# RECENT SEISMIC RETROFIT TECHNIQUES OF EXISTING RC BUILDINGS IN JAPAN

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***SUMMARY***

*Following the 1995 Hyogoken-nambu Earthquake, seismic evaluation and retrofit of existing buildings designed in accordance with dated seismic codes have been accelerated. This trend caused the increase in number and structural type of buildings to retrofit, and hence structural designers more often find it difficult to retrofit a building using conventional schemes. To solve such problems, both communities of researchers and practitioners in Japan are currently trying to develop new but reliable and cost-effective retrofit techniques, and some of them have been applied to existing buildings. This report will briefly overview techniques for seismic retrofit and their applications in Japan, which were recently developed and applied, or will be applied in the near future*

## 1. INTRODUCTION

The 1995 Hyogoken-nambu Earthquake (Kobe Earthquake) which caused devastating damage to urban centers triggered a new direction in the seismic retrofit of existing vulnerable buildings in Japan. The widespread damage especially to older buildings designed to meet the code criteria of the time of their construction revealed the urgency of implementing retrofit of seismically vulnerable buildings. On December 25, 1995, a new law to promote seismic retrofit of existing buildings was enforced, and retrofit is currently an upsurge among nationwide projects concerning earthquake preparedness planning.

Before the Kobe Earthquake, retrofitted buildings, most of which were schools or governmental offices, were localized in Tokyo Metropolitan Area including Chiba and Kanagawa prefectures, or in Shizuoka prefecture where a large-scale earthquake named "hypothetical Tokai Earthquake" is predicted to occur in the near future from the seismological point of view. Basically conventional retrofit schemes such as installation of new shear walls or steel framed braces into existing frames, and jacketing of existing columns with steel profiles have been applied to them. However, since the new law is applied throughout Japan, covering hospitals, apartment houses, commercial buildings such as hotels, department stores, offices etc. as well as schools and governmental offices, the number of buildings to retrofit is tremendously increasing, causing wider variety of their structural and/or architectural types. This is often resulting in difficulties in their retrofitting with conventional schemes, and development and application of new retrofit schemes are highly desired among practitioners including structural engineers and architectural designers.

For this purpose, both communities of researchers and practitioners in Japan are trying to develop new but reliable and cost-effective techniques which include innovative technologies such as the use of seismic isolation, supplemental energy dissipation, active control, high performance materials etc. to improve the safety of existing seismically vulnerable buildings. The main objective of this report is to briefly overview techniques for seismic retrofit and their applications in Japan, which were recently developed and applied, or will be applied in the near future.

## 2. BASIC CONCEPT FOR SEISMIC RETROFIT AND CONVENTIONAL SCHEMES

It is well accepted that the lateral strength and ductility are most essential factors which govern the seismic performance of a building. Therefore, the following three concepts are recommended for seismic retrofitting of buildings with poor seismic capacity [1,2]. These three concepts are schematically illustrated in Figure 1.

(a) to increase the ultimate strength of overall structure
(b) to improve the deformation capacity, i.e., ductility
(c) combination of (a) and (b)

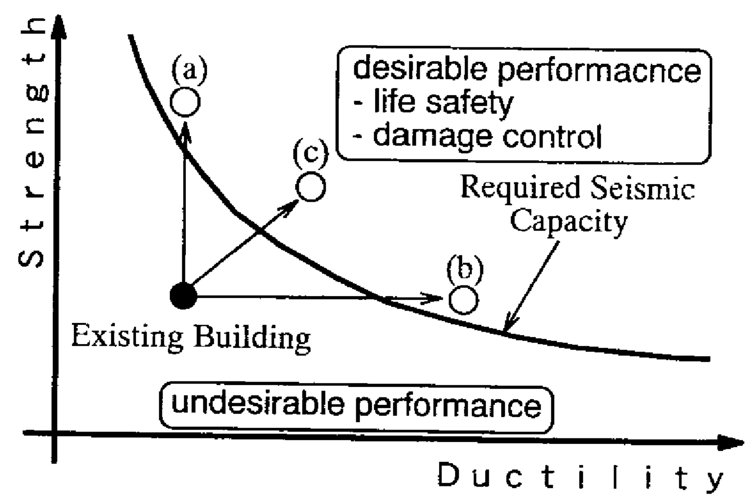


*Figure 1 Basic concept for seismic retrofitting [3]*

The scheme (a) provides strength higher than the original, and hence the seismic response may be smaller than its deformation capacity. As shown in Figures 2 and 3, most typical techniques for scheme (a) include infilling new RC wall or steel framed brace in an existing frame.

The scheme (b) provides larger deformation capacity (ductility) and hence the structural response can be smaller than the deformation capacity. Jacketing of column with steel sections or supplemental reinforced concrete may be the primary technique for scheme (b). Figure 4 shows an example of jacketing technique with steel plates.

The scheme (c) is a combination of the schemes (a) and (b), and both higher strength and deformation capacity are expected.

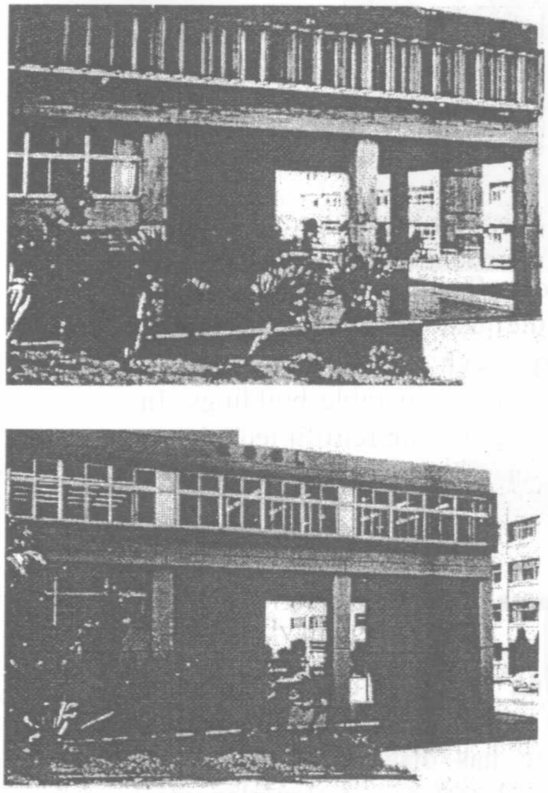

*Figure 2. Retrofit with new shear wall*

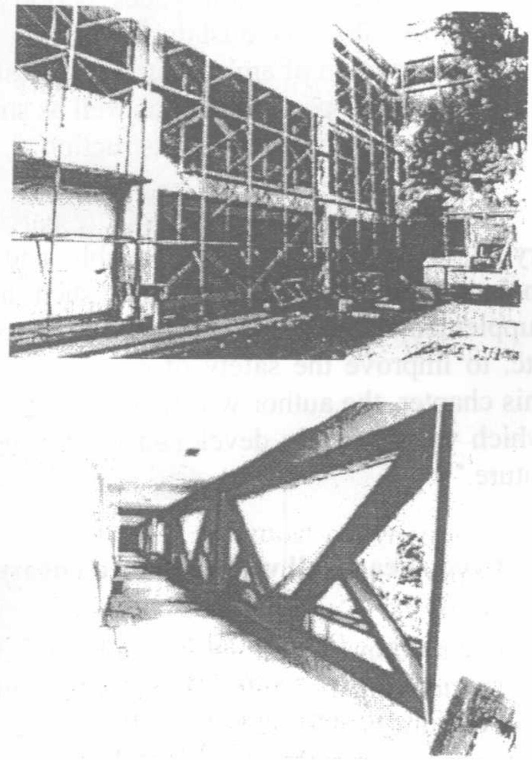

*Figure 3. Retrofit with steel framed brace*

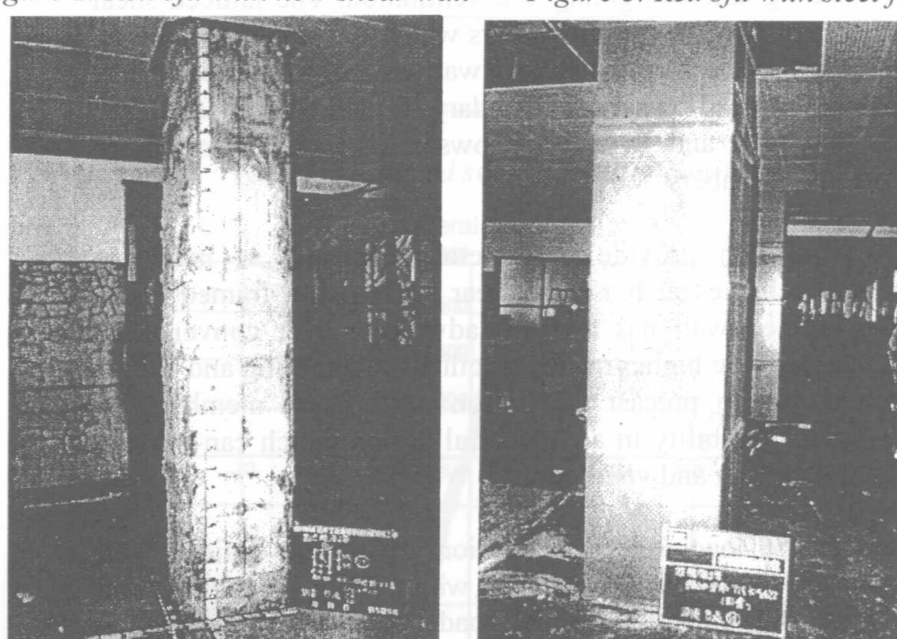

*Figure 4. Jacketing of column with steel plates*