Structures 66 (2024) 106866

Contents lists available at ScienceDirect

Structures

journal homepage: www.elsevier.com/locate/structures

Comparative study on seismic behavior of corroded RC columns strengthened by ECC combined with steel cage /fiber grid/CFRP

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ARTICLE INFO

Keywords:
Corroded RC column
Seismic behavior
ECC strengthening
Restoring force model

ABSTRACT

A method for strengthening was proposed to improve the seismic behavior of corroded reinforced concrete (RC) columns by using engineered cementitious composite (ECC) combined with a steel cage/fiber grid/carbon fibre reinforced plastics(CFRP). The corroded RC columns strengthened with ECC combined with a steel cage, fiber grid, and CFRP were subjected to low cyclic compression tests at design axial pressure ratios (n) of 0.3 and compared with corroded and uncorroded columns. Experimental results showed that ECC strengthening of corroded RC columns not only significantly improved their load-carrying capacity, displacement ductility, and energy dissipation capacity but also effectively reduced the degree of damage and stiffness degradation. The ductility coefficients of ECC/steel cage composite strengthened columns and ECC/CFRP composite strengthened columns are 35.58 % and 34.13 % higher, respectively, compared to ECC fully strengthened columns, while the ductility coefficient of ECC/fiber grid composite strengthened columns decreased by 4.33 % compared to ECC fully strengthened columns. Among them, the ECC/steel cage composite-strengthened columns exhibited the highest number of hysteresis loops, the strongest energy dissipation capacity, and the best strengthening effect. Additionally, a restoring force model for ECC-strengthened corroded RC columns was established, and its validity was verified through theoretical calculations.

1. Introduction

As a crucial component of the transportation network, the safety of bridges has received significant attention. Bridge piers, being integral to bridges, may undergo varying degrees of corrosion of internal steel bars over time due to factors such as water erosion and weather conditions. Corrosion of the rebar leads to a reduction in the effective cross-sectional area and mechanical properties [1–7], significantly impacting the load-bearing capacity, service life, and seismic behavior of the bridge structure [8–15]. To address this issue, many engineering researchers have proposed various solutions, including increasing the thickness of the protective layer of steel bars, enhancing the strength level of concrete, and repairing and strengthening corroded RC columns. Strengthening using external methods is considered a more economical, convenient, and feasible solution.

However, the use of different strengthening methods for corroded components produces varying effects. The seismic behavior of strengthened corroded RC components has been investigated by numerous researchers. Combining numerical analysis and experimental methods, Li et al. [16] studied the influence of composite strengthening, such as carbon fiber cloth wrapping and increasing concrete sections, on the seismic behavior of corroded RC columns. The results indicated that this method was highly effective, enhancing the ductility, ultimate bearing capacity, and energy dissipation capacity of the specimens. Based on previous research, Li et al. [17] conducted low-cycle reciprocating load tests on strengthening corroded concrete columns, concluding that each strengthening method can effectively enhance the seismic behavior of corroded columns. In comparison with uncorroded specimens, the energy dissipation capacity of the steel-encased strengthened specimens, carbon fiber reinforced polymer (CFRP) strengthened specimens, and glass fiber-reinforced polymer (GFRP) strengthening specimens increased by 222.3 %, 123.9 %, and 98.5 %, respectively. Similarly, the ductility coefficient also rose by 45.3 %, 22.3 %, and 25.6 %, respectively. It is evident that the steel-encased strengthening method is optimal, and CFRP strengthening surpasses GFRP strengthening. Wang et al. [18] also reached a similar conclusion that strengthening corroded RC columns with CFRP significantly improved displacement ductility and reduced residual displacement. Based on the aforementioned research results, while the ductility of the

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https://doi.org/10.1016/j.istruc.2024.106866
Received 23 February 2024; Received in revised form 3 June 2024; Accepted 2 July 2024
Available online 9 July 2024