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State of the art of buckling-restrained braces in Asia

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Abstract

This paper presents a summary of buckling-restrained braces (BRBs). BRBs show the same load-deformation behavior in both compression and tension and higher energy absorption capacity with easy adjustability of both stiffness and strength. Research and developments of various types of BRBs with different configurations in Asia, especially in Japan, are introduced. Analyses and experiments are illustrated to show the conditions necessary for restraining steel braces from buckling. Some key issues of BRB configurations, such as gap and debonding processing between core braces and encasing members, contraction allowance in BRBs and necessary clearances between restraining panels and surrounding frames, BRB projection stiffening approaches to prevent it from buckling, are also described. Based on initial deflections of core braces, both stiffness and strength requirements of encasing member to prevent buckling of core brace are given. Applications for both new high-rise steel buildings and the seismic retrofit of existing buildings show good prospects of using BRBs.

Keywords: Steel frame; Buckling; Buckling-restrained braces; Cyclic loading test; Damper; Hysteretic behavior

1. Introduction

Lateral displacements on structural buildings have been of great concern for engineers. In order to minimize the effect of earthquake and wind forces braces have been used successfully. However, when the braces are subjected to large compressive forces they

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Notation

A	Cross-sectional area
E	Modulus of elasticity
E_s	Modulus of elasticity of core brace
l	Length
l_t	Length of square steel tube
I	Moment of inertia
I_s	Moment of inertia of core brace
I_k	Moment of inertia of steel square tube
I_c	Moment of inertia of encasing concrete member
k	Coefficient
p	Distributed load per unit length
D	Depth of steel square tube
M	Moment
M_y	Yielding bending moment
M_C^B	Bending moment of encasing member
M_y^B	Yielding bending moment of encasing member
m_y^B	Nondimensional bending moment
N	Axial force
N_y	Yielding strength of core brace
N_B^E	Euler load of encasing member
N_{cr}	Euler load
n_E^B	Nondimensional axial force
R	Reaction
s	Size of gap between core brace and encasing member
v	Deflection, deformation
v_0	Initial deflection
α	Initial deflection in the midlength; or resistant coefficient
σ_k	Extreme stress of square steel tube
σ_{ky}	Yielding stress of square steel tube
δ	Deflection in the midlength

exhibit buckling deformation and show unsymmetrical hysteretic behavior in tension and compression, and typically exhibit substantial strength deterioration when loaded monotonically in compression or cyclically, as shown in Fig. 1(a). If buckling of a steel brace is restrained and the same strength is ensured both in tension and compression,