mix concrete.

Mixing

Thorough mixing is basal for endlessly producing high-quality concrete. Subject area have shown that a foodstuff of aggregates, cement, and water may increase concrete's pack together strength. A "separate paste mixing" procedure is what this really is. Pastes with water-to-cement mass ratios of 0.30 to 0.45 are often ready-made using a shear-type sociable. The last step in mixing concrete involves using conventional mixing equipment to blend the aggregates, premixed paste, and any excess batch water.

Sample analysis—work-ability

Pouring, pumping, spreading, tamping, and vibrating while filling molds and forms requires a workable, pliable concrete mixture. There are many variables that might affect an aggregate's work-ability. These include the water content, the aggregate's age, its shape and size distribution, the degree of cementation, chemical additives such supercritical carbonate, and the volume of water. Concrete might be made more manageable by adding chemical additives or by increasing its water content. Inadequate mixing of cement and particles leads to increased bleeding and segregation, which in turn lowers the quality of the concrete. Grains in concrete, despite the material's adaptability, could reduce its work-ability. There are a lot of potential reasons why an unfavourable gradient might occur.

Curing techniques avoiding water loss by evaporation

The usual method for curing and fully hydrating newly poured concrete is to treat its surface with "curing compounds." In the film-making process, hydrophobic compounds like wax are often used. The coating may be worn away by foot motion after it achieves the proper consistency. Water spritzing or pouring over curing concrete is standard procedure. As can be seen in the picture below, pounding involves soaking the setting concrete and covering it with plastic to keep it from drying out. With this, tackling this problem becomes less of a challenge. Another common method is to cover freshly mixed concrete with plastic or damp burlap to let it cure. Concrete may have its strength increased by using a quick curing procedure. To hasten and enhance the hydration process, steam is often used to heat the poured concrete. The concrete is multipurpose since it is heated and whetted at the same time.

RESEARCH METHODOLOGY

To develop a methodology for selecting the Bailey aggregate gradation technique for Self-Compacting Concrete (SCC) mixture design, we need to break down the key steps involved in both the mix design process and the specific role of the Bailey method in optimizing aggregate gradation for SCC. In this work, the experimental methodologies of the investigation are described in depth. A wide range of SCC combinations, both fresh and hardened, were tested, including with methodology, preliminary research results, bailey gradient design, specimen preparation techniques, and testing protocols. It goes hand-in-hand with a thorough approach to aggregate processing that makes use of RAP and TRCA. There are a number of other ways to investigate the binding materials, such as particle size distribution studies and X-Ray Diffraction (XRD). The aggregate was covered with a thin coating of asphalt in the first step. Because asphalt is almost viscous-elastic, it largely shielded the thin layer from weathering in this instance. After that came the part when the thick asphalt archeology layer was added; this layer was sterner and thicker than the one before it. The weathering process revealed its dense covering. The last step was to sort the RAP into fine and coarse aggregate by sifting it. Using untreated TRCA as the primary aggregate fraction source has a significant impact on the archaeological performance in SCC. Ageing procedures were used to TRCA fractions in order to resolve these difficulties. As the TRCA adhering mortar was subjected to repeated freezing and thawing, its fragility increased.

RESULTS AND DISCUSSIONS

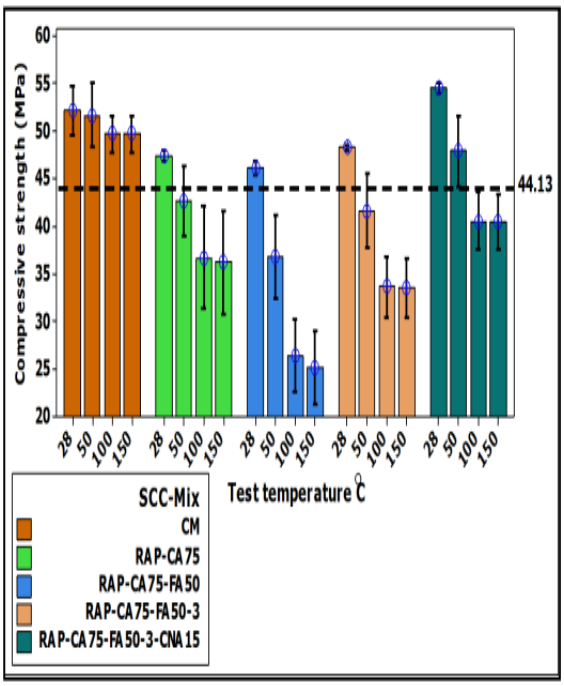
Table 1 displays the identified compounds together with their chemical formulae. At 90 days, we ran the XRD to see whether the peak heights had changed or if any new peaks had developed. The after 90 days of age, or two thetas degrees 43, the lite and be-lite intensities decreased, and a new Clinotobermorite (CSH) peak was found. Peak heights were also found to be greater for ternary pastes, lending credence to the theory that CNA intensified the crystalline phase.

The findings show that adding CNA had a favourable impact, which is indicative of the dense structure. Results showed that up to 66% of CSH gels formed thick paste structures when OPC, FFA, and CNA15 were combined.

Table 1: Determination of the trilobite name and natural science

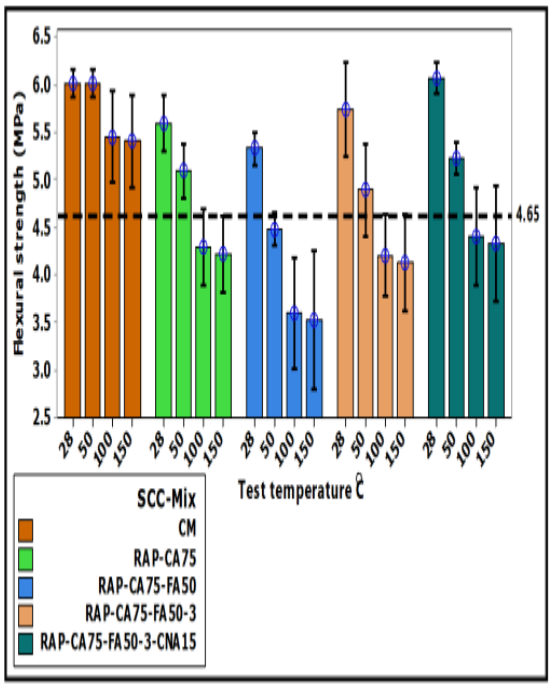
Identity	Ref. code	Compound name	Chemical formula
CSH	96-100-0047	Clinotobermorite	$Ca_5Si_6O_{18}H$
CH	96-900-0113	Portlandite	$Ca_1O_2H_2$
E	96-901-2923	Ettringite	$Ca_{12}A_{l4}S_6O_{10}{}_0H_{128}$
CC or CaCO3	96-900-9668	Calcite	$Ca_6C_6O_{18}$

The material's basic structure is compromised, which speeds up the collapse process. Both the 100°C and 150°C tests yielded identical results for all combinations. Asphalt, like many other materials, has a melting point of around 100°C, if that helps. When comparing RAP-CA75, RAP-CA75-FA50, and RAP-CA75-FA50-3 side by side, it becomes clear that fine RAP is ineffective at higher temperatures, which is a major drawback when utilizing it in SCC.



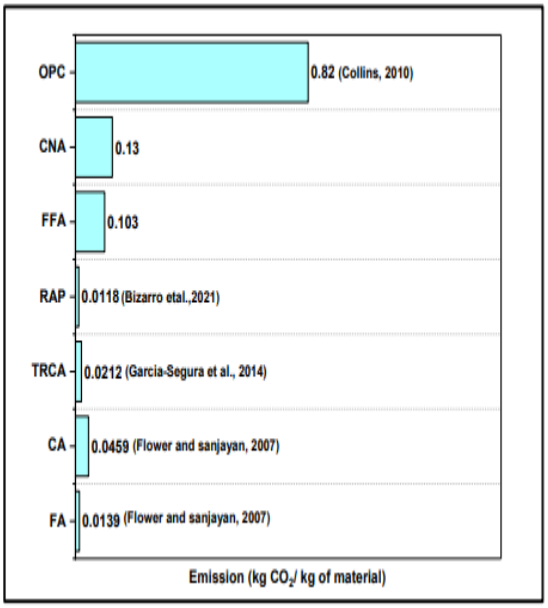
Graph 1: The correlation between curing time and compressive strength at 90 days

Graph 2 shows that the patterns of extramural and compression strengths in concrete are independent of temperature and all combinations thereof. At 50°C, RAP-CA75, RAPCA75-FA50-3-CNA15, and RAPCA75-FA50-3-FA50-3 all achieved the required temperature. The combination of RAP-CA75-FA50-3-CNA15 must be used promptly.



Graph 2: Flexural military posture roentgen test physical property at the 90 days solidification playing period

Graph 3 also shows the CO_2 emissions of the primary ingredients used in each SCC mix. We counted the energy used during drying, sieving, and grinding to find out how much was required to make CNA and FFA more reactive.



Graph 3: CO2 emission of major constituent used in all SCC mixes

The fuel consumption of the truck for 100 kilometers to deliver one metric tonne of CNA to the processing and treatment plant was calculated in order to estimate the transportation-related emission component. Looking at the various components, we identified OPC, CNA, FFA, CA, TRCA, FA, and RAP as the primary sources of CO2 emissions.

CONCLUSIONS

Researchers found that adding recycled aggregates (RAP and TRCA) to self-compacting concrete before cementation material CNA improved its performance. Results in self-compacting concrete were very good when the Bailey aggregate grading technique was used with an emphasis on sustainability. By utilizing an optimized aggregate gradation, the Bailey method reduces the demand for fine materials and chemical admixtures, thereby making the mix design more cost-effective. The optimized gradation lowers the amount of cement and water required, reducing costs and environmental impact. The flexibility of the Bailey Aggregate Gradation technique allows for adjustment based on specific construction requirements, such as higher slump flow or lower viscosity. This adaptability makes it suitable for various SCC applications, whether for structural or non-structural elements. The technique promotes sustainable construction by optimizing raw material usage and reducing waste. By minimizing the need for additional admixtures, it supports eco-friendly practices and lowers the carbon footprint associated with concrete production. Research can focus on tailoring Bailey gradation for high-performance SCC in specific applications, such as high-rise buildings, marine structures, and infrastructure requiring high durability. This involves fine-tuning gradation parameters to achieve even greater

flowability and strength specific to these environments. Future studies could explore using sustainable or recycled aggregates, such as recycled concrete aggregate (RCA) or industrial by-products, in conjunction with Bailey gradation.

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