Behavior of Hot Rolled Steel Section and Axial Compressive Stress-Strain Relationship of Structural Lightweight Aggregate Concrete

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Abstract

The lightweight aggregate-only concrete lacks the mechanical properties of regular concrete and is therefore unsuitable for structural applications. A hybrid aggregate system can be used to boost the performance of concrete by replacing some of the natural crushed stone with synthetic lightweight aggregate. Expanded shale was used as the artificial lightweight aggregate in the previous work to investigate the stress-strain relationship and the Poisson effect in concrete. The mechanical properties of concrete were investigated as a result of the experiment's use of four distinct volumes of shale aggregate. Peak stress and modulus of elasticity decreased as shale aggre- gate volume increased. However, the axial and lateral stresses associated with the peak stress also rise in proportion to the percentage of shale aggregate volume. The lateral strain-to-axial strain ratio showed a stronger Poisson effect the higher the concrete's concentration of shale aggregate. It is now possible to analytically define the stress-strain connection between lightweight aggregate and lightweight concrete.

1. INTRODUCTION

Steel-reinforced concrete (SRC) columns are a popular choice for high-rise structures due to their greater deformability and larger bearing capacities. This kind of structural structure is not specifically covered by any design codes at this time. In an effort to better comprehend the unique characteristics of ISRC (isolated steel reinforced concrete) columns, this study focuses on them. Scaled ISRC columns were tested in two phases based on a typical mega column in an ultra-high rise building. Static stresses are applied to six 1/4-scaled ISRC columns with eccentricity ratios of 0, 10, and 15% in Phase 1. Each specimen underwent simulated seismic loads of 10% and 15%, respectively, using four 1/6-scale ISRC columns under quasi-static stresses during Phase 2 of the experiment. A FEA was performed in addition to the physical testing to acquire a deeper comprehension of the behavior of "mega columns." An improved Plastic Distribution Method has been developed to determine the specimens' carrying capacity. The method is based on simplicity that is comparable to that of EC4 [1]. The scope of this standard is limited to a single steel profile. The method has been shown to be accurate in comparison to both experimental and numerical simulations using modern finite element algorithms. More than 10 billion tons of concrete are produced annually, making it the most important building material in the world. It is true that this practice is becoming increasingly popular, despite its negative effects on the environment. 1] Every year, between ten and eleven billion tons of aggregate are used worldwide, and natural aggregates of high quality are becoming increasingly scarce. Concrete is made with synthetic aggregate rather than natural crushed stone in order to meet environmental and sustainable development requirements [2–9].

The porous structure of lightweight aggregate (LWA) makes it weaker and more susceptible to deformation than natural aggregate. If LWA is used as the aggregate in its entirety, the mechanical properties of concrete will decrease significantly in all aspects. In a typical hybrid aggregate system, natural crushed stone and synthetic aggregate are frequently utilized together. According to previous research [10–11], the strength and content of LWA have a significant impact on the mechanical properties of concrete. Since low-strength LWA is widely acknowledged to be the material's weakest component, adding it to lightweight aggregate concrete (LWAC) weakens its mechanical properties [13]. Numerous studies have demonstrated that when LWA strength is greater than that of the mortar matrix, concrete's mechanical properties do not suffer significantly. Building systems for high-rise structures always require optimization and smaller structural components. The challenge is always to keep vertical structural components as small as possible while preserving projects' economic viability and limiting their significant role in high-rise floor plans. Composite structural parts that can be used in a variety of ways can be created by combining steel and concrete with higher-quality materials. Concrete-filled tubes and continuous caissons created by welding massive plates are two common structural options at this time. In addition to the high cost of the equipment, preheating and maintenance are required for large plates.

“This study defines composite mega columns as vertical structural systems consisting of multiple hot-rolled steel sections embedded in concrete and subject to significant vertical loads and bending moments brought on by seismic events. Although composite structural components are the subject of codes and standards, they do not provide explicit design guidance for composite sections with two or more enclosed steel sections (AISC 2016 Specifications, for instance). Because codes are ambiguous, it is necessary to conduct experimental testing in order to gain knowledge of the axial, bending, and shear behavior of composite mega columns. “These tests aid in the development of numerical techniques for describing and validating the designs and simplify the design process. The experiment was conducted at CABR Laboratories and Tsinghua University's Beijing Laboratories. MPOs may become a more significant driver of regional development in the twenty-first century. Understanding the purpose and history of MPOs, as well as transportation planning prior to the majority of MPOs' establishment, is essential before addressing the issue of MPOs. A critical meta-review of the research on MPOs and regional transportation planning is carried out in this paper. I have three objectives: The practice of urban planning in the United States dates back to the 1960s and continues to this day. To the best of my knowledge, no one has connected the dots. Second, I'm curious about how these past and current MPO issues are connected. The third and final objective of this essay is to investigate various strategies for improving urban transportation planning.

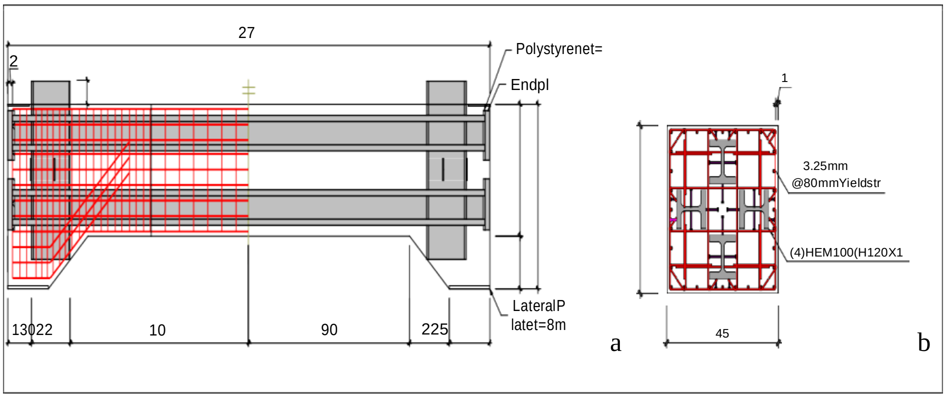

Fig.1 Detailsofthestatictests:a)steellayout–longitudinalview;b)Crosssectiondetails

2. LITERATURE REVIEW

According to Chinese standard GB175-2007, cement with a compressive strength of 42.5 MPa was utilized. Man-made sand made up the fine aggregate. Crushed granite is the natural coarse material used in this project's construction, measuring 5–20 millimeters in diameter. It was the expanded shale, which had a diameter of 5–20 mm, a 5% water absorption capacity, and a compressive strength of 8.5 Mpa. Before mixing, the shale had to be soaked in water for 12 hours to prevent it from affecting the water-to-cement ratio. To improve the material's workability, an aphthalene-based superplasticizer was utilized. Solid materials are listed in Table 1 according to their apparent or bulk density. The percentage of mix is set by the Chinese standard JGJ 55-2011. The samples' observed density was slightly higher than their predicted density because they absorbed water. This was made possible by using different proportions of expanded shale to make four different volume containers. The compressive strength of LWAC with a 20% LWA volume fraction is lower than that of regular concrete, as shown in Figure 3(b). In the tests conducted by Chi et al., an increase in volume fraction does not alter the compressive strength. and Ke and others, Similar results were deemed significant. When the LWA volume content is 60%, the lateral and axial peak stresses rise by approximately 75% and 8%, respectively. As can be seen in the figure, the Poisson ratio of typical concrete in this experiment ranged from 0.08 to 0.16. LWAC's Poisson ratio is nearly identical to that of regular concrete when the load is light. In comparison to regular concrete, LWAC has a Poisson ratio that rises as the stress level rises. As the stress ratio approaches 1.0 in LWAC-20, the Poisson ratio rapidly rises. When LWA has a volume percentage of 40% or more, the Poisson ratio gradually rises in comparison to LWAC-20 at peak stress. The LWAC-60 group has the highest Poisson ratio of the four, according to the findings. This is evident in the LWAC-60 Poisson ratio, where the stress ratio can be changed from 0.66 to 1.0. As a result, it is possible to draw the conclusion that the volume content of LWA increases the lateral expansion ductility of LWA. The following procedure must be followed in order to enhance lateral expansion's ductility. LWA has a lower modulus of elasticity and a higher Poisson ratio than natural crushed stone because of its greater deformation. The internal-curing process of LWA, on the other hand, reduces the transition between the two surfaces. Additional data are provided for relative steel-concrete section displacements, axial stiffness, vertical and horizontal displacements, curvature and ductility, and the composite mega column's resistance to deformation. As the axial stress rises as a result, fractures expand in both the vertical and horizontal directions. The test is stopped when the deflections are significant because the axial load decreases. After reaching its maximum value, the axial load on only axial specimens begins to decrease as a result of the increasing vertical deflection. Failure of the column results in significant damage and deflection, which lowers the second load level. After the highest point, eccentric specimens rarely experience a progressive decrease in applied stress. On the parts of reinforced concrete that are under stress, horizontal deflection and concrete degradation also continue to grow. Longitudinal rebar buckling and tie breakage can be observed on only axial specimens. The progression of cracks throughout the loading period is depicted in Figures 3 and 4. Steel profiles are naturally flexible but do not buckle. It has been determined that the profiles do not significantly deformed

Table 1:Mechanical and physical properties of concrete.

Groups	Density(kg/m^3)	Cubiccompressivestrengthf_{cu}(MPa)	Compressivestrengthf_c (MPa)	Modulusofelasticity E_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

3. PROPOSED SYSTEM

Figure shows the relationship between bending moment and rotation. 5a for the specimens' central section. Despite the curvature, the central section's bending moment remains constant. As rotation increases, the slope of the curve decreases, indicating a decrease in bending stiffness. Because the magnitude of the moment multiplied by the angle equals the amount of energy, the area beneath the "moment vs. rotation" curve represents mid-absorbed energy. To put it another way, according to the Plumier technique et al. [, the ductility of columns with an eccentricity ratio under 15% is exceptional. 3], [4], and the locations of the trial connection in Fig. 5b correspond to the association bend that was worked on. Due to the fact that the typical material assets of the test instances are used to construct cooperation bends, the recorded data of interest bends and connection bends tend to differ. The plan provides an incentive for this pressure, so the hub load design value cannot be met because the significant hammering stresses outside the stirrups are less than 3.5-E-3. The test's results suggest that when people are put under unusual loads, they get angry. In both models, experimental results are expected to be worse when the hub is stressed. Both scenarios have fewer actual characteristics than the typical six-part example. Additionally, the effects of clasping and P-impacts have not yet been taken into account in the outcomes of these two cases. Because shear powers are absent, steel profiles, concrete, and longitudinal rebar may all experience the same amount of stress. Steel sections and longitudinal rebars remain malleable as long as the hub example reaches its maximum deformation. On eccentric specimens, longitudinal steel sections and rebars fail before the specimen reaches its full capacity. During this test phase, the "Plane Section Assumption" is confirmed by the midsection strain distribution. Because the eccentricity ratios are so similar, the quasi-static tests behave very similarly in general. FIG. Based on crack distributions and failure mechanisms, specimens 10 exhibit a combination of compression and flexure pattern failure. The test specimens do not exhibit significant deformations or cracking during the initial loading stage. During the second stage of loading, the specimen develops cracks and concrete crush, and the specimen eventually collapses as a result of the accumulation of damage at the column corners. Static experiments demonstrate that the "Plane Section Assumption" theory is correct within a 15% eccentricity ratio. Despite the damage to the concrete's exterior surface, steel fragments prevent the core concrete from crumbling by acting as a confining force. Due to the confinement of the concrete core, steel components cannot buckle. Local bowing has been observed in longitudinal rebar and transverse ties. Hysteretic curves that are both stable and circular demonstrate the capacity to release energy without significantly affecting the eccentricity ratio (Fig. 11). A linear strain distribution in concrete and steel sections at ten percent eccentricity until failure supports the "Plane Section Assumption." For specimens evaluated at a yield load level of 15%

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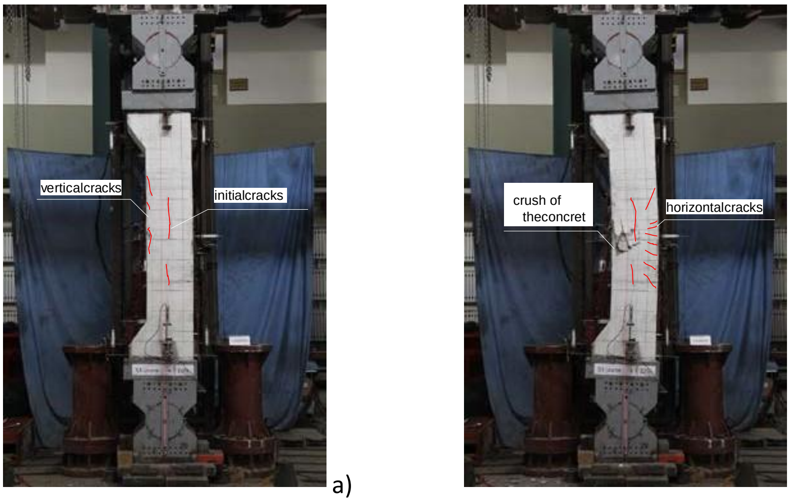
eccentricity, the assumption holds true. LONGitudinal rebar defies the assumption due to buckling. When LWA has a volume percentage of 40% or more, the plane section assumption is more likely to be proven within a 15% eccentricity ratio. The LWAC-60 group has the highest Poisson ratio of the four, according to the findings. This is evident in the LWAC-60 Poisson ratio, where the stress ratio can be changed from 0.66 to 1.0. As a result, it is possible to draw the conclusion that the volume content of LWA increases the lateral expansion ductility of LWA. The following procedure must be followed in order to enhance lateral expansion's ductility. LWA has a lower modulus of elasticity and a higher Poisson ratio than natural crushed stone because of its greater deformation. The internal curing process of LWA, on the other hand, minimizes the transition between the two surfaces.



a) b)

Fig.3 Proposed Methodology

4.CONCLUSION

In order to confirm the behavior and performance of mega columns with embedded steel profiles, two sets of experiments were carried out. The anticipated outcomes are provided by the two processes. The specimens exhibit failures in compression and flexure. Even when the steel parts are not connected to one another during the test, the composite action can still be seen. The test results show that the "Plane Section Assumption" holds true for specimens with e/h values of 10% and 15%. However, the interface slip increased with eccentricity, suggesting that mega columns may require more shear. The "moment vs. curvature" ductility of the static specimen is exceptional. The deformation capacity of quasi-static specimens meets regulations' minimum requirements. The specimens consistently use energy, indicating their resilience to earthquakes. A lower-strength concrete part or composite member can be used to calculate the structure's first-order elastic response. The second-order effect and concrete fracture may be simplified in this manner during moderate or severe earthquakes. The results of this program make it abundantly clear that the stiffness reduction factor of the EC4 method could be decreased to 0.6. Only the concrete part is affected by the factor.).

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