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INNOVATIVE SELF STRENGTHENING REINFORCED CONCRETE BEAM

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ABSTRACT

Concrete structures deteriorate over time, regardless of the workmanship, natural disasters, concrete lifespan, or overloading structures beyond their initial design load. To overcome this dilemma, additional materials may be installed at the critical stress area of the beam's cross-section to increase the strength of a weakened reinforced concrete (RC) beam structure. One of the most common methods to strengthen the RC beam is by using prestressing force. In RC beams, prestressing helps to minimise existing deformations and crack occurrences. However, conventional prestressing techniques require specialised hydraulic jacking and anchorage systems, which may not be feasible in certain situations. Shape memory alloy (SMA) has the ability to recover its original shape upon deflection by heating. Therefore, the initial stress forces could be introduced into the RC beam to increase its capability without the need of jacking tools. This project aims to propose a self-strengthening RC beam. A 3D finite element model using ABAQUS software was executed and subjected to a four-point bending test. The result showed that the self-strengthening RC beam obtained an increment of 30% in load capacity compared to conventional beam.

Keyword: *RC beam, shape memory alloy, self-strengthen*

1. INTRODUCTION

The degradation of concrete structures, especially in reinforced concrete (RC) beam, has become one of the most recently discussed topics in structural engineering. Degradation of RC beams can occur for various reasons, including natural disasters, inadequate workmanship or material quality, concrete lifespan, and overloading of intended design load. Concrete also faces significant damage when exposed to elevated temperatures. When strength deterioration of a structure occurs, an engineer must find out the degree of the problem and come up with a solution either to retrofit or to demolish and re-construct a new building. A desirable decision should provide the most environmentally sustainable solution, such as maintaining human needs while preserving the environment, and using the available resources efficiently. Therefore, repairing the structure should be the best option depending on the amount of damage to the affected structures.

The RC beam's strength can be improved by installing additional material at the tension region in the cross-section. External bonding and near-surface mounted (NSM) technique are the most common methods to install additional reinforcement to strengthen or retrofit existing concrete structures (ACI Committee 440, 2017). According to El Hacha and Soudki (2013), fiber-reinforced polymer (FRP) is preferable as the strengthening material because of its lightweight, non-corrosive, and high tensile strength. In some cases, the FRP is prestressed to increase the efficiency of the NSM technique to decrease the beam deflection.

However, prestressing FRP requires special jacking and anchorage tools, which might not be accessible in certain circumstances. In addition, the special tools are expensive. Therefore, an innovative, self-strengthening RC beam is proposed in this study. The objective of this study is to investigate the possibilities of the self-strengthening RC beam performance in comparison to the conventional RC beam.

2. METHODOLOGY

To model the 3D finite element model of self-strengthening RC beam, the experiment conducted by Rojob and El-Hacha (2015) was used as the reference study. Two beams loaded with a four-point bending scheme were modelled: one conventional RC beam and one self-strengthen RC beam. The RC beam dimensions employed in this study are 150 mm x 200 mm rectangular cross section with 750 mm length. The RC beam was assumed to be simply supported. The concrete material behaviour was modelled using concrete damaged plasticity (CDP). The concrete compressive strength utilised in this study was 30 MPa and reinforced with steel reinforcement of yield strength 500 MPa. The steel reinforcements behaviours were modelled based on an isotropic hardening plasticity model. The strengthening materials, iron-based shape memory alloy (Fe-SMA) behaviour was adopted from the study of Zhang et al. (2022). Predefined stress that corresponds to the actual stress value developed in the Fe-SMA rebar after heating was introduced to the Fe-SMA to induce the self-strengthening abilities of the RC beams. The size of the mesh was optimised to reduce the computational efforts and, at the same time, make sure the results are mesh independent. Figure 1 shows the illustration of the RC beam model.

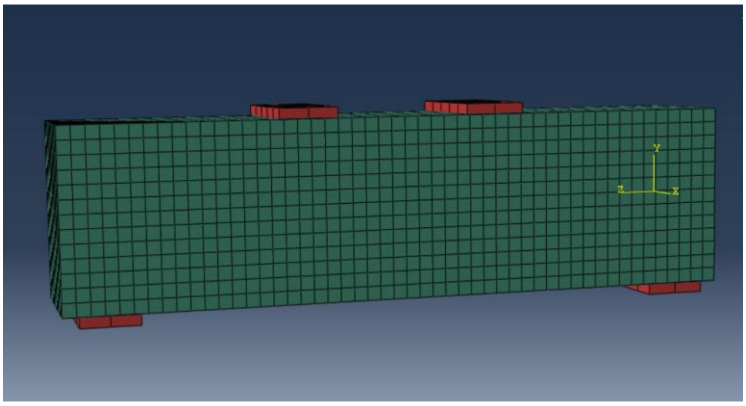

Figure 1 RC Beam

3. FINDINGS

The self-strengthening RC beam has shown an improvement of capabilities by 30% compared to the control beam, as shown in Figure 2.

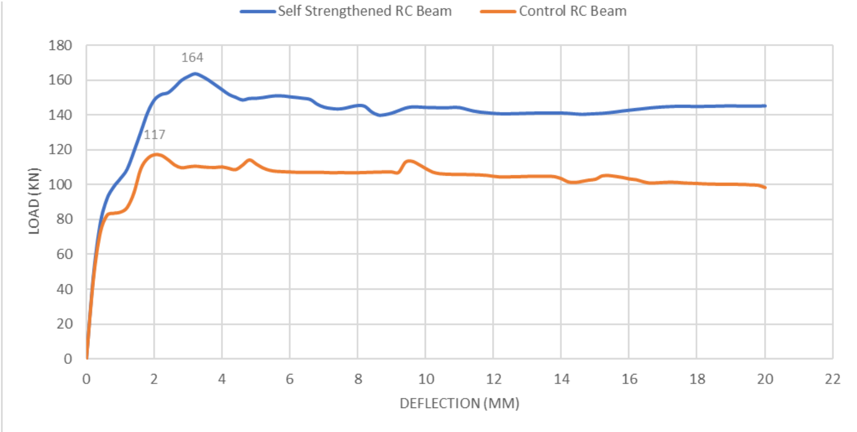

Figure 2 Load vs Deflection Comparison Result

4. CONCLUSION

In the present study, finite element modeling successfully demonstrated the application of an iron-based shape memory alloy (Fe-SMA) in RC beam. The general feasibility of ribbed Fe-SMA rebar for reinforcing and self-strengthening the RC beam was demonstrated. The Fe-SMA rebar could be activated by using only an oxy torch, and the self-strengthening force could be transferred to the concrete section instead of using complicated tools. Self-strengthening RC beam offers many advantages, including reduced crack widths, reduced deflections, reduced stress in the internal steel, and increased load-carrying capacities. The self-strengthening RC beam shows good performance by an increment of 30% load carrying performance, thus allowing for taking fuller advantage of the strength of the material compared to the conventional beam.

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