Development of DYNA-FRAME with Steel Damper at the Bottom Flange of Beam-End for Passive Response-Controlled Structures

1. Introduction

In the world of architectural structures, the concept of passive response-controlled structures having good earthquake resistance has become widespread. Since the Great Hanshin-Awaji earthquake, in particular, earthquake risks have become more widely recognized. These risks include not only the loss of life caused by the damage or collapse of buildings, but also the loss of property and the dysfunction of buildings. Passive response-controlled structures are those in which the building frame is divided into two parts-one part supporting the building and the other absorbing the shock of an earthquake, or seismic energy-by providing the building with a damper, such as an unbonded brace, so as to improve the earthquake resistance of the building. The salient characteristic of such structures is that the damper reduces the shock of an earthquake.

Many conventional buildings are designed so that the ends of the beams at the column-beam joints are allowed to deform (become plastic) first in the event of a large earthquake. After the massive earthquake of Hanshin-Awaji, it was confirmed that many of the damaged buildings had collapsed at the column-beam joints. It has been pointed out that the quality control of welding in those days may have been insufficient (see **Fig. 1**). It should be noted that even buildings with passive, response-controlled structures are ultimately designed such that the beam ends become plastic first. Thus, the building is not completely free of damage during a big earthquake.

However, a DYNA-FRAME restrains the shock of an earthquake and efficiently and effectively prevents damage to the structure by means of a damper installed at the end of each beam, which would otherwise be damaged in a big earthquake.

2. Characteristics

There are two types of dampers that can be installed to beam ends (see **Fig. 2**). They are the plastic split-tee (ST) type and the plastic splice plate (SP-PL) type. The former employs a bolt joint in place of a welded joint at the beam end, and the latter employs a splice plate which is made of plastic by the conventional bracket joint. In particular, when columns of concrete-filled tubes (CFT) are adopted for a high-rise building, the plastic SP-PL type is necessary because the plastic ST type damper with bolt joints cannot be replaced with a new one once it is damaged by an earthquake. The major features of DYNA-FRAME are as follows.

1) When installed to beam ends that tend to buckle comparatively easily, DYNA-FRAME reduces the damage to the beam in an earthquake since the damage caused by the earthquake is concentrated on the beam-end damper.
2) Even after a big earthquake, the main structure can continue to be used safely by replacing the beam-end dampers and vibration-resisting devices with new ones. Thus, DYNA-FRAME helps prolong the life of the main structure.
3) DYNA-FRAME can be installed even to those parts where the building plan does not permit using a brace or stud-type damper. With DYNA-FRAME, there is no need for concern about the space for installation.

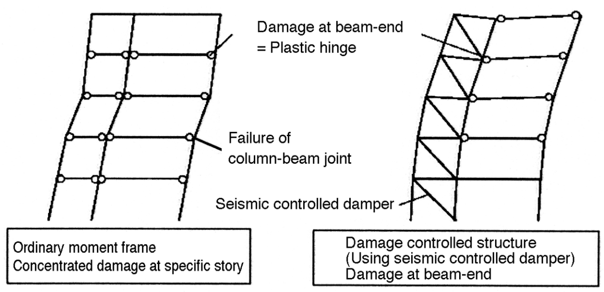

Fig. 1 Ordinary steel frame

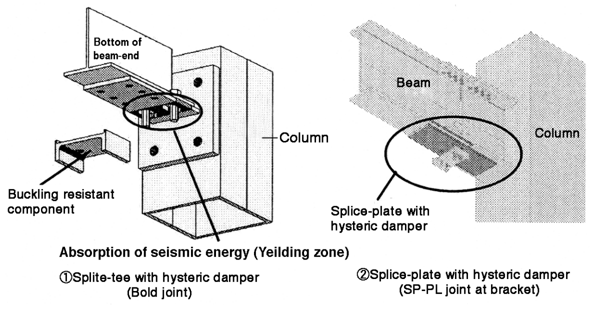

Fig. 2 Composition of Dyna-frame

3. Application Example

The beam-end damper is installed to the end of each short-span beam because the beam end is subject to a large moment. For a long-span beam subject to a small moment, a frame with conventional joints is made to play the role of an elastic frame (see **Figs. 3** and **4**).

An 11-storied building of steel frame construction in Shibuya, Tokyo is equipped with DYNA-FRAME.

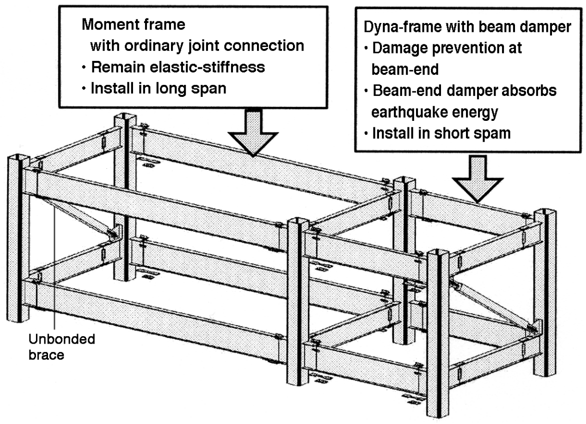

Fig. 3 Application for Dyne-frame structure

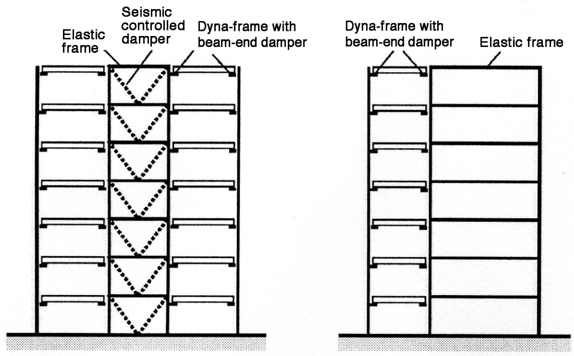

Fig. 4 Concrete example

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