Chapter 5

A Comparative Investigation of Structural Performance of Typical and Non-Ductile Public RC Buildings Strengthened Using Friction Dampers and RC Walls

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ABSTRACT

Strengthening of non-ductile public buildings is a never-ending issue. Selection of the suitable strengthening method and appropriate analysis type for the assessment of pre- and the post-intervention performances are still open to question. The displacement or drift limitations are crucial as well as demand capacity ratios for determination of such buildings performance under severe ground motion. In this chapter, an investigation of seismic performance focused on displacement criterion of strengthened non-ductile public RC buildings in Turkey is presented. Both the nonlinear static and response history analysis were conducted. Friction dampers which are fairly modern technique and conventional RC wall implementation method were introduced to as-is building. For the simplicity and the easy of the process, 2D frame selected for investigation. Comparison of the aforementioned techniques for non-ductile public RC buildings and performances particularly by means of displacement obtained using different methods for those investigated schemes are carried out and presented in the chapter.

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INTRODUCTION

Adequate structural performance is the key-point of the earthquake-proof buildings. The arising question is how the engineers define this adequacy and how they supply the sufficient structural performance for the existing buildings. The seismic assessment and the performance evaluation methods are varying from linear to nonlinear manners as well as from equivalent analysis techniques to the most sophisticated state of the art method namely response history analysis. There exists also another balance needs to be considered for the assessment issue which is time and cost effectiveness. Although the linear and the static analysis methods are the easiest ways of the evaluation task, it is a well-known fact that they lead to accumulated errors. On the other hand, there is no doubt for the nonlinear way of thinking and the dynamic analysis methods converge to more realistic results. Recently, nonlinear static pushover method is the most widely preferred way of the seismic assessment and performance evaluation issue. Relative simplicity and fair reliability are the reasons behind the popularity. Despite that existing numerous variation of the method available, force-based single mode pushover analysis is the most applied technique for the regular, low height to mid-height buildings. Time history response analysis is the all-time winner for the structural analysis cluster as it considers the real time equation of the strong ground motion. Unfortunately, its time consuming manner due to the intensive calculations in time domain and related complex and costly nature generally results in that it is not preferred in design practice carried out in regular design offices.

Reinforced concrete (RC) buildings dedicated to public services are generally subjected to intensive superimposed loads and expected to be almost functional and to have limited damage after strong ground motions. Therefore, smaller displacements and drift ratios are expected as a good performance indicator along with the other performance parameters for such buildings as compared to regular residential counterparts. There exist considerable amount of such RC public buildings as well as other aged structures which were constructed before modern building codes. Unfortunately, neither ductile behavior nor adequate structural performance can be obtained from such buildings and immediate measurements need to be taken for them to satisfy the public safety. Once structural performance was assessed using aforementioned analysis methods, most probably the next step will be the action to improve the behavior of the building of which performance level evaluated as not adequate under considered strong ground motion. There exist numerous ways of strengthening techniques for improving the structural performance of RC structures. They classify as two main stream philosophy called member strengthening and system strengthening. If the overall behavior and the drift ratios are in a range of satisfying level, only the member strengthening such as RC jacketing, FRP wrapping, steel encasing or FRP or steel plate implementation to the surfaces could be enough to achieve the desired performance. On the other hand, if the exhibited global behavior may not be as good as at an expected level in terms of either lateral drifts or horizontal displacement, beyond the essential member improvements, then global structural intervention techniques such as RC shear wall addition, diagonal steel bracing inclusion, damper implementation or base isolation utilization need to be used.

Global system interventions are proved as considerably adequate techniques to satisfy the performance objectives for the RC buildings designed according to old seismic codes by not only analytical studies but also through experimental investigations. Conventional RC shear wall addition inside the existing frames is the most popular example for the system strengthening methods (Figure 1a and 1b). However, introducing such rigid RC shear walls to structures as a global intervention leads to increasing the lateral load demand. Consequently, high seismic loads on these additional wall elements always lead