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2- Methodology

In this paper, the finite element model of 3 reinforced concrete beams with the dimension of 500×100×80 mm was produced in ANSYS software (Figure 3).

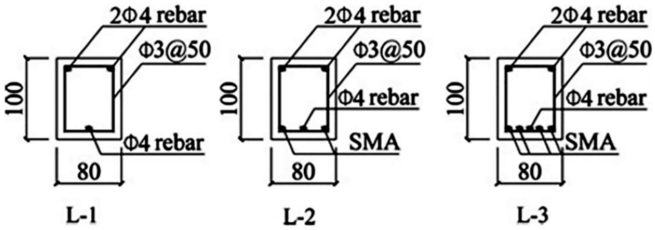

Figure 3. Details of the beams [4]

The characteristics of materials used in the construction of finite element model were taken from the experimental study [4].

After the models were made in ANSYS, they were loaded up to a target deflection of 5.5 mm in the mid-span and then were unloaded. Loading were applied to the models by using displacement control method.

3- Results

After the finite element analysis, the hysteresis diagrams of models were plotted (Figure 4). Diagrams showed that, adding nitinol wires in the tensile zone of the beams increase both the load capacity and absorbed energy of the beams (Table 1).

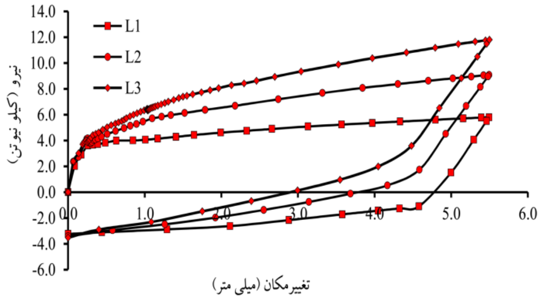

Figure 4. Hysteresis diagram of the beams

The residual displacements of the models were calculated and it was concluded that by adding nitinol wires in the tensile zone of the beams, the residual displacements of beams were reduced. Table 2 shows the residual displacement and the reduction of residual displacement in models.

Table 2. Residual displacement and reduction of residual displacement of models

Reduction of residual displacement (%)	Residual displacement (mm)	Beam
0	4.75	L1
20.42	3.78	L2
39.16	2.89	L3

4- Conclusions

The main results were obtained as follows:

1. Adding nitinol wires in tensile zone of beams increase both loading capacity and ductility. This issue caused that beams with nitinol wires have better seismic performance compared to beams with no nitinol wires.
2. By adding nitinol wires in tensile zone of beams and cyclic loading, the residual displacement has been reduced significantly.
3. However by adding the nitinol wires in tensile zone of beams, the cracks spread more during loading, but after the models were unloaded, it was obvious that the cracks in critical zone were closed. This performance is significant for beams located in earthquake zone t, because the possibility of retrofitting such members (without demolition of the members) will be provided.

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Table 1. Displacement, load capacity and absorbed energy of the beams in different conditions

Beam	L1	L2	L3
Displacement, when the steel rebars reached the yield stress(mm)	0.216	0.333	0.323
Load capacity, when the steel rebars reached the yield stress (kN)	3.852	4.041	4.413
Ultimate displacement (mm)	5.5	5.5	5.5
Ultimate load capacity (kN)	6.374	10.713	14.222
Inelastic energy (kN.mm)	28.617	37.109	46.350
Total energy (kN.mm)	28.938	37.998	47.228

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F.E. Modeling and Experimental Comparison of RC Beams Consisting Shape Memory Alloys under Cyclic Loading

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ABSTRACT: Shape Memory Alloys (SMA) are a kind of smart materials that their unique mechanical and thermal performances such as the ability to return to its original shape (Shape Memory Effect) and the ability to recover large strain (Super Elasticity), caused their wide application in various industries such as civil engineering. Due to the superplastic behavior of theses alloys, undergoing cycles of loading and unloading, results very little residual strain, even after exceeding the yield strain. This property causes recover forces in the structure so that they can close the cracks in the tensile zone of RC members and therefore, it is significant for structural members located in earthquake zones. In this paper the F.E modeling of reinforced concrete (RC) beams utilizing of shape memory alloys is produced and results of different loads response of modeling is verified with the available experimental results. For this purpose, firstly the finite element model of three RC beams by adding Nitinol wires in the tensile zone was made by ANSYS software. Then the beams were subjected to cyclic loading and their hysteresis curves were compared with the similar available experimental beams. The numerical results revealed, utilization of Nitinol wires in tensile zone of the beams resulted, increase in both loading capacity and ductility and decrease in residual displacement.

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1- Introduction

In recent years, the idea of designing and constructing smart structures has been getting closer to reality. By employing science metallurgy, civil engineers achieved new structural materials which demonstrate predetermined features in the various conditions. The structural materials which are used in this paper are a class of smart materials named Shape Memory Alloys and the type of Nitinol. For the first time, Nitinol was discovered by Buhelr in the Naval Ordinance Laboratory in 1963 [1].

Shape Memory Alloys (SMA) like other metals and alloys have more than one type of structure or crystal phase with a constant chemical composition. These alloys have two crystal phases, the phase that is stable in high temperature (Austenite) and the phase that is stable in low temperature (Martensite). These two phases can be converted to each other by using stress or heat.

Shape Memory Alloys have two unique properties. The first is the shape memory effect; the ability to return to its original shape (Figure 1) and the second is super elasticity; the ability to undergo large strain (Figure 2). Civil engineers use these two properties of SMAs to design smart structures [2, 3].

In this paper, the finite element analysis and verification of reinforced concrete beams was discussed by adding Nitinol wires in the tensile zone. For this purpose, the properties of materials is introduced first, then finite element modeling and comparison of finite element analysis and experimental results are investigated.

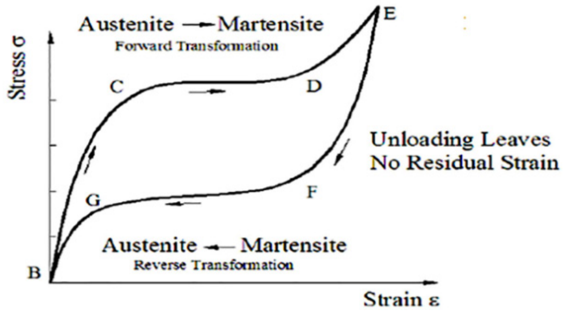

Figure 1. Shape Memory Effect of SMAs [2]

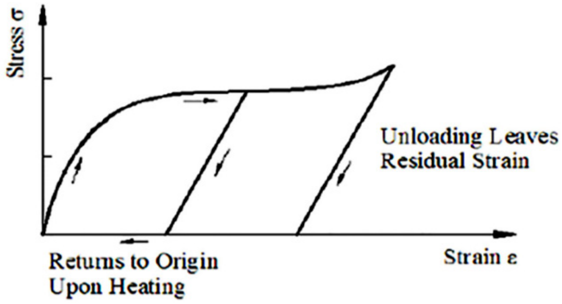

Figure 2. Super-elastic behavior of SMAs [3]

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