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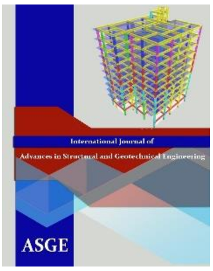

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Mohamed F. M. Fahmy, Lamiaa K. Idriss

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COMPARATIVE STUDY BETWEEN FLEXURAL BEHAVIORS OF A LARGE SCALE SEMI-PRECAST RC T-BEAM WITH RECYCLED CONCRETE AND A TRADITIONAL RC T-BEAM

Mohamed F. M. Fahmy[1], Lamiaa K. Idriss[2]

[1]Associate Professor, Dept. of Civil Eng., Faculty of Eng., Assiut Univ., Assiut, Egypt

Email: mfmf1976@yahoo.com

[2]Assistant Professor, Higher Institute of Engineering and Technology, El-Menia, Egypt

E-mail: lamiaidriss@yahoo.com

ABSTRACT

This work presents a comparative study between the flexural behavior of traditionally cast large-scale reinforced concrete (RC) T-beam made of natural aggregate concrete (NAC) and the response of a similar semi-precast RC beam made of both NAC and recycled aggregate concrete (RAC). The semi-precast beam was composed of a precast U part, in which both the beam longitudinal tensile reinforcement and the transverse reinforcement were built-in. The core of the beam web and the beam flange were cast using RAC. Both beams were simply supported and tested under the effect of two-point loading system. The shear span to depth ratio of both beams was equal to 3.0. The test results pointed to the successful production of a new generation of semi-precast RC beams using both NAC and RAC that can ensure the required durability and achieve a comparable flexural response to that of the traditional RC beam.

Keywords: T-beams, Recycled aggregate, Traditional casting, Semi-Precast, Flexural.

INTRODUCTION

Many investigators have showed various studies to identify the possibility of using the waste of buildings in modern constructions. Compared to conventional concrete behavior, several experimental studies have measured the behavior of medium and high strength recycled aggregate concrete (RAC) under the effect of different loading conditions [Peng et. al. 2013, Silva et al. 2014]. Others studied the flexural behavior of structural elements made of RAC [Sato et al. 2007, Kaarthik and Subrmanian 2014, Xiao et al. 2015]. This study introduces the recycled aggregate concrete as filler for the semi-precast reinforced concrete beams. This system ensures the required durability for modern constructions according to the current design provisions, which in turn can have a positive impact on the wide spread of RAC application in structural elements. A large scale semi-precast beam was constructed using RAC as a filler to the beam web and the beam flange, and the test results are compared to the response of a similar beam made of 100% natural aggregate concrete.

MATERIAL PROPERTIES

The basic properties of coarse aggregate are given in Table 1, the mixing properties of high strength concrete based on natural aggregate and recycled aggregate (HSC, HSRCA, respectively) are shown in Table 1, and the 28 day mechanical behavior of the resulting concrete is presented in Table 2. Steel reinforcement bars of 8mm, 10mm, and 12 mm diameters were used as steel stirrups, compression and tension reinforcements, respectively as shown in Fig. 1. The characteristic yield strengths of the steel reinforcement bars were 305 MPa, 578 MPa, and 509MPa, respectively.

Table 1: Mixing components of the different concrete types

Concrete type	RCA replacement percentage (%)	Cement (kg/m^3)	Sand (kg/m^3)	NCA (kg/m^3)	RCA (kg/m^3)	Water (kg/m^3)	Silica fume (kg/m^3)	Sikament (kg/m^3)
HSC	0	475	500	1200	0	166	25.0	12.5
HSRCA	100	507	1020	0	673	155	27.0	13.4

Note: NCA= natural coarse aggregate, RCA= recycled coarse aggregate

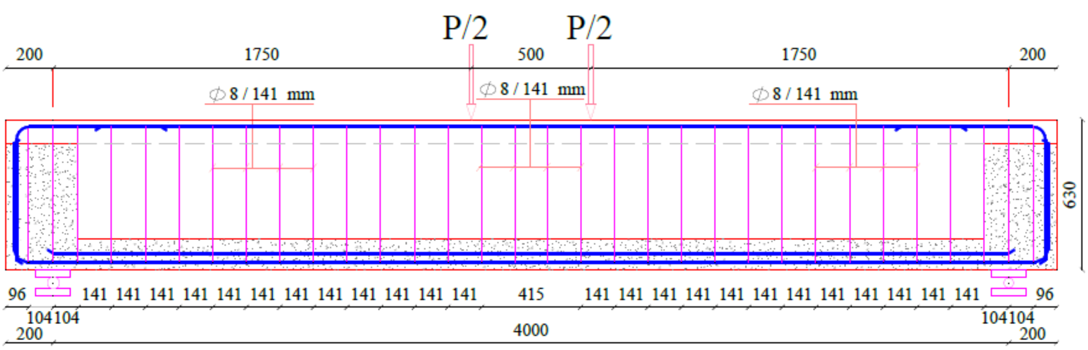
Table 2: Characteristic properties of concrete after 28 days curing

Specimen	Average concrete compressive strength (MPa)			Average concrete tension strength (MPa)	
	U	C	F	U	C
RH	38.8	38.8	38.8	2.8	3.0
UH-CRH-FRH	43.7	52.9	52.9	3.2	3.0

Note: U= outer U part of the beam web, C= core of the beam web, and F= beam flange]

EXPERIMENTAL PROGRAM

The main construction details of the semi-Precast reinforced concrete T-beams are given in Fig.1. The beams had the same cross section: the web width= 250mm, the web depth= 530mm, the thickness and the width of the beam flange = 100mm and 500mm, respectively. The loaded span of the beam was 4000mm, which was simply supported on roller and hinge supports. Two loads were applied and they were a parted by 500mm. Shear reinforcement was steel stirrups of 8mm diameter, which was spaced at 141mm. Both beam were designed to fail in a flexural failure mode, so the tensile reinforcement was 7 bars of 12mm diameter at the tension side and 2 d12mm and 4d10 mm reinforcement bars at the compression side, as shown in Fig. 1(a). Fig 1(b) shows the cross-section of both semi-precast beams.



(a) Reinforcement details of all beams

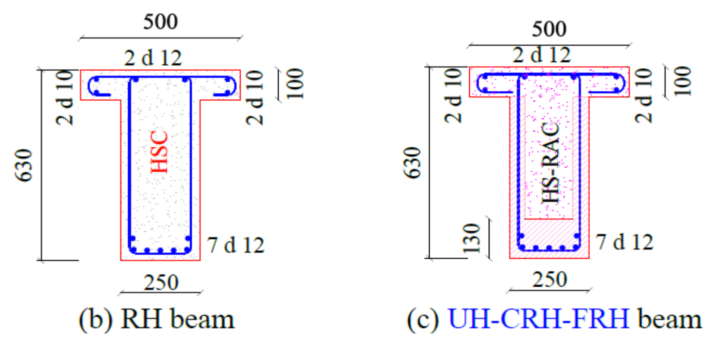


Fig. 1: Schematic drawings for the reinforcement details and concrete dimensions

Instrumentation and Test Procedure

Figure 2 is a schematic drawing showing all instruments used to capture the difference in the behavior of the tested beams: 11 strain gauge at the beam tension side, 2 linear variable differential transducers (LVDTs) measuring the crack width at two critical sections, 4 LVDTS measuring the beam vertical deflection at different locations starting from the beam mid-span and going toward the beam support, two strain gauges were affixed to the beam compression side, and a load cell to define the applied load. All instruments were attached to a data acquisition system, as shown in Fig.2 .

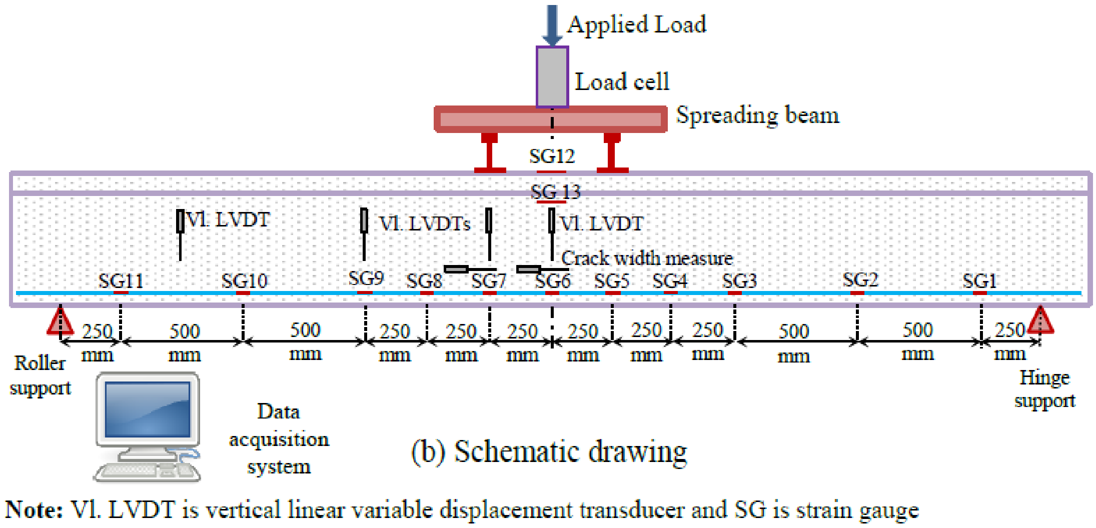


Fig 2: Arrangement of instrumentation and measurements (unit: mm)

EXPERIMENTAL RESULTS AND DISCUSSION

Crack Pattern and Failure Mode

The first cracking load for both beam were comparable, however, the semi-precast beam showed a higher stiffness, which could be attributed to the higher characteristic strengths of the concrete used. Before yielding of the steel reinforcement, both beam showed a comparable crack pattern, and the semi-precast beam experienced yielding at 172.5kN, which was 95% of that of the RH beam. Notably, most of the flexural and flexural-shear cracks could not reach to the beam flange for the semi-precast beam. Beyond the yielding level, further cracks developed at the critical flexural zone and flexural shear cracks developed and others propagated toward the beam flange between the applied loads and the beam supports; as shown in Fig. 3. Fig.4

indicates that the high deformability of the beams was dependent in the expensive ductility of the beam tensile reinforcement. Ultimately, both beams failed in clear flexural failure mode with crushing of the concrete flange after realizing high deformability level

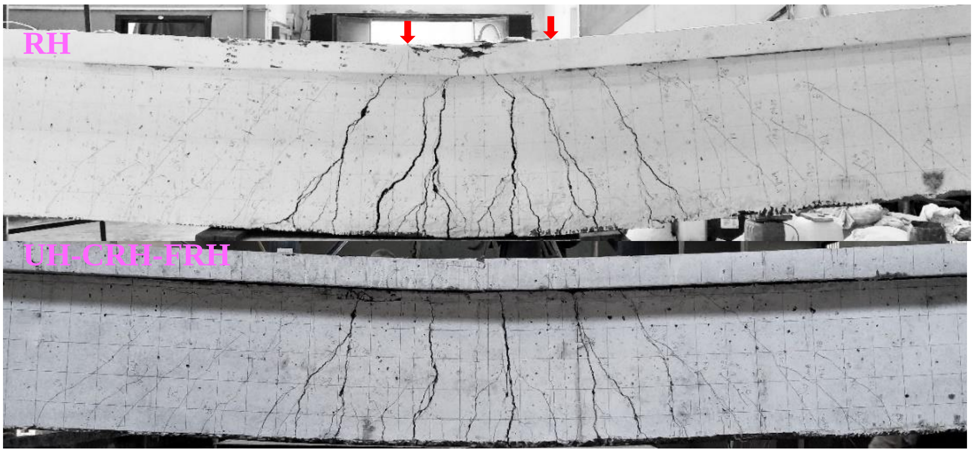


Fig. 3: Final failure mode of the test beams

Axial Strains

Obviously, Fig. 4 shows that the measured induced axial tensil strains after steel yielding were significant along the beam span (from SG3 to SG9, as shown in Fig.1). The maximum captured strains exceeded 20 times of that of steel yielding strain in both beams. The compression strains versus the applied loads are shown in Fig. 4(c) for comparison between the traditional cast beam and the semi-precast beam with RAC. It seems that the adoption of RAC as concrete filler in the semi precast construction system is promising as the beam during the serviceability state showed a comparable response to that of the reference beam.

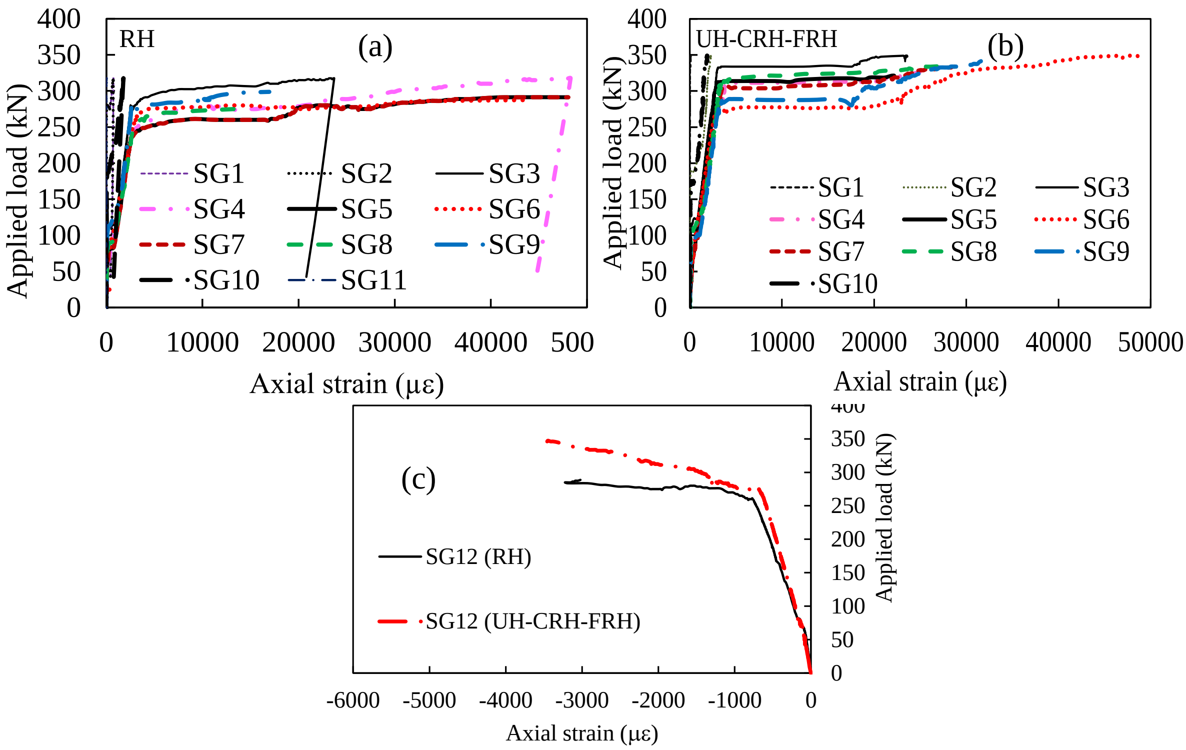


Fig. 4: Applied load versus the tensile axial strain (a) RH beam, (b) the semi-precast beam, and (c) the compression strains for the RH and UH-CRH-FRH beams

Crack Width

Fig.5. confirms the above mentioned conclusion, as it is evident that the semi-precast beam showed a somewhat lower width for the main crack of the beam. However, it is worth mentioning that this behavior could be due to the observed higher properties of the concrete used in the construction of the semi-precast beam .

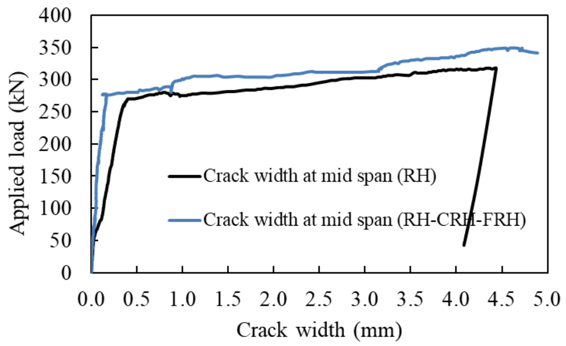


Fig. 5: Applied load versus crack width at the beam mid span

Load-Deflection

The following figure (Fig. 6) presents the relationship between the applied load and the recorded deflection of the test beams at the critical mid-span section. Both beams approximately achieved a comparable elastic behavior, and the yield of the semi-precast beam was 5% lower than that of the reference beam. After yielding, the RH beam showed a faster widening rate of the developed cracks, and excessive deformability was measured to reach a maximum deflection of approximately 126.0 mm. However, the semi-precast beam showed a higher resistance to the beam deformability, reaching approximately 300 kN, after which the beam showed a lower increase rate of the beam deformability with the increase in the applied load. This again approved the effect of the concrete compressive strength of the RAC used in the semi-precast beam. The semi-precast beam was not able to achieve the same ultimate deformation of the reference beam, and it showed a degradation of the strength at 85 mm beam deflection. The reference beam and the semi-precast beam achieved maximum flexural strength of 317.5 kN and 348.8 kN, respectively. The flexural strengths of both beams were calculated using the material properties of both beams in the light of the design codes provisos and considering the steel hardening: the predicted values were 339 kN and 346 kN for the reference beam and the semi-precast beam, respectively. The strength of the reference beam was 6% lower than that of the expected flexural strength can be related to the observed intensive flexural cracking of this beam.

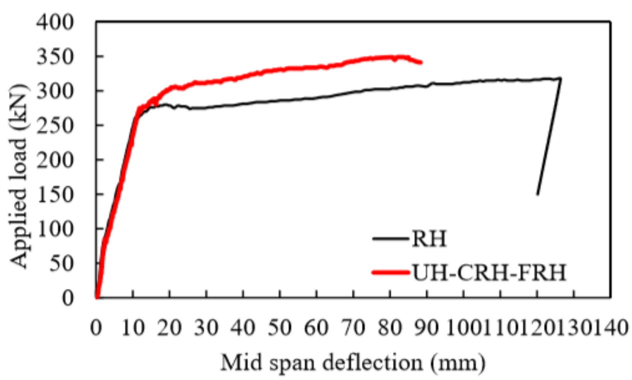


Fig. 6: Load versus deflection at the beam mid-span

CONCLUSIONS

The present study showed a comparative evaluation for the performance of semi-precast beam made of both natural aggregate and recycled aggregate concrete (NAC and RAC, respectively) in the light of the flexural behavior of a reference beam cast monolithically using 100% natural aggregate concrete. The results proved the successful performance of the proposed application of RAC as concrete filler to the beam web and also to cast the beam concrete flange. The crack pattern, the failure mode, the serviceability state, and the flexural resistance were, in general, comparable to those of the traditionally cast beam with NAC.

REFERENCES

1. Peng, G. F., Huang, Y. Z., Wang, H. S., Zhang, J. F., & Liu, Q. B. (2013), "Mechanical properties of recycled aggregate concrete at low and high water/binder ratios", Advances in Materials Science and Engineering, 2013, DOI: 10.1155/2013/842929.
2. Sivakumar, N., Muthukumar, S., Sivakumar, V., Gowtham, D., & Muthuraj, V. (2014), "Experimental studies on high strength concrete by using recycled coarse aggregate", International Journal of Engineering and Science, 4(01), 27-36.
3. Silva, R. V., De Brito, J., & Dhir, R. K. (2014), "Properties and composition of recycled aggregates from construction and demolition waste suitable for concrete production", Construction and Building Materials, 65, 201-217.
4. Sato, R., Maruyama, I., Sogabe, T., & Sogo, M. (2007), "Flexural behavior of reinforced recycled concrete beams", Journal of Advanced Concrete Technology, 5(1), 43-61.
5. Kaarthik, M., & Subrmanian, K. (2014), "Flexural behavior of concrete beams using recycled fine aggregate and steel fibres", In International Conference on Biological, Civil and Environmental Engineering (BCEE-2014) March (Vol. 17, No. 18, p. 2014).
6. Xiao, J.Z., Pham, T. L., & Ding, T. (2015), "Shake table test on seismic response of a precast frame with recycled aggregate concrete", Advances in Structural Engineering, 18(9), 1517-1534.