Review Paper on Optimization of Concrete Mix Design for Various Climatic Condition

Sanket D Pattewar
Department of Civil Engineering
JSPM's Rajarshi Shahu College of Engineering, Tathawade Pune, Maharashtra, India

Chetan B Rathod
Department of Civil Engineering
JSPM's Rajarshi Shahu College of Engineering, Tathawade Pune, Maharashtra, India

Amruta U Nandurkar
Department of Civil Engineering
JSPM's Rajarshi Shahu College of Engineering, Tathawade Pune, Maharashtra, India

Amrutraj D. Patil
Assistant Prof., Department of Civil Engineering
JSPM's Rajarshi Shahu College of Engineering, Tathawade Pune, Maharashtra, India

Urmila Mahadikl
Assistant Prof., Department of Civil Engineering
JSPM's Rajarshi Shahu College of Engineering, Tathawade Pune, Maharashtra, India

Abstract**: The optimization of mixture proportions for concretes, contain many constituents and are often subject to several performance, constraint, can be difficult and time consuming task. Statistical experiment design and analysis methods have been developed specifically for the purpose of optimizing mixtures. The performance of concrete changes with change in climatic conditions, that's why it is necessary to design an optimum concrete mix according to change in climatic condition.**

Keywords: Optimizing, Concrete Mix

I. INTRODUCTION

The concrete mix design is a process of selecting suitable ingredients for concrete and determining their proportions which would produce, as economically as possible, Concrete that satisfies the job requirements, that is concrete having certain minimum compressive strength, workability and durability. The proportioning of ingredients of concrete is an important phase of concrete technology as it ensures quality and economy. The proportioning of concrete mix is accomplished by the use of certain imperial relations which afford reasonably accurate guide to select the best combination of the ingredients so as to achieve the desired properties. "Optimization is the act of optimum the best result under given circumstances" in design, construction and maintenance of any engineering system, engineers have to take many technological and marginal decisions at several stages. The ultimate goal of such decisions is either to minimize the effort required or to maximize the desired benefit. Since the effect required or the benefit desired in any practical situation can be expressed as certain decisions variable, optimization can be defined as the process of finding the conditions that give the maximum or minimum value of a function.
The main objective of this study is to provide the resident engineer with guidelines for concrete mix design used in construction applications. These recommendations are meant to supplement presently used guidelines and specifications for the mix proportions of concrete. The research presented is intended to address the most commonly observed due to change in climatic condition or temperature variation concrete gets affected.

II. LITERATURE REVIEW

Compressive Concrete Mixture Optimization Using Statistical Mixture Design Methods.
Author: Marcia J Simon, Eric S Lagergren, Kenneth A Snyder.
The optimization of mixture proportions for high performance concrete, which contain many constituents and are often subject to several performance constraints, can be a difficult and time consuming task. Statistical experiment design and analysis methods have been developed specifically for the purpose of optimizing mixtures, such as concrete, in which the final product properties depend on the relative proportions of the components rather than their absolute amounts. Although mixture methods have been used in industry to develop products such as gasoline, metal alloys, detergents and foods, they have seen some detail application in the concrete industry. These paper describe an experiment in which a statistical mixture experiment was used a 6 component concrete mixture subject to several performance constraints. The experiments was performed in order to assess the usefulness of this technique for high performance concrete mixture proportioning in genera. In high performance concretes consisting of many components, where several properties are of interest, it is critical to use a systematic approach for identifying optimal mixes given a set of constraints. Statistical experiment design and mixture experiments provide such an approach. They permit a thought examination of feasible region of interest in which to identify optimal mixes. Fitted models are obtained from the experimental data and are used to identify optimal mixes over the region. Conclusion and recommendations of paper is that in high performance concretes consisting of many components, where several properties are of interest, it is critical to use a systematic approach for identifying optimal mixes given asset of constraints. Statistical experiment design and mixture experiment provide such an approach. They permit a thorough examination of a feasible region interest in which to identify optimal mixes. Fitted models are obtained from the experimental data and are used to identify optimal mixes over the region.

Concrete Mixture Optimization Using Statistical Methods
Author: M.J. Simon, Eric S. Lagergen.
High Performance Concrete (HPC) has been referred to as “engineered concrete,” implying that an HPC mixture is not specified in a generic recipe, but rather designed to meet project-specific needs 1. Such a definition gives a concrete producer or materials engineer greater than usual latitude in selecting constituent materials and defining proportions in an HPC mixture, since fewer or possibly no prescriptive constraints, such as minimum cement contents or maximum water-cement (w/c) ratios, are included in specifications. HPC mixtures are usually more expensive than conventional concrete mixtures because they usually contain more cement, several chemical admixtures at higher dosage rates than for conventional concrete, and one or more supplementary cementations materials. As the cost of materials increases, optimizing concrete mixture proportions for cost becomes more desirable. Furthermore, as the number of constituent materials increases, the problem of identifying optimal mixtures becomes increasingly complex. Not only are there more materials to consider, but there also are more potential interactions among materials. Combined with several performance criteria, the number of trial batches required to find optimal proportions using traditional methods could become prohibitive. This report presents the results of a research project whose goals were to investigate the feasibility of using statistical experiment design and analysis methods to optimize concrete mixture proportions and to develop an Internet-based software program to optimize concrete mixtures using these methods. Two experiment design approaches (classical mixture and factorial-based central composite design) were investigated in laboratory experiments. In each case, six component materials were used, and mixtures were optimized for four performance criteria (properties) and cost. Based on the experimental results, the factorial based approach was selected as the basis for the Internet-based system. This system, the Concrete Optimization Software Tool (COST), employs a six-step interactive procedure starting with materials selection and working through trial batches, testing, and analysis of test results. The end result is recommended mixture proportions to achieve the desired performance levels. COST was developed as a tool to introduce the industry to the potential benefits of using statistical methods in concrete mixture proportioning, and to give interested parties an opportunity to try the methods for themselves.

Full Factorial Optimization Of Concrete Mix Design For Hot Climates
Author: K A Soudki, E F El-salakawy And N B Elkum
In hot climates, especially in tropical and sub-tropical countries, there are special problems involve in concreting. These problems concern the mixing, placing and curing of concrete. A fresh concrete, a high temperature increases the water demand, the rate of slump loss, rate of setting and tenancy for plastic cracking and crazing. As a result high temperature can adversely affect the mechanical properties and serviceability of hardened concrete. This paper

present the results of statistical analysis aimed to optimize a concrete mix design for hot climates. A full factorial factorial experiment with 3 * 4 * 4 * 3 treatment combinations (432) samples) of 48 mixes at three levels of temperature was used. The influences of the water/cement ratio (0.4, 0.5, and 0.6), coarse aggregate/total aggregate ratio (0.55, 0.6, 0.65, and 0.7), total aggregate/cement ratio (3, 4, 5, and 6), and temperature (24, 38, and 52'C) on compressive strength were characterized and analyzed using polynomial regression. Mathematical polynomials were developed for concrete strength as a function of temperature and mix proportion. Based on the statistical analysis, recommendations are provided on the optimum concrete mix for different temperatures as well as the mix that is least sensitive to temperature variations. A full factorial experiment with 3 * 4 * 4 * 3 treatment combinations was used including 48 concrete mixes at three levels of temperature. The test variables include the water/ cement ratio (*W*/*C*),

aggregate/cement ratio (*TA*/*C*), coarse aggregate/ total aggregate ratio (*CA*/*TA*), and temperature

(*T*). Three levels of elevated temperatures were considered, 24, 38, and 527C. Different values of *W*/*C* ratio, 0.4, 0.5, and 0.6, were selected so that all degrees of workability are considered. Four values of *TA*/*C*, ranging from 3 to 6, and four values of *CA*/*TA*, ranging from 0.55 to 0.70, were selected to cover a wide practical range of variation of these factors. Sixteen mixes for one *W*/*C* ratio were used instead of using one *W*/*C* ratio for one mix design. No additives or super-plasticizers were added to determine interactions among the main factors of normal concrete mix .A statistical model for concrete strength as a function of the water/cement ratio (*W*/*C*), total aggregate/cement ratio (*TA*/*C*), coarse aggregate/total aggregate ratio (*CA*/*TA*), and temperature (*T*) has been established in terms of significant factors and also in the form of an interpolating polynomial. The temperature has a significant effect on the compressive strength; as the temperature increases, from 24 to 52C, the strength decreases sharply. The optimum mix combination, which is the least sensitive to variations in the temperature considering the effect of all other variables, is

(1) *W*/*C* to be maintained at 0.4;

(2) *CA*/*TA* to be maintained between 0.55 and 0.60; and

(3) *TA*/*C* to be maintained between 3.0 and 3.60

From the paper it is clear that the strength decreases when the temperature increases. A slight reduction was observed when temperature increases from 24 to 38 c. However the rate of decreases becomes more significant beyond 38c. The compressive strength is lowest at 52c.Strength decreases consistently when TA/C increased from 3 to 6. When TA/C increased from 3 to 4 the strength decreases slightly for W/C of 0.4.Effect of W/C- comp. Strength decreases as W/C ratio increases.

Multi objective optimization of mix proportion for a sustainable construction material
Author: Mangesh Madurwar, Vishakha Sakhare, Rahul Ralegaokar

The rapid industrialization and urbanization resulted in large quantity of waste generation and in turn, environmental degradation. Recycling of solid waste into a sustainable construction material with optimum mix proportion is the global need to reduce its adverse environmental impacts. The present paper aimed at optimization of mix proportion for designing a sustainable material. Sugarcane bagasse-ash (SBA) was identified as a principal raw material over a study area. It was used further in combination with quarry dust, lime for various proportions to develop to suitable bricks. In all 35 compositions for SBA-QD-L bricks were developed and physico mathematical properties were evaluated using standard laboratory tests as per IS. A statistical cubical regression model was formulated for compressive strength of brick as a function of mix proportion using XLSTAT software. To achieve the criteria of sustainability, constraints were developed in terms of achieving maximum compressive strength and minimum embodied energy. A multi objective non-linear optimization model was formulated and optimum mix proportion was obtain using software LINGO. The optimum value of compressive strength and embodied energy predicted by this model was 5.41 M pa and 2.32 MJ. The embodied energy was estimated to be 47% and 5% lower than the conventional burnt clay and fly ash bricks. A cost analysis was also carried out between optimum composition of SBA-QD-L bricks and commercially available fly ash bricks. The percentage reduction in the cost was found to be 49% and 59% as compared to fly ash and burnt clay bricks. A mathematical model for the estimation of compressive strength based on the mix proportion of constituent elements was derived. To achieve maximum compressive strength and minimum embodied energy a multi objective non-linear optimization has been carried out using lingo optimization software for the design of sustainable brick with bagasse-ash as principal raw material. The optimum value of comp. Strength and embodied energy predicted by this model was 5.4 Mpa and 2.32MJ. Cost analysis was also carried out between the optimum composition of SBA-QD-L bricks and commercially available fly ash brick. The % reduction in fly ash is found to be 49% and 58% as compare to fly ash and burnt clay bricks.

OPTIMIZING COCRETE MIX DESIGN TO PRODUCE COST EFFECTIVE MIX
Author: Chris c. Rameyer, Roozbeh Kiamanssh
This research is designed to study effect of mechanically activated fly ash on fresh concrete properties and the ultimate strength of the hardened concrete. Six types of fly ash that are locally available in Oklahoma State where used in this study. The activation of fly ash is performed with the modified ball mill to increase the hydration reaction rate of the fly ash particles. Two primary variables where studied in this research, grinding duration and % of ash as apportion of cementious material. The fly ash ground for 30 to 120 minutes. The ground fly ash used as a cementious material in the concrete in various proportion 20, 40 and 60% of the weight. The strength of each of each mix was compared with plain cement concrete and the concrete sample with unground fly ash to determine any changes. The results shows that concrete with higher proportion of fly ash has higher workability, although the strength of the sample decreases in most cases if high volume of fly ash is used. However the result indicate that the grinding of fly ash can mechanically active the particles and not only improve the strength of sample with high proportion of fly ash but also increases strength higher than the traditional Portland cement concrete.

III. CONCLUSION

Following conclusions can be drawn based on the experimentations conducted on the concrete cubes.

- The temperature has a significant effect on the compressive strength; as the temperature increases, from 24C to 52C, the strength decreases sharply.
- The main effects of *CA*/*TA*, *TA*/*C*, *T*, and *W*/*C* were shown to be highly significant.
- The optimum mix combination, which is the least sensitive to variations in the temperature considering the effect of all other variables, is (1) *W*/*C* to be maintained at 0.4; (2) *CA*/*TA* to be maintained between 0.55 and 0.60; and (3) *TA*/*C* to be maintained between 3.0 and 3.60.

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