7th International Conference on Seismology & Earthquake Engineering
18-21 May 2015
00603-SR

OPTIMUM RETROFIT OF A 3-STORY RC FRAME CONSIDERING NONLINEAR SSI

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Keywords: Retrofitting, Optimization, CFRP, Target Displacement, Soil-Structure Interaction

Design codes of structures are changing persistently and with recent progressions in knowing true behaviour of structures against seismic and dynamic loads, existing structures seem to lack a lot when it comes to resist dynamic loads especially earthquakes. In this regard, parallel to new approaches to designing structures against these types of loadings, methods of retrofitting of existing structures continue to evolve so that structures in need of contrivances keep serving without being required to get totally rebuilt. Among several materials and methods of retrofitting structures, FRP's are finding their way to be more and more common as a result of their many distinguishing features. CFRP's specifically, whose effects are studied in this research, are getting popular among other types in Iran as a result of their relative reasonable price and good workability. To retrofit a structure, two main aims should be considered: First, satisfying new design codes necessities, and second having an eye on economical issues. The economical aspect of the problem induces the tendency of finding the minimum material needed to gain the optimum response.

A 3-story reinforced-concrete (RC) frame shown schematically in Figure 1 is assumed, which needs to be retrofitted so as to satisfy the requirements of new codes. In the first stage, the structure is retrofitted to a level which leaves no shortage in carrying the loads caused by the pushover analysis, making it possible to meet all desired criteria. The Teaching-Learning Based Optimization (TLBO) algorithm, which is summarised in Figure 2 so that it may match the scope of this abstract, is used to do the optimization of the needed retrofitting material i.e. CFRP. Figure 3 illustrates the pushover curve along with its bilinear representation.

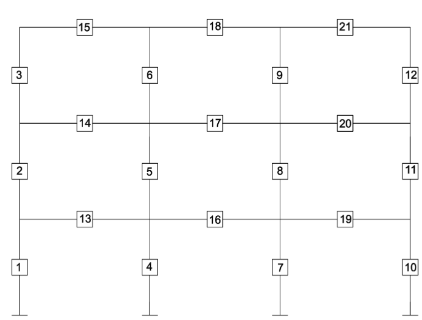

Figure 1. The 3-story 3-interval frame to be retrofitted

Studies are done once more considering nonlinear soil-structure interaction using the UCD soil model in which the foundation is supposed to be placed on springs reaching softened constants under bigger strains than a threshold. Figure

4 illustrates this state for a single footing schematically. All modelling and the programming are done in the OpenSees software environment.

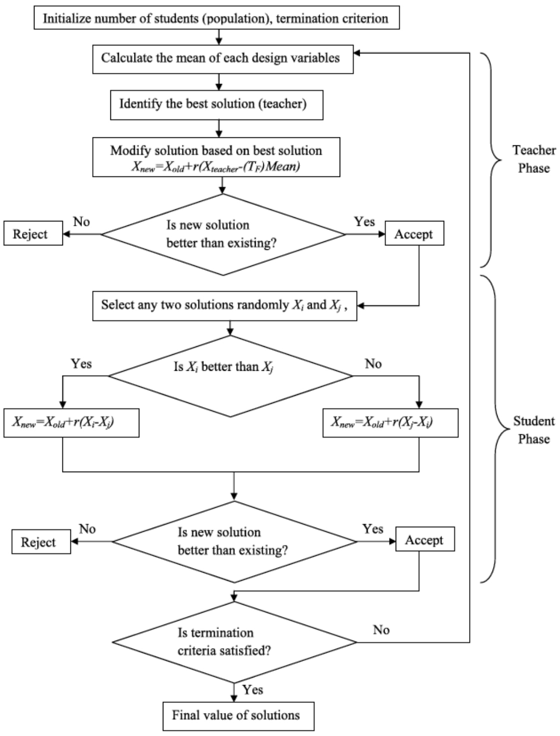

Figure 2. Flow chart of the TLBO algorithm (after Rao et al., 2011)

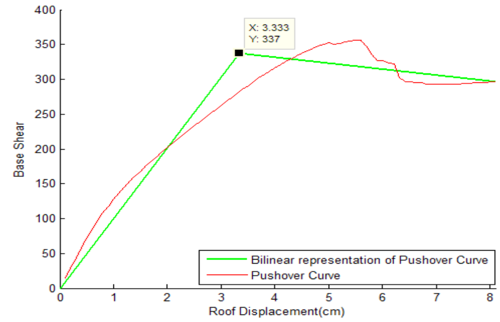

Figure 3. Bilinear representation of pushover curve

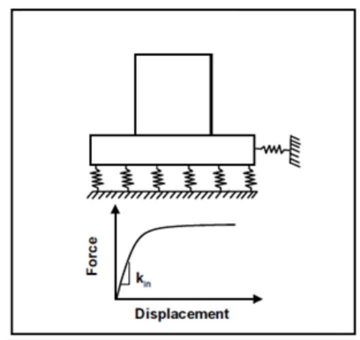

Figure 4. Behavior of footing on UCD soil (after Raychowdhury and Hutchimson, 2008)

The target displacement to be met for all states of the structure is yielded from Equation 1:

$$S_t = C_0 C_1 C_2 S_a \frac{T_e^2}{4\pi^2} g \tag{1}$$

Table 1 shows suitable values for parameters in Equation 1, based on the last revision of the Iranian Code of Retrofitting of Existing Structures no. 360.

Table 1. Needed parameters to calculate target displacement (Iranian Code of Retrofitting of Existing Structures no. 360)

	$_t$(cm)δ	S_a	C_2	C_1	C_0	T_i	C_m	V_y(KN)
Primary structure (no SSI)	8.00	0.72	1.015	1.07	1.30	0.533	0.90	337
Primary structure (SSI)	8.70	0.70	1.012	1.06	1.30	0.570	0.90	334
Retrofitted structure (no SSI)	7.40	0.72	1.0003	1.01	1.30	0.533	0.90	748
Retrofitted structure (SSI)	8.30	0.70	1.002	1.02	1.30	0.570	0.90	559

Table 2. Area and cost of CFRP required for optimal retrofitting of the frame

	CFRP area required to satisfy the considered retrofitting purpose (m^2)	Required CFRP cost (rials)
Pushover (no SSI)	74.4	111600000
Pushover (SSI)	98.4	147600000

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The Iranian Code of Retrofitting of Existing Structures no. 360