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Research on the Axial compressive stress-strain relationship and the behavior of structural lightweight aggregate concrete

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ABSTRACT

Lightweight aggregate-only concrete is not appropriate for structural applications because it lacks the mechanical properties of conventional concrete. One way to make concrete work better is to employ a hybrid aggregate system, which involves mixing natural crushed stone with synthetic lightweight aggregate.In earlier studies, expanded shale was used as an artificial lightweight aggregate to investigate the stress-strain relationship and the Poisson effect in concrete. Using four different volumes of shale aggregate, the experiment investigated the effects of volume on the mechanical properties of concrete. Peak stress and modulus of elasticity were found to decrease when the amount of shale aggre-gate was increased. Axial and lateral strains connected to the peak stress, however, grow in proportion to the volume % of shale aggregate. The lateral strain to axial strain ratio, which measures the impact of the Poisson effect, increased as the concentration of shale aggregate in the concrete increased. Finally, an analytical definition of the stress-strain relationship between lightweight aggregate and lightweight concrete is within reach.

1.INTRODUCTION

Concrete is the most important construction material in the world, with an annual production of about 10 billion tonnes. Despite concerns about the practice's effects on the environment, its rising popularity cannot be denied. [1] Globally, we consume around 10–11 billion tonnes of aggregate per year, and there is a steady decline in the supply of high-quality natural aggregates.Synthetic aggregate is replacing natural crushed stone in concrete production to meet the needs of sustainable development and environmental protection [2-9].

Because of its porous nature, lightweight aggregate (LWA) is less durable and more easily deformed than its natural counterpart. Incorporating LWA as an aggregate into concrete would drastically alter its mechanical properties. It is not uncommon to see a hybrid aggregate system that combines natural crushed stone with synthetic material.Both the amount and strength of LWA significantly affect the mechanical properties of concrete, according to earlier research [10, 11]. Since low-strength LWA is known to be the material's weakest link, adding it to lightweight aggregate concrete (LWAC) reduces the material's mechanical properties [13]. Numerous investigations have shown that mechanical characteristics of concrete are mostly unaffected when LWA strength exceeds that of the mortar matrix.

2.Experimentalstudy

2.1Materialsandmixproportion"

In accordance with the Chinese standard GB175-2007, cement was used with a compressive strength of 42.5 MPa. Manufactured sand made up the fine aggregate. Crushed granite, a naturally coarse stone with a diameter ranging from 5 to 20

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millimetres, is being used for the building of this project. A cylinder compressive strength of 8.5 Mpa, a water absorption capacity of 5%, and a diameter ranging from 5 to 20 mm were all characteristics of the expanded shale. Soaking the shale in water for 12 hours before to mixing was important to avoid any impact on the water-to-cement ratio. The material's workability was enhanced by including an aphthalene-based superplasticizer. The bulk density and apparent density of solids are listed in Table 1. This blend's percentage is defined by the JGJ 55-2011 standard in China. The samples' water absorption caused their actual density to be somewhat higher than their expected density. This discrepancy was corrected by utilising four different capacity containers made from expanded shale in varying amounts.The compressive strength of LWAC with a 20% LWA volume fraction is lower than that of normal concrete, as shown in Figure 3(b). The compressive strength remains constant regardless of the increase in volume percentage. Consistent results were obtained in the studies conducted by Chi et al. and Ke et al.

Table 3:Mechanical and physical properties of concrete.

Groups	Density(kg/m^3)	Cubiccompressivestrengthf_{cu}(MPa)	Compressivestrengthf_c(MPa)	ModulusofelasticityE_c(GPa)
CC	2520	52.4	41.8	34.3
LWAC-20	2400	50.7	35.1	28.7
LWAC-40	2300	48.1	37.3	28.3
LWAC-60”	2240	50.6	40.0	26.3

For example, peak strains grow with increasing volume percentage of LWA, and the lateral peaks strain is more important. The lateral and axial peak stresses rise by around 75% and 8%, respectively, when the LWA volume content is 60%. In this experiment, the Poisson ratio of typical concrete ranged from 0.08 to 0.16, as seen in the figure. When the load is mild, LWAC's Poisson ratio is almost identical to that of regular concrete. The Poisson ratio of LWAC increases as the stress level increases, compared to the Poisson ratio of regular concrete. In LWAC-20, there is a rapid rise in the Poisson ratio as the stress ratio approaches 1.0. As compared to LWAC-20 at peak stress, the Poisson ratio increases gently when LWA has a volume percentage of 40% or more. According to the findings, the LWAC-60 group's Poisson ratio is the highest of the four. This may be observed in the Poisson ratio of LWAC-60, where the stress ratio can be altered from 0.66 to 1.0. As a result, it can be concluded that the lateral expansion ductility of LWA increases with the volume content of LWA. In order to improve the ductility of lateral expansion, the method described below must be used. As a result of its greater deformation, LWA has lower modulus of elasticity and a greater Poisson ratio than natural crushed stone. LWA, on the other hand, has an internal-curing process that reduces the transition between the two surfaces.

CONCLUSIONS

By subjecting an expanded shale to compression and expansion up to an average cylinder compressive strength of 8.8 MPa, researchers in this study are investigating the mechanical characteristics of LWAC. The research makes use of four different volume sizes. The following is an overview of the main points covered in this study.When the density and strength of LWA are same, the fact that LWA volume % affects concrete compression strength is non-monotonic. Compressive strength decreased as the percentage of LWA volume increased, according to our experimental results. The compressive strength of LWAC is about the same as regular concrete when the volume percentage is 60%. With the right proportions of natural aggregate and low-water-absorption (LWA), compressive strength may be attained.

The importance of deformation compatibility in the interaction between LWA and natural aggregate has been known for a long time. Our experiment shows that the modulus of elasticity of LWAC is lower than earlier studies. This is due to the fact that LWAC is more deformable than natural aggregate. Learning how LWAC deforms laterally when subjected to uniaxial compression is our primary objective. The graph below clearly shows that the axial peak strain increases at a slower rate than the lateral peak strain due to the LWA volume fracture. When comparing lateral expansion, LWAC and regular concrete both perform better. This quality can be useful for a compressed steel tube component.

The volume fraction of LWA is used as a model variable in order to create elasticity models for LWAC using the experimental data. During uniaxial compression, these three features may be utilised to characterise the LWAC stress-strain curve. Nonlinear

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analysis and LWAC structure design are two areas where the model can be useful. Everyone knows that the mechanical properties of concrete are heavily impacted by the kind of LWA. Additional tests using other forms of LWA will be carried out in the future to get a deeper comprehension of the mechanical characteristics of LWAC.

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