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Theoretical and Experimental Study of Parameters Influencing the Buckling Behavior of the Drawer Bracing System

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ABSTRACT: The researches show that the buckling of braced frame, remarkably decrease the ductility and energy absorption of the system which lead to use an innovative system called “Drawer Bracing System (DBS)”. This innovative system improve the seismic performance of the system through buckling elimination. The Drawer Bracing System (DBS) is a passive energy dissipation device made up of three parallel plates that are connected by some plates which are located at a right angle to the parallel plates and undergo minor axis bending. Energy dissipated through the inelastic behavior of these plates. The parallel plates are designed to remain elastic and to prepare the required strength and stiffness to transfer the load to the energy dissipating component of the system. In contrast to other bracing systems, removing destructive effects of buckling phenomenon is the main advantage of this system. The energy is dissipated with the use of sliding movement of its components. In this paper, the tests are carried out by the authors explain. Besides this, analytical investigation is made and the parameters which affect the buckling behavior of the system are evaluated. The results show that the buckling strength of the system is 3 percent higher and 17 percent lower than the ultimate strength of DBS in tests 1 and 2, respectively. Thus, to prevent the occurrence of buckling in the system, the buckling strength of the parallel plates should be selected larger than the ultimate strength of the system with keeping it safe margin.

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1- Introduction

The Drawer Bracing system (DBS) is a new hysteretic energy dissipating device that can be used to enhance the seismic performance of bracing members. In comparison to other bracing systems, buckling elimination is the main advantage of such system.

The hysteretic behavior of typical braced frames was studied before by many research groups such as Goggins et al. (2006) [1], Shaback and Brown (2003) [2], Elchalakani et al. (2003) [3], Boutros (1999) [4]. The effects of slenderness ratio, boundary conditions, connections, width to thickness ratio and section properties, on the seismic performance of the system were studied by these researchers. They conclude that the main cause of fracture in a bracing members, which remarkably decreases ductility of the system, is buckling, formation of plastic hinges and propagation of local buckling at these regions, respectively. The fracture of the system occurs after a few cycles of formation of this phenomenon.

In the present paper, the analytical and experimental study of parameters influencing the buckling behavior of the drawer bracing system is investigated. The results show that the buckling strength of the parallel plates should be selected larger than the ultimate strength of the system with keeping it safe margin to prevent the occurrence of overall buckling.

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2- Theoretical and Experimental Study of Buckling Behavior of The Drawer Bracing System

In the drawer bracing system, the system is composed of three parallel plates that are connected via energy dissipating plates at a right angle. Seismic energy is dissipated through the formation of flexural plastic hinges at its both ends (Figure 1).

As shown in Figure 1, the dissipating elements are placed from their minor axis in the system. The parallel plates should be designed to remain elastic and to prepare the required strength and stiffness to transfer the load to the energy dissipating component of the system. Height, width, thickness and the number of energy dissipating elements can be varied to reach the desired strength and stiffness. In contrast to other bracing systems, converting the brittle behavior of buckling to ductile behavior, is the main advantage of this system.

In this research, two half-scale DBS component are tested under cyclic load. The effect of height variation is investigated through these tests. Lower grade steel is used for energy absorbing elements to increase ductility and energy absorption of the system.

The slow cyclic test is used for its simplicity, affordability and getting basic information about the strength, stiffness, deformation capacities, cyclic softening or hardening effects and to assess the seismic performance of the system.

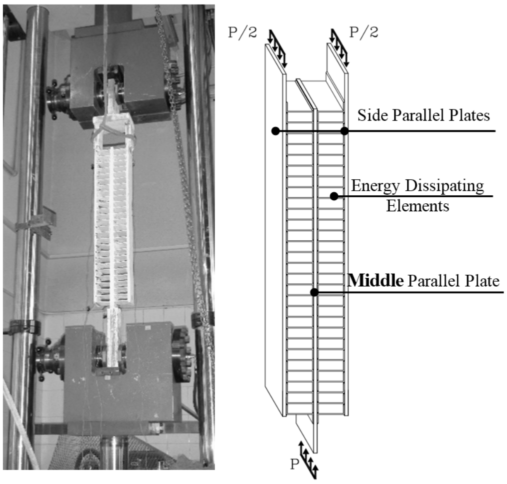

Figure 1. Drawer Bracing System

Excessive generation of residual stresses is reduced by using energy dissipating elements in Z-shaped form and the space between them is filled with only one pass groove weld. The results showed that in the final cycles, system with lesser height, is on the verge of buckling instability. Failure of energy dissipating plates and formation of plastic hinges at its both ends were the reasons to stop testing.

According to derived hysteretic loops of tested specimens, it be concluded that the ductility of the proposed system is substantial and during an earthquake, the system dissipates large amount of energy.

Besides doing an experimental study, theoretical studies are developed either and the parameters which affect the buckling behavior of the system are determined. The results show that to prevent the occurrence of overall buckling in the system, the buckling strength of the parallel plates should be selected larger than the ultimate strength of the system with keeping it safe margin.

3- Conclusions

The results show that:

- In compliance with the design guidelines discussed in the article, the occurrence of any local and overall in-plane buckling of the DBS is prevented. The energy absorption capability of the system is enhanced significantly.
- The stability requirement for bracing of the parallel plates is provided by the energy-absorber plates. In other words, these plates always provide the minimum required strength and stiffness to stabilize individual parallel plates.
- Energy-absorber plates have an indirect role in determining of critical buckling load of the DBS. The role of these plates is to provide the bracing for the parallel plates and to provide the required ultimate strength for the system, which should be less than the critical buckling load of the system.
- To prevent systems overall buckling these three limitations should be considered for safe structural design:

o The maximum lateral deformation of system has to be restricted to the region with compress normal stress to avoid destructive P-delta effects.

o The total stiffness of the energy-absorbing elements should be lesser than the shear stiffness of the web plate regarding opening in it.

o The ultimate buckling strength of the system has to be lesser than the summation of critical buckling load of each parallel plate.

- Properly designed system can ensure that the occurrence of buckling in the system is prevented and sliding movement of the system guaranteed.
- In the drawer bracing members, the dissipating elements almost always provide the required strength and stiffness for lateral supporting the parallel plats and they have no effect on the critical buckling strength of the drawer bracing system. The critical buckling load is derived by using the dimensions of parallel plates. The effects of dissipating elements reflected in determining the ultimate strength of the system.

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