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Influence of Light Weight Coarse Aggregate on the Mechanical Properties of Concrete

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Abstract: ***Light weight concrete has significant importance in the field of construction. The main purpose of using light weight concrete is to reduce the dead load of concrete structure. Light weight concrete is prepared by using light weight aggregate and weight of light weight concrete is less than the weight of normal concrete. In this research cement, fly ash, fine aggregate, bottom ash, coarse aggregate and light weight aggregate have been used as a main ingredient in making concrete. To compose concrete as lightweight, the light weight aggregate such as Light Expanded Clay Aggregate (LECA) and Lytag light weight aggregate are used in place of coarse aggregate. Practical study on concrete mix M20 is carried out by substituting fly ash in place of cement, bottom ash in place of fine aggregate and LECA in place of coarse aggregate at the rate of 5%, 10%, 15%, 20%, 25%, 30% and 35%. In the same way an additional practical study on concrete mix M20 is carried out by substituting fly ash in place of cement, fine aggregate (no replacement) and Lytag light weight aggregate in place of coarse aggregate at the rate of 5%, 10%, 15%, 20% and 25%. In the above mentioned study, the concrete cube and cylinder are used analyze their Split Tensile Strength (STS), Compressive Strength (CS) at 7, 28 and 56 day. The Flexural Strength (FS) and Deflection (D) of concrete beam were discussed on the basis of optimum dosage of replacement in compressive strength and split tensile strength of concrete. The result came from the concrete made with 5% substitution of LECA and for concrete made with 10% substitution of Lytag was found to be good performance in CS, STS and FS of concrete. After this evaluation process, the important intention of the projected technique is to frame the mathematical modelling with help of optimization technique. Mathematical modelling is used to forecast the CS, STS, for 7, 28 and 56 days and deflection (D) of the concrete. The mathematical model is used to forecast the strength with minimum error. The techniques likes Particle Swarm Optimization (PSO), Artificial Fish Swarm Optimization (AFSO) and Harmony Search (HS) are used to optimize the result that the attained error values between the output of the practical and the forecasted value are nearly equal to zero in the designed model. From the result, the accuracy of 95.56% on LECA based concrete and 94.23% on Lytag based concrete is find by mathematical modelling in AFSO algorithm.***

Keywords: Light weight concrete; Light weight aggregate; Light Expanded Clay Aggregate (LECA) ; Lytag light weight aggregate; split tensile strength (STS); Compressive Strength (CS); Flexural Strength (FS); Harmony search (HS); Artificial Fish Swarm Optimization (AFSO); Particle Swarm Optimization (PSO).

1. Introduction

Concrete is prepared by using four main constituent such as course aggregate, fine aggregate, Portland cement and water. Concrete has quite high compressive strength and low tensile strength .Because of it reinforced Concrete is prepared by enforcing steel rods in concrete which boost tensile strength of concrete.

Invention of new technique in strengthening of concrete is in progress from long time. In the construction industry, the main concentration is to use fly ash and bottom ash as the substitute for cement and fine aggregate respectively as it contains fastening possessions. With use of it, Light Expanded Clay Aggregate (LECA) and Lytag light weight aggregate has been also utilized as an option of coarse aggregate to decrease the self weight of concrete. Light Expanded Clay Aggregate (LECA) is a unique kind of light weight aggregate which is pelletized and fired at very temperature in a rotary kiln. As it is fired, the organic compounds are burn off forcing the pellets to expand and outer surface of each granule become melt. The resulting ceramic pellet is light weight, porous and has a very high crushing resistance. Density of LECA aggregates vary from 400 to 800 kg/m^3, rely on the size (10-20 mm) of LECA. Lytag light weight aggregate is prepared from the fly ash of fired coal in power station. Fly ash is converted into small round pallets, which are then heated upto 1100 degree Celsius. Permeability of Lytag is high and its water absorption is around 15%. Lytag aggregate is small in size, light in weight and thermally insulating elements of burnt clay. Dead load of structure affected significantly due to lowering of density of aggregate. Lytag aggregate also having fire resistance quality because it is made by refractory process.

1.1 Background and Importance of Light weight coarse aggregate

Murat Kurt et al. (2016), have done the investigational study concerning the effects of pumice powder, different water/ (cement + mineral additive) ratios and pumice aggregates on mechanical and physical properties of self-compacting light weight aggregate concrete. The literature suggested that pumice is used as light weight aggregates. Test were conducted to investigate the number of properties of self-compacting pumice aggregate light weight concretes like unit weight, flow diameter, V-funnel time and L-box tests, 7, 28, 90 and 180 days compressive strength, 28 days splitting tensile strength, dry unit weight, water absorption, thermal conductivity and ultrasonic pulse velocity. For this purpose, 24 series of concrete samples were tested in two groups. Abul Bashar Emon et al. (2016) have studied about the chips of brick and recognize as Light Weight Aggregate (LWA) due to their light weight and porous structure. Brick chips concrete considered as a type of Light Weight Aggregate

Concrete (LWAC) and in compare to any other conventional normal weight concrete brick chips had lower mechanical property and higher brittleness. Thus, a detailed examination had been done in the above literature survey on the growth of strength and ductility of concrete which have brick chips as a coarse aggregate using locally generated cheap and lightly galvanized mild steel wire fiber as a substitute to conventional steel fibre. Steel fibers are very difficult to found in local markets in some countries like Bangladesh and importing is also relatively expensive. Compressive strength and splitting tensile strength off test cylinders in addition to load–deflection and cracking behaviour of test beams had been assessed using different fiber content. Corinaldesi et al. (2015) have inspected the fiber reinforced SCLWAC (Self Compacting Light Weight Aggregate Concrete) mixtures which was associated with synthetic fiber. Eight different SCLWACs were made in which, fine and coarse expanded clay were used in different combination as an aggregate, also slightly replaced by either quartz sand or aggregate generated from concrete recycling. Value of Tensile strength and flexural strength were consistent with different class of concrete strength, while the elastic modulus was relatively low with respect to normal weight Self-Compacting Concrete (SCC). Mohammad Abdur Rasheed et al. (2015), have studied the Cellular Light weight Concrete (CLC).In recent time, masonry had showed outstanding reputation due to its sustainability, density, low thermal conductivity and utilization of minimum mortar joints. To arrange a better alternative in place of aerated autoclaved concrete blocks for structural use of masonry, the literature described to growth the high performance fiber reinforced cellular concrete. Avinash & Dhinakaran (2015), have studied that High Performance Light Weight Concrete (HPLWC), could be considered as a union of high performance concrete and structural light weight concrete. In this study cement were replaced moderately bye Ground Granulated Blast Furnace Slag (GGBFS) then met kaolin in two different percentages. In whole there were eight different unions of mixes were studied at three different ages of concrete such as 7, 14 and 28 days. Between the different mixes organized, addition of 0.4% air entraining agent with 10% metakaolin and 30% GGBFS formed superior compressive strength. Similarly, when 25% extended clay used as a light weight aggregate with 12% metakaolin and 28% GGBFS formed better solutions. Adnan Al-Sibahy et al. (2012), have studied and evaluated the performance of the modern class of light weight concrete at both ambient and greatest temperatures. Different ratio of by-product materials, consisting recycled glass and metakaolin, were used in combination with extended clay to provide the light weight concrete mixes. For defining their complete thermal activities, thermal conductivity, density, and accurate heat characteristics were primary controlled at ambient and high temperatures. A test of heat flow had been conducted with the help of the single directional heat flow system and the solutions obtained were systematically computer-generated in the name of the time–temperature aspect.

1.2 Advantage of using light weight coarse aggregate

1) Fast and relatively simple construction.
2) Low-cost in terms of transportation as well as reduction in manpower.
3) Light weight concrete has improved nailing and sawing properties in comparison to usual concrete.
4) Reduce the dead load of the building.
5) Improves the workability.
6) Good resistance to freezing and thawing action when compared to conventional concrete.

1.3 Disadvantage of using light weight coarse aggregate

1) In the mixture extremely quick to respond with water content.
2) Because of the porosity and angularity of the aggregate it is very difficult to place and finish.
3) It is possible that mortar can separate from aggregate and float toward the surface.

1.4 Objectives of Present Work

The specific objectives of the present thesis have been laid down as

- The chief objective of this study is to examine the mechanical property of the light weight concrete where in place of coarse aggregate light weight is used as a partial replacement.
- Arithmetical modelling by using various optimization techniques to forecast the value of error in strength of the concrete.

1.5 Scope of Present Work

The scope of the work is to evaluate the compressive strength, split tensile strength and flexural strength of the concrete. Practical examination on concrete mix M20 is carried out by substituting fly ash in place of cement, bottom ash in place of fine aggregate and LECA in place of coarse aggregate at the rate of 5%, 10%, 15%, 20%, 25%, 30% and 35%. Similarly one more practical study on concrete mix M20 is carried out by substituting fly ash in place of cement, fine aggregate (no replacement) and Lytag light weight aggregate in place of coarse aggregate at the rate of 5%, 10%, 15%, 20% and 25%. The split tensile strength and compressive strength of concrete is calculated for 7, 28 and 56 days depending on the minimum dosage of substitution in compressive strength and split tensile strength of concrete. After this assessment process, the importance of the projected technique is to design an arithmetical modelling with the help of optimization technique. Arithmetical modelling is used to forecast the compressive strength, split tensile strength at 7, 28 and 56 days and deflection of concrete. The various optimization techniques like Particle Swarm Optimization (PSO), Artificial Fish Swarm Optimization (AFSO) and Harmony Search are used to get minimum weight such as α and β of the arithmetical modelling. All optimum result show that the obtained value of error between experimental output value and the forecasted output value are nearly equal to zero in the proposed presentation.

2. Mathematical Modeling

Klaas van Breugel (2015), have investigated the concrete as a system aids us to understand its difficulty and its response to outside loads and long-term Function and it releases the

manner for adjusting conventional concrete mixtures and designing once with already defined property. The actual importance of empathetic and modelling cementitious resources had been presented in the literature. Different types of models, i.e. models replacement on different length scales, are quickly presented and unanswered fundamental questions had been registered. Then, three instances are presented where investigational studies and mathematical modelling have invented the insight in the function of cementitious materials. Mainly the practice of a micro-scale model had been deliberated for mixture optimization of combined cements. Hidallana- Gamage et al. (2014) have studied the comprehensive mathematical procedure to take care of the blast response of Laminated Glass (LG) panels and train the motivation of important material parameters. After crack show of the LG panel and the effect of the interlayer towards blast resistance are conserved. Result indicates that the tensile strength of glass considerably influence the blast response of LG panels even if the interlayer material property have a major effect on the reaction underneath superior blast loads. Principally, glass panes absorb the majority of the blast energy, but later the glass breaks, interlayer distorts again and absorb the majority of the blast energy. LG panels should be projected to be unsuccessful by ripping of the interlayer rather than adversity at the requirements to achieve an expected level of security. From the evaluation of above literature, labelled the material property of glass, interlayer and Sealant joints show important roles, but incorrectly they are not considered in the present design principles.

2.1 Different optimization techniques

Hadi Mash hadban et al. (2016), have explore the possessions of Fibres on the role of Self Compacting Concrete (SCC). New, mechanical and durability property and ultrasonic pulse velocity of all SCC mixtures were evaluated. The literature elucidated the investigational information had been used to coach the feed onward artificial neural network type. Last of all the skilled ANN (Artificial Neural Network) and PSOA (Particle Swarm Optimization Algorithm) had been used to construct a polynomial replica for Confront SCC properties. The achieved solutions showed that the mechanical stuffs can be improved by fibre validation and workability of the SCC reductions with collectively fibre substance. Additionally, PSOA United with the ANN is flexible and precise technique in computation of Mechanical things of fibre strengthened SCC properties.

2.2 Research Significance

From the context it is explore that the practice of fly ash as a substitute of Cement and bottom ash as a substitute to fine aggregate is ordinary. The Several gain of light weight concrete and aggregate will floor the approach for choice of a appropriate optional material for construction industry. The idea of the optimization technique is utilized to examine the enforcing loads on the concrete structures and to make a note of the alteration of the concrete structure. The optimization technique is utilized to get the values of the different element that diminish the objective function while fulfilling the constraints. In arithmetical modelling, the well-known input and output datasets are utilized to coach the network for getting the best possible output of the projected method.

3. Result and Conclusions

The present work enables to arrive at the following important conclusions:

- The broad examination held out in this study meant to give realistic fact.
- Quality of concrete is proficient by trial mixes arrived at by the use of some traditional relationship between different parameters.
- The result display that 5% substitution of fly ash in place of cement, bottom ash in place of fine aggregate and LECA in place of coarse aggregate was found to be good performing in compressive strength, split tensile strength and flexural strength of beam in 56 days in comparison to 28 days strength and also dry weight of specimen have been decreased.
- The result show that 10% substitution of fly ash in place of cement, fine aggregate and Lytag light weight aggregate in place of coarse aggregate was found to be good performing in compressive strength, slit tensile strength and flexural strength in 56 days in comparison to 28 days strength.
- Because of using of light weight coarse aggregate dead load of concrete also decreases.
- Deflections were measured at left, middle and right of the beam in both type of concrete mix. when applied load increases the deflection also increases gradually in all level.

4. Recommendation for Future Works

The process has been automated so that the model can be updated when new experimental sets are added to these databases. Since the model is confirmed with various data sources and display a good efficiency to forecast concrete strength, it can be used as a dependable tool for estimating the design strength of concrete. Artificial Neural Network (ANN) and Neuro Fuzzy Predictor (NFP) is some other appropriate predictive tool in soft computing techniques.

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