APPLICATIONS OF HYSTERETIC STEEL DAMPERS IN BUILDINGS OF NOVEL FEATURE

JAPAN ASSOCIATION FOR EARTHQUAKE ENGINEERING

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Spectacular Projects of Passively-Controlled Buildings

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1. INTRODUCTION

Opened to the public in March 2000, the Osaka International Convention Centre (OICC) in Nakanoshima, Osaka, Japan, consists of five major facilities in a plot area of 6,756 m2 and a total floor area of 67,545m^2.

2. THE STRUCTURE

The six structural cores at the four corners and the midpoints on the long sides have concrete walls up to the first floor, and above that, the 14m x 12m frame of the superstructure consists of 1.2m x 1.2m steel H-section columns, with flanges and webs up to a maximum thickness of 80mm.

The supertrusses span between the cores in every third level, with intermediate floors either hung or lifted up from them to create column-free spaces in between. The ‘unbonded braces’, developed by Nippon Steel Corporation, are used throughout the structure, which is a system of passive seismic energy absorbing device, providing hysteretic damping and limiting the force levels generated in non-sacrificial structural elements. These braces are used in each of the six structural cores, along with the columns and beams. The cores are also connected to each other by 20m long unbonded-braces that spans over two full stories and provides horizontal resistance.

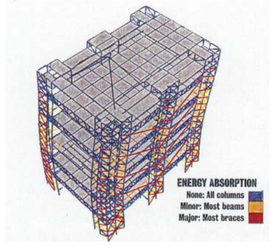



3. SEISMIC PERFORMANCE BASED DESIGN

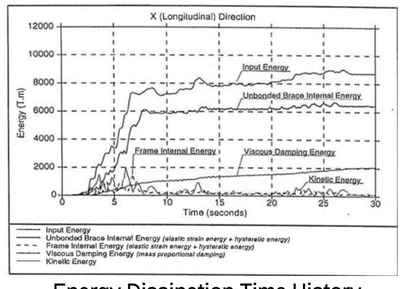
Two seismic events, commonly referred to as ‘Level 1’ and ’Level 2’ must be considered. However, in the aftermath to the damage observed at Kobe, the performance criteria were redefined, together with the inclusion of two additional design events, ’Level 3 earthquake’ and ’active fault effect’.

4. THREE DIMENSIONAL NON-LINEAR FINITE ELEMENT TIME HISTORY ANALYSIS

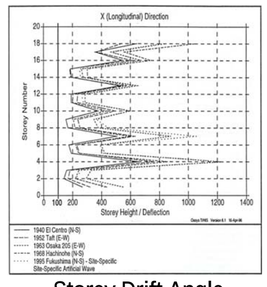
The analysis software LS-DYNA3D was used to perform the three-dimensional finite element time history analyses. Unbonded braces can absorb 75% at longitudinal direction, 45% at transverse direction of the total seismic energy, effectively reducing the energy input to the super frames.



Three Dimensional Analysis Model



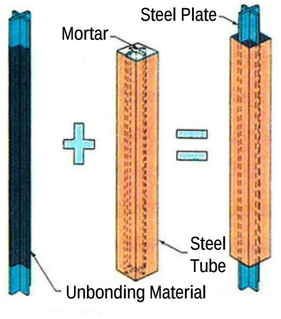
Energy Dissipation Time History



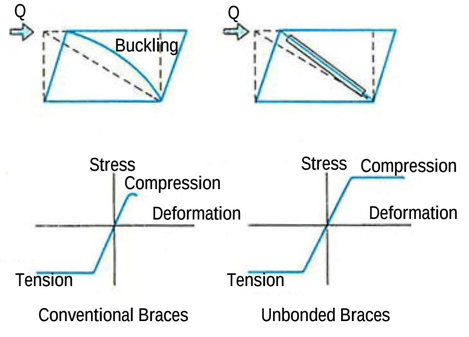
Storey Drift Angle

5. DAMAGE-TOLERANT DESIGN

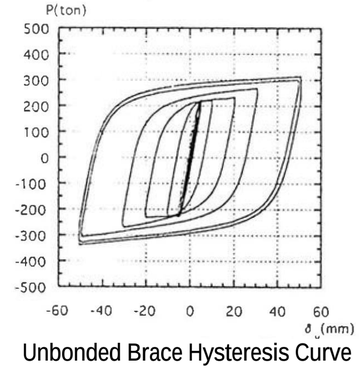
‘Unbonded braces’ are passive devices which absorb seismic energy efficiently during an earthquake. In the ’damage-tolerant approach to design adopted for the OICC, these braces are sacrificial elements designed to leave the rest of the building with little damage from large seismic events.



Unbonded Brace



Conventional Braces Unbonded Braces



Unbonded Brace Hysteresis Curve