SOME ANALYSES ON MECHANISMS TO DECREASE EARTHQUAKE EFFECTS TO BUILDING STRUCTURES (PART 7, STEEL DAMPERS FOR TALL BUILDINGS)

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SUMMARY

Dampers made of steel coils and pipes were invented and installed in high rised steel buildings. The dampers show good capacity of energy absorption with their spindle-shaped force-deformation diagrams in low cycle fatigue tests.

Response calculations show that installation of the dampers decreases shearing stresses as much as 25% compared to those without the dampers.

Coil dampers are to be inserted between columns, beams and walls, while pipe dampers are to be used as connecters of precast RC walls to steel frames.

BACKGROUND

There are two fundamental directions in aseismic design of building-structures; to increase strength of structures and to decrease earthquake effects on structures. Authors have published research works [1)∿6)] on the latter and have reported the various types of mechanisms which improve dynamic characteristics of structures and decrease the seismic loads on them. They can be classified into two groups such as mechanisms to varify the natural frequencies of the structures and those to increase their damping-capacities.

Dampers installed in buildings for absorption of energy in strong earthquakes should be reasonable in both initial and maintenance costs with no or small decay of the capacities for the life of the buildings.
To satisfy the above mentioned conditions, the authors invented steel dampers; dampers to absorb energy with plastic hysteresis of the steel.

SHAPES OF DAMPERS

In order to have damping effects for even small dynamic behaviour of buildings, shapes of dampers are so designed that they may start yielding to the smallest deflection. Short bent beams, S-shaped beams, rings, coils and pipes were designed (Fig.2.1) and checked and some of the test-results were reported[6)]. Of these designs steel coil dampers were used in a high rised building, an eighteen storied SRC building (Fig.2.2) and pipe dampers are to be installed in a steel building (S and SRC of twenty one stories with a penthouse, Fig.2.3).

LOW CYCLE FATIGUE TESTS

Through dynamic fatigue tests, the energy absorbing capacities were checked and some improvements on the mechanisms were made and re-tested.

Coil dampers directly welded to plates have good spindle-shaped force-

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deformation (P-δ) hysteresis but the welded parts suffer big stresses and breaks take place at the welds (Fig.3.1, 3.2).

Pipe dampers connected to plates with highly tensioned bolts have superior characteristics to coil dampers except that they are available only to wall-connections where the main directions are in a plane. Trials to increase ductility of the damper against cyclic loading were successful through shifting bent parts by plural supporters of the pipe. But even a single-support type is ductile enough as it is changable to a new one after a strong earthquake (Fig.3.3 to 6). Besides, it is much reasonable in the price.

RESPONSE CALCULATION

Comparisons were made in the earthquake responses between those of structures with and without dampers. Coil-dampers were inserted in a double column system which was provided only at the basement of an eighteen storied SRC building. In the double column system, inner columns are made of steel tubes filled with concrete and outer ones are of heavy RC and are connected to thick RC walls of the floor. All of the weight of the upper stories are supported by the inner columns, while horizontal loads are resisted by both inner and outer columns which are indirectly connected with coil dampers and are separated with plastic cushions (Fig.4.1). The results of the computations are shown in Fig.4.2 and 3. On the other hand, pipe dampers are to be distributed to almost all stories of a building at the connections of PC walls to the steel frames. As the maximum force that can be transfered through the damper is cleary fixed, they are also available at the connection of PC curtain walls to the frames. This means, outer curtain walls, which are usually tied with loose-connections so that they may follow a big deformation of the structure and are considered only to be dead loads, can contribute to the total stiffness and strength of the structures. They especially increase the resistibility against torsional motions. Computed response are illustrated in Fig.4.4 and 5.

CONCLUSIONS

Installation of dampers to building-structures are very effective to calm their responses to strong earthquakes. Proposed steel coil and pipe-dampers show good characteristics such as:

i) they are cheap and give small effects to the cost of buildings,
ii) they require no maintenance-costs,
iii) they are renewable after strong earthquakes,
iv) they have good capacities of energy-absorption,
v) they decrease the maximum values of response; Comparisons in sample response calculations show around 25% decrease of the shearing forces.
vi) except the dampers, most of the structural members including RC walls can remain in elastic range against strong earthquakes, and reparation costs are expected to be reasonable,
v) pipe dampers improve the resistibility of buildings against torsional motions.

ACKNOWLEDGEMENT

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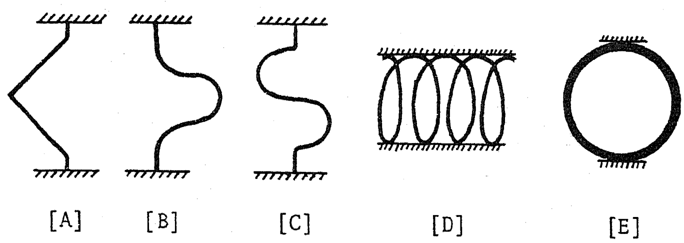


Fig 2-1 Various Types of Steel Dampers

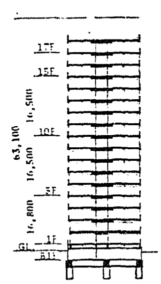


Fig. 2-2 SRC-18 Stories

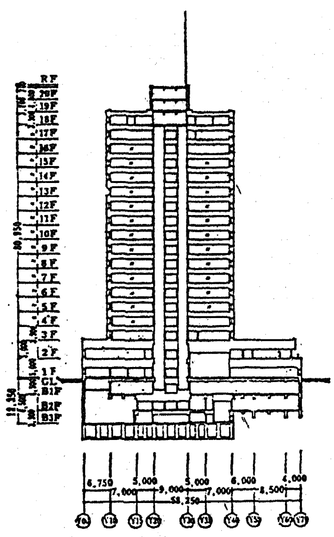


Fig. 2-3 S&SRC-20 Stories

Fig. 3-1

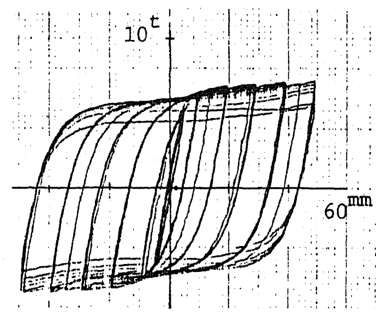


Fig. 3-2

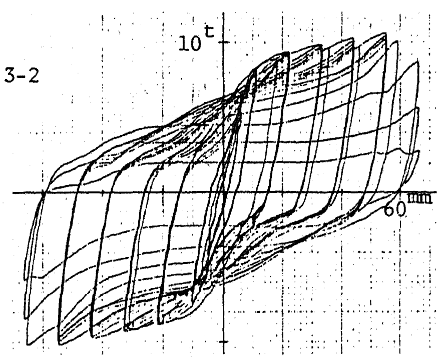


Fig. 3-3

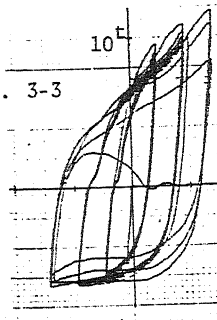


Fig. 3-4

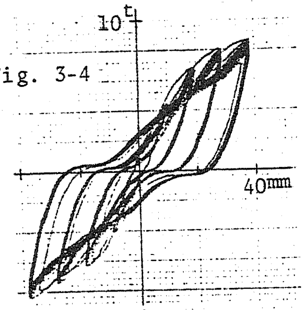


Fig. 3-5

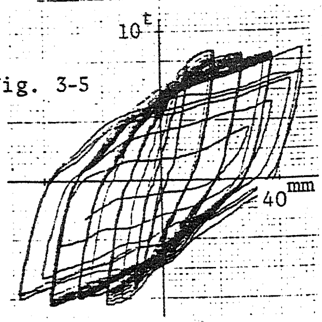
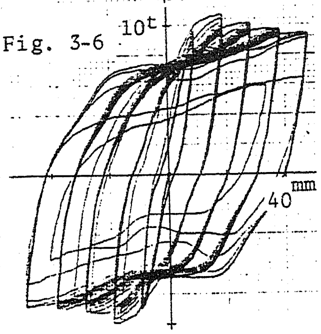


Fig. 3-6



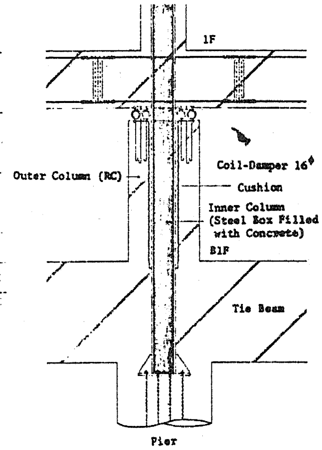


Fig. 4-1 Double Column System in Detail

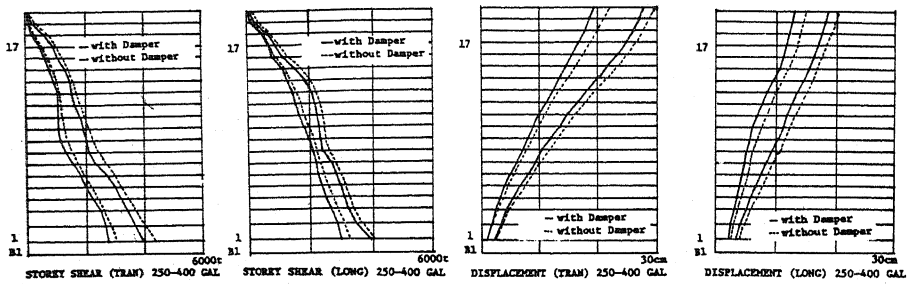


Fig. 4-2&3 Comparison of Behav. of 18-SRC With & Without Dampers

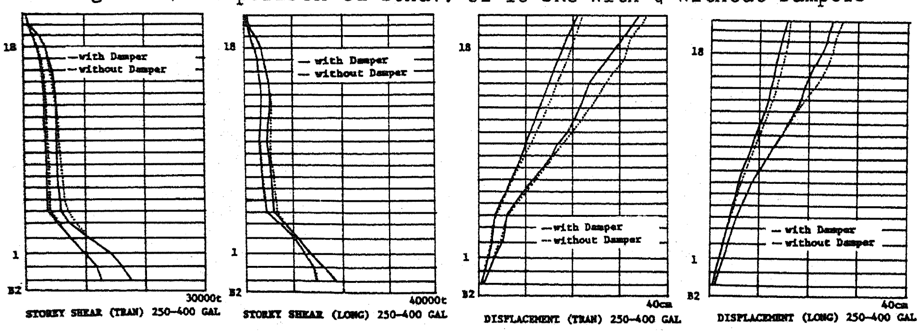


Fig. 4-4&5 Comparison of Behav. of 20-S&SRC With & Without Dampers