ECONOMICAL CONSIDERATIONS IN THE DEVELOPMENT OF CONSTRUCTION MATERIALS – A REVIEW

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Abstract:

Design and manufacturing of construction materials have been investigated. The aim is to identify methods to produce sustainable economic materials used for soil foundation and concrete structure. Several additives have been analyzed in order to develop acceptable economical construction materials. They are expected to support soil foundation and concrete materials design for sustainable development. A comparative study has been made based on the available theoretical and experimental results reported in literature. It has also been revealed that design of appropriate steel fiber optimizes shear morphology, increases applied force, minimizes deflection, improves mechanical performances and reduces time to failure of concrete beam. Also, nanotechnology supported and enhanced compressive strength of concrete has been explained. Soil mixing to support embankment seismic design has been discussed so as to introduce suitable methods for soil foundation enhancement.

1 Introduction

The fiber reinforcement concrete mix design helps in enhancement of ultimate flexural strength and time to first crack of ultra-high strength concrete [1]; there are many factors in improving the effect of steel fiber for reinforcement of concrete mix design such as placing methods of concrete, increasing volume and length of fiber [2-6]. The small steel fibers with different lengths and proportion have been experimentally designed to improve concrete beam flexural strength and crack-free morphology. This design has strongly supported cost effective concrete beam. The shear crack of concrete beam has been mitigated in

1.1 Concrete, cement mortar and cement paste

appropriate design of small steel fibers [7]. The kaolin and bentonite have been mixed in equal quantity and heated in order to modify compressive strength of concrete in early age. The acceptable level of heat and appropriate proportion of additive were produced in development of acceptable compressive strength of concrete. To support research outcome, X-ray and FESEM experiments have been used [8]. The oil palm shell ash mixture is a waste agricultural material. The effect of oil palm shell ash on the compressive and flexural strength of cement mortar has been evaluated. The results have indicated that the deflection, load

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sustainability and time to failure for compressive strength have independent fluctuation of flexural strength [9]. Kaolinbentonite clay was replaced by the cement paste, in order to increase the compressive strength of concrete. The specimen content of cement-kaolin-bentonite paste, after 90 days of curing, exposure to 500 º C, and cooling down in water, exhibited an increment of the compressive strength about 60 % in comparison with the process without using additive and without being exposed to heat [10]. The effect of seashell powder, which is another waste material, is applicable to modify the flexural and compressive strength of cement mortar. The result showed replacement of 1% seashell, deflection, and that time to failure and maximum load to failure of concrete beam has been improved. Besides, the strain, time to failure and compressive modulus elasticity of cubic specimen has not been considerably changed [11]. To satisfy stability of the structure, the quality of the construction material has to be at an acceptable level. For enhancement of the compressive strength of concrete, a simple method has been proposed. The results indicate the best level of heat necessary to produce additives from kaolin and bentonite. Modification of nanoparticles of cement paste during hydration has been discussed [12].

1.2 Soil mechanics

This experimental work has presented the effect of heat treatment on the mineralogy and morphology of kaolin, used in soil mixing design. The shear strength parameters have been modified. The tests showed some economical concept for improving shear strength parameters of mixed soil technique [13]. The numerical modeling and wave theory are used in tsunami mitigation analysis. The results reveal that sea forests help in reducing ecological impact and economical effect of tsunami, in reducing dangerous wave effects in design and urban construction, and in reduction of air pollution as well as improvement of climate [14]. To mitigate seismic hazards and risks in sandy embankment, accurate placement of dense zones in the embankment models have been considered. The stress path analysis has been supported in embankment stability prediction [15]. To economically enhance bearing capacity of red soil, the mixed soil method has been proposed. The mixed soil design method provided soil foundation stability against geo-technical problems or instabilities. The laboratory tests were evaluated by improved characteristics of red soil using various methods. Both economical and uneconomical mixed soil designs have been identified [16]. Realization of sustainable economic design and manufacturing of construction materials is the aim of this review work. Several cases of improved concrete, cement mortar, cement paste and soils have been considered. Economic research methodology for sustainable design of soil foundation and concrete materials is expected to be introduced.

2 Discussions

2.1 Concrete, cement mortar and cement paste

To improve the structure stability, optimizing construction cost and quality have to be considered. The cost effective technique and less time consuming for enhancement of flexural strength of concrete beam has been introduced by steel-concrete mixture design, and also by using different proportion and length of steel fibers. The proportion and linear distribution of steel fiber have been involved to enhance cost effectiveness and safe beam.

The morphology of crack has been studied. Shear crack, flexural crack and intermediate shear-flexural crack depend on the level of steel fibers. An increase of 1% in the quantity of steel fiber results in conversion of the type of crack from shear crack to flexural crack. The steel fiber has been controlled by shear crack morphology (Figs. 1-2). The strain gauge has been shown as the level of applied force, deflection and time to failure of beams (Figs. 3-4) [7].

Figure 1. Failure mode for beam B2, non-fiber reinforced concrete [7].

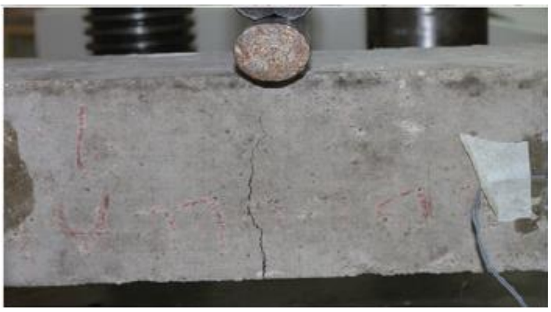

Figure 2. Failure mode for beam B2, content 1.0% steel fibers [7].

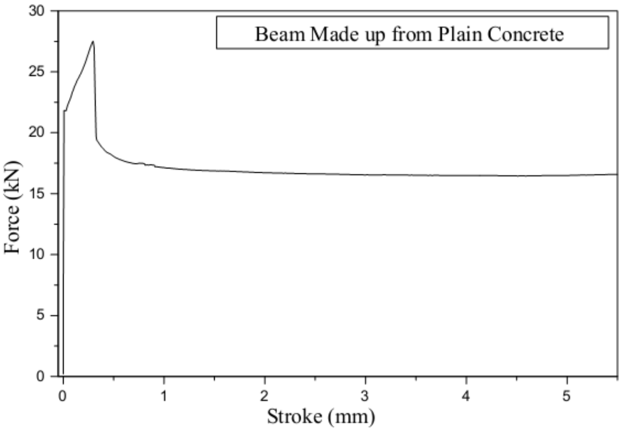

Figure 3. Force vs stroke in beam B2, non-fiber reinforced concrete [7].

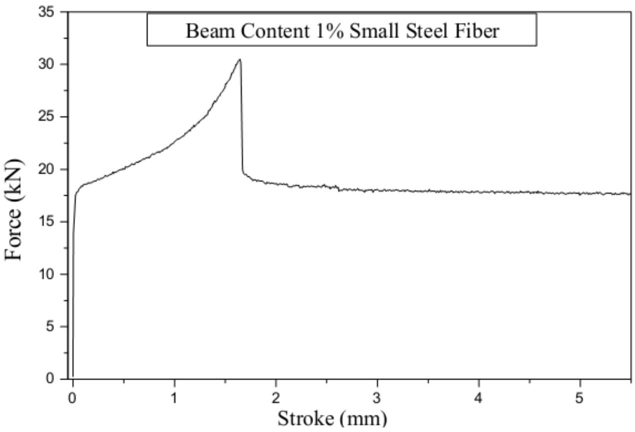

Figure 4. Force vs stroke in beam B2, content 1.0% steel fibers [7].

The crystal structure of cement paste is enhanced by concrete compressive strength (Figs. 5-6). Rearrangement of the crystal structure of cement paste depends on the proportion of additive [8]. This is an application of nanotechnology in economically enhanced concrete compressive strength.

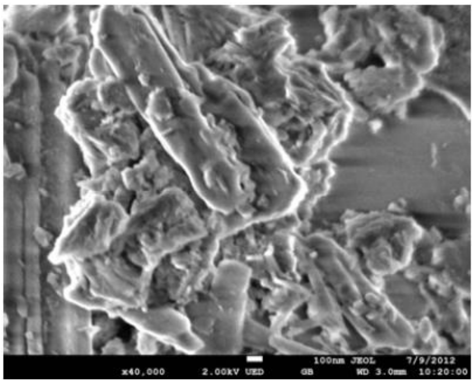

Figure 5. Image FESEM of cement [8].

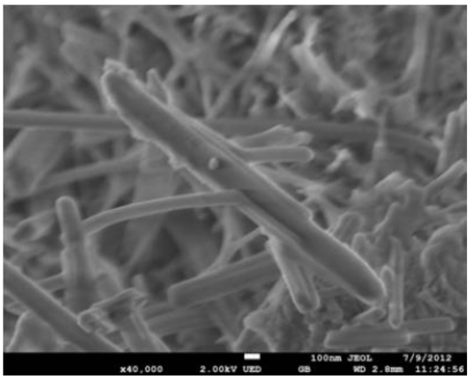

Figure 6. Image FESEM of cement mixed with 12% additive [8].

The palm shell ash used in cement mortar mix design has reduced the modulus elasticity of cement mortar considerably [9]. Heat treatment in materials engineering has been used to improve the compressive strength of cement paste-kaolin-bentonite. Humidity, room temperature and elevated temperature are important factors in fire resistance design, fire mitigation and curing time of concrete. The microstructure analysis of cement paste has been supported for realization of hydration and compressive strength. The compressive strength has been increased about 60% compared to the process without using additive and without exposure to heat. The work resulted in an economical outcome, in producing an acceptable concrete with acceptable compressive strength [10]. The seashell powder has been used for upgrading the quality of flexural strength, time to failure, deflection and load to failure of beam and cubic specimens of cement mortar in early age and the stress path [11]. It has been planned to produce low cost concrete with better compressive strength. The FESEM image shows the morphology of nanoparticles in modified cement paste. An increased level of heat employed on kaolin and bentonite, helps to perform (EN 206-1) code, by reducing the consumption of minerals in concrete mix design [12].

2.2 Soil mechanics

To enhance soil foundation, optimizing construction cost and quality have to be considered.

There is an investigation into the effects of shear strength of peat soil. It was observed that, when cohesion increases, the internal angle of friction decreases. The mineralogy of soil has thus been controlled by shear strength parameters. The economical outcome has been the result of this research work. And it is applicable to many earthworks [13]. The mathematical modelling and numerical simulation of tsunami mitigation result in economically safe society [14]. The possibility of understanding the behavior of embankment subjected to dynamic loading entails placement of dense wall in suitable location of the subsoil controlled settlement. Creep deformation exhibited on both subsoil and embankment increases time necessary for achieving the stability of embankment during applied dynamic force (Fig. 7) [15]. The installation of dense zone walls is a support in economic design of embankment.

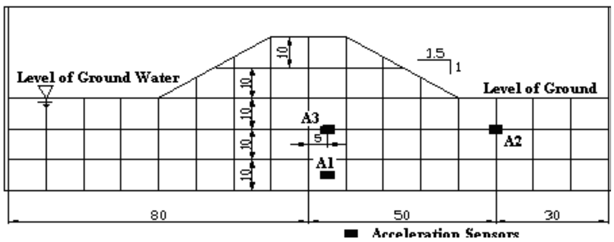

Figure 7. Transducer position [15].

Red soil mix design effect on increasing cohesion, angle of friction and unit weight of soil. These characteristics could increase soil foundation stability. Plasticity, morphology, compatibility and Optimum moisture content are the main factors involved in the soil safe bearing capacity. Proper morphology, plasticity, optimum moisture content in any soil mixed model could support stability of the soil foundation and disable forces applied to the soil mixed model (Fig. 8) [16].

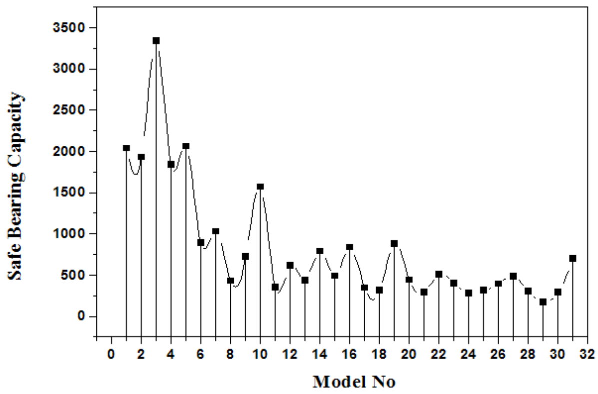

Figure 8. Model No vs Safe Bearing Capacity [16].

3 Definition for application of results and research requirement

There is an experimental and analytical research work into the compressive behavior of steel-reinforced super high-strength concrete columns under axial loading, the analytical work supported for validation of experimental outcome [17]. The modern construction projects are trust to high strength concrete, and an improvement of concrete characteristics that have been introduced by many methods [18-21]. The implementation of urban planning and design particularly for mitigating natural hazard like tsunami applied by various researchers [22-24], is required to improve the research into debris produced by natural disaster, to reproduce all types of construction materials, to apply them to mixed soil design for ground improvement. Among the seismic ground improvement, liquefaction mitigation required special attention due to the behavior of nonlinear stress in soil foundation.

The mixed soil technique is an economical method, and application that requires the attention to local conditions, reliability analyses of results, economical effectiveness, and minimizing the construction time schedule [25-28]. The analytical investigation revealed understanding soil-structure interaction of concrete pile, with analysis of ultimate load capacity, settlement and factor of safety of piles installed in the soil. To extend the application of mixed soil design, several soil foundations are numerically designed. It is observed that the mixed soil technique has ability to mitigate soil foundation. The methodology and founding from this research work support geotechnical engineering in design of soil foundation [29-30].

Besides, stress prediction finite element method and soil behavior image process enhance economical design of soil foundation and structural elements [31-32]. Beyond the above mentioned concepts, the seismic stress-strain behavior of material is one of the important issues in economic design of construction materials, and needs to be experimentally and analytically investigated and verified through the theoretical concept. The effect of soil-structure interaction on economic production of construction material has to be investigated.

4 Assessment for sustainable development

Sustainable economical development in construction industry requires appropriate experimental analysis, methodology and technology. The results of this research work indicate acceptable technique in concrete mix design governed by macro and micro properties of concrete, and also by properties of soil dynamic and soil mechanics control load applied to the soil foundation. The construction material has direct collaboration with soil-structure interaction, serviceability of soil foundation and structure. The shear morphology, applied force, deflection and time to failure of concrete beam are controllable by introducing suitable methods for enhancing soil foundation. The soil foundation has a key role in seismic force behavior applied to the structural elements. The model in Fig. 7 has presented a placement of dense wall in a suitable location of the subsoil to develop soil foundation with minimum settlement, creep deformation and time to achieve the stability of earth structure subjected to dynamic force. It can be concluded that placements of any structure on the suitable soil foundation result in seismic failure or damage mitigation of the structure.

5 Conclusion

1) The economically steel fibers design improved shear morphology, applicable force, deflection and time to failure of beams.
2) The nano-technology has been used in economical enhancement of the concrete compressive strength. Heat treatment of materials engineering has been used to improve the compressive strength of concrete. And to support European Standards (EN 206-1), by reducing consumption of minerals in concrete mix design.
3) The mathematically modelling, numerical simulation and soil mixed design result in economical development of sustainable urban area.
4) Seismic design of embankment by installation of dense zones in subsoil is an economic embankment design.
5) The mineralogy and mechanical properties of materials play a vital role directly on soil foundation, concrete material, cement mortar and structural concrete design. The settlement of soil foundation is a first step in prediction of economic concrete design.
6) The soil-structure interaction on the economic production of construction material has to be investigated through the numerical analysis and simulation, and moreover, to validate a research work, the experimental investigation has to be verified before being applied to the product in construction industry.

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