

Research Status of Mix Design and Preparation of Lightweight Aggregate Concrete

Jingyu Li

School of Henan Polytechnic University, Jiaozuo 454150, China

Abstract

The influence of material components on the properties of lightweight aggregate concrete in the mix design and preparation process is summarized. Firstly, in the aspect of mix design, the characterization performance of concrete is improved by adjusting the mixture ratio between materials, particle size gradation and adding fiber. And in the preparation of concrete, The methods of uniform distribution of aggregate, feeding and mixing process and forming mode are summarized.

Keywords

Lightweight Aggregate Concrete; Mixture Ratio Design; Properties Characterization; Aggregate Floating.

1. Introduction

Lightweight aggregate concrete mix design is based on the use, material characteristics, construction technology and continuous gradation theory, combined with the general mechanical properties of concrete, thermal properties, apparent density, to determine the allocation of each material proportion, in order to meet the purpose of component functional parameters. The mix ratio of lightweight aggregate concrete greatly affects its working performance, material cost and other engineering factors [1]. The mix design of lightweight aggregate concrete is similar to that of ordinary concrete. It is mainly composed of cementing materials (cement, fly ash, silica fume, mineral powder, etc.), lightweight aggregate, admixture, fiber, etc, and each component has an impact on macro - meso mechanical properties.

2. Influence of Material Composition on Concrete Performance

2.1 Influence of Cementitious Materials on Concrete Properties

Lightweight aggregate concrete cementitious materials are generally composed of cement, fly ash, silica fume, mineral powder, etc. The mechanical properties and workability of concrete are affected by the material properties and the proportion of cementing materials. Sarfaraz Ahmed Kagadgar[2] By replacing cement with fly ash in different proportions, it is found that slump value increases with the increase of fly ash percentage, so fly ash can improve concrete workability. Mechanical properties: Adding proper amount of fly ash can improve the mechanical properties and durability of concrete in later stage, but can reduce the strength of concrete in early stage. Wu Jihao et al. [3] analyzed the effect of silica fume content on the microstructure of the interfacial region of concrete at 28 days of age by scanning electron microscope, Found that silica ash can fill microcracks and pores between cement particles and aggregate interfaces, At the same time with hydration products to form gel, improve the interface transition zone porous defects, Increase the compactness of ITZ, Macroscopically improve the interfacial shear strength, tensile strength and other bond strength. Sun Song et al. [4] found that the mechanical properties of concrete first increased and then decreased with the increase of mineral powder. This is mainly because the addition of a small amount of mineral powder refines the internal pores of concrete, making the internal structure more dense. However,

with the increase of the dosage, micro cracks and pores appear inside the concrete, resulting in the increase of structural porosity, resulting in the gradual decline of mechanical properties.

2.2 Influence of Aggregate Grade on Concrete Performance

Aggregate size gradation is also an important factor affecting the mechanical properties and failure mechanism of concrete. The coarse and fine aggregate in concrete supports the skeleton and fills the pores. Accounting for 60%~80% of the total volume of concrete, Is the main reason for the heterogeneity of concrete materials [5], Is also an important factor affecting the performance characterization of concrete. Jin Liu et al. [6] started from a microscopic perspective, The dynamic tensile failure behavior of concrete with high strain rate and low strain rate under different aggregate size was studied, it was found that there was basically no failure of aggregate at low strain rate. Aggregate size has significant influence on failure mode and tensile strength of concrete, The size effect of tensile strength decreases with the decrease of aggregate particle size, At high strain rates, some cracks penetrate the aggregate, Therefore, the influence of aggregate particle size on dynamic tensile strength and size effect of concrete can be ignored. Zhang Yingxue et al. [7], based on the random aggregate model, From the mix ratio of concrete specimens, Calculate the area content of each aggregate particle size interval, Random placement of aggregate particles, The meso-model of convex polygon random aggregate with the maximum particle size of 20 mm, 40 mm, 60 mm and 80 mm was established, respectively, Based on the measured values of elastic modulus and compressive strength of mortar and concrete, The macro mechanical parameters of the interfacial transition region were determined by inversion method. It is found that with the increase of aggregate particle size, its bond strength decreases gradually, However, the elastic modulus of interfacial transition zone almost does not change with the increase of aggregate particle size. Gao F[8] found that aggregate particle size grading of concrete is closely related to strength, A continuous grading is formed between fine aggregate and coarse aggregate, Conducive to dense accumulation between cementitious material and coarse and fine aggregate, So as to improve the compressive strength of concrete and other mechanical properties. Close packing of materials is a difficult problem in the mixing process of concrete, The concrete mix design optimized by Packing theory has great advantages in both mechanical properties and economic cost [9, 10]. Wang Shangwei et al[1] elaborated on the development process of close packing theory, The continuous gradation theory, discontinuous gradation theory and wet stacking theory are analyzed in detail, It provides reference for the theory of compact packing to guide the mix design of concrete.

2.3 Influence of Fiber on Concrete Properties

at the present stage, commonly used fiber polypropylene fiber, steel fiber and basalt fiber. The addition of fiber in the mix design is conducive to improving the mechanical properties of concrete, The presence of fibers reduces the pores inside the concrete, reducing stress concentration by reducing the number of cracks, At the same time, the gap expansion resistance is strengthened. Thus, the cracking resistance and toughness of concrete are improved. Huang Keyun et al. [11] used drop weight testing machine to carry out impact test on shale ceramite lightweight aggregate concrete, By controlling the content and length of polypropylene fiber [12], the influence of fiber on the impact resistance of lightweight aggregate concrete is explored, It is found that adding a certain amount of polypropylene fiber into concrete can significantly enhance the impact resistance of concrete, and the size of specimen deformation after impact is inversely proportional to the length of the fiber. Li Qing et al. [13] studied the early strength of concrete with steel fiber, It is found that the failure pattern of steel fiber reinforced concrete is basically the same as that of unsteel fiber reinforced concrete, Shear failure occurs in all cases, But the damage of undoped steel fiber concrete is more serious, And with the concrete falling off, At the same time, the elastic modulus at 3 d age can be significantly improved by adding steel fiber.

3. Preparation of Lightweight Aggregate Concrete

3.1 Light Aggregate Floating

Because light aggregate concrete adopts loose porous lightweight aggregate, it can reducedead weight, Strong thermal insulation, Good deformation performance and different from ordinary concrete, It is also easy to separate due to the easy floating of aggregate quality and uneven distribution of aggregate [17], It is a difficult problem in the preparation of lightweight aggregate to solve the flotation problem. Liu Li et al[18],adopted a special model for buoyancy evaluation of lightweight aggregate, The effects of slump of concrete, type of lightweight aggregate, mineral admixtures and viscosifying admixtures on floating stratification of mixed aggregate were studied, It is found that the floating delamination of lightweight aggregate increases rapidly with the increase of slump; Material factors such as appearance, low density grade and particle size are also important reasons for floating stratification of lightweight aggregate. By changing the viscosity of concrete, mineral admixtures such as fly ash, silica fume and polymer thickeners can restrain the floating delamination of lightweight aggregate or reduce the aggregate particle size and increase the specific surface of aggregate, Make the aggregate and cement slurry matrix full contact to increase the friction resistance between them.

3.2 Feeding and Mixing Process

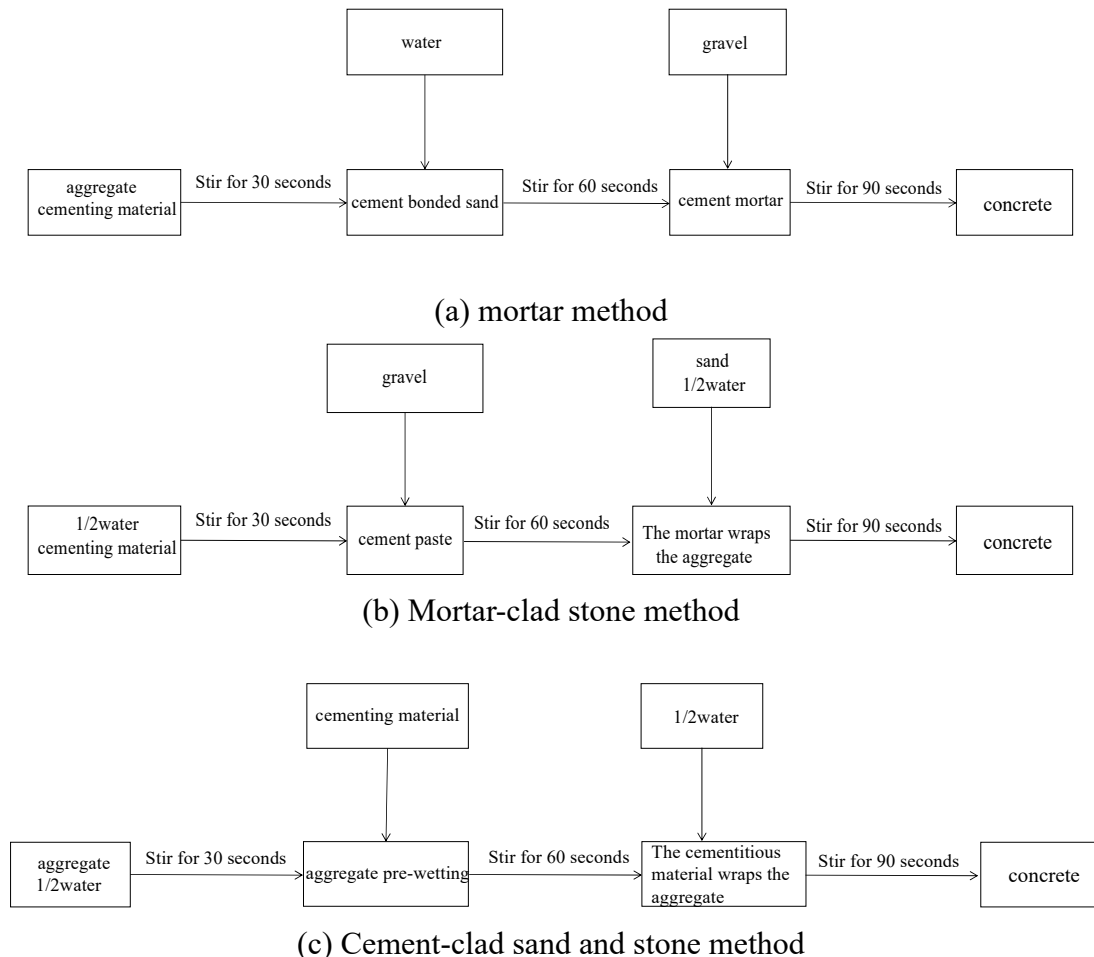


Fig 1. Mixing process flow chart

The existing concrete feeding and mixing technology is divided into primary feeding and secondary feeding. The traditional single-feed mixing technology is to put the cementitious materials, sand, fiber and admixture into the mixer for mixing after weighing; Secondary feeding mixing process is to use the feeding mixing sequence to affect the internal structure of concrete, A method to comprehensively improve concrete performance, It mainly includes first mixing cement mortar method, cement

wrapping stone method, cement wrapping sand stone method, etc. as shown in the figure, Sun Zengzhi et al[19] carried out tests on basic mechanical properties such as compressive and flexural resistance by using two mixing processes, one feeding method and cement mortar method respectively, And a comprehensive microscopic analysis was carried out by scanning electron microscopy, The test results show that the compressive and flexural strength of concrete increases with the mixing process of cement mortar, The cement mortar method makes the aggregate surface have a dense interfacial transition zone, and the strength increases obviously. Li Weishi et al [20] prepared lightweight aggregate concrete with different mixing processes, the dry apparent density and strength of concrete obtained by the mixing process are both greater than those obtained by the mixing process of one-time feeding. Therefore, in terms of mixing technology, The performance and characterization of concrete made by the secondary feeding mixing process are superior to that of the single feeding mixing process, In the selection of different mixing processes, it is also necessary to consider the relative density of cementitious material and aggregate and select the appropriate secondary feeding mode to avoid the uneven distribution caused by the subsidence and rising of aggregate.

3.3 Forming Method

At present, concrete has a variety of forming methods, such as vibration forming, compaction forming and manual inserting and ramming forming [14]. Different forming methods will affect the mechanical properties, interface distribution characteristics and porosity of concrete. Li Yue [15] adopted different molding methods, The influence on the mechanical properties of concrete is studied, It was found that vibration molding and compaction molding had different effects on the compressive properties of specimens. in the early stage, The compressive strength will increase, But as the variable increases, The strength of specimens made by vibration molding tends to increase gently, Compaction molding will reduce the strength of the specimen. Wang Xifeng [16] studied the influence of different forming methods on concrete strength by using single factor method, It was found that mechanical vibration and inversion had the highest strength, The compression molding method has the lowest strength. Different concrete forming methods ultimately affect the porosity of the internal structure of concrete, and then affect the size of the strength. For lightweight aggregate concrete, the upside-down and vibration combined molding method can also effectively avoid the lightweight aggregate floating.

4. Conclusion

This paper summarizes the factors that affect the performance of lightweight aggregate concrete during the design and preparation of mix ratio, The mixing ratio of materials, particle size gradation and mixed fiber are the main factors affecting the performance of concrete, The strength of concrete is affected mainly by changing the pore structure of concrete. At the same time, the influence of different forming methods on the strength of lightweight aggregate concrete in the preparation process is expounded. The vibration forming method is the most favorable to the strength of concrete, and the vibration and inverted forming method can be used to further reduce the internal pores to improve the strength. Aiming at the floating phenomenon of lightweight aggregate, the uniform distribution of aggregate is achieved by increasing the viscosity of slurry.

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