8th International Conference on Seismology & Earthquake Engineering
11-13 Nov. 2019, Tehran, Iran

A NEW REPAIRABLE CONCENTRIC BRACE WITH DUAL-PERFORMANCE

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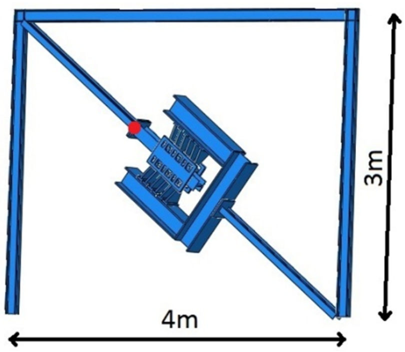
Keywords: Repairable, Dual-performance, Concentric brace, Yielding plates, Finite element method

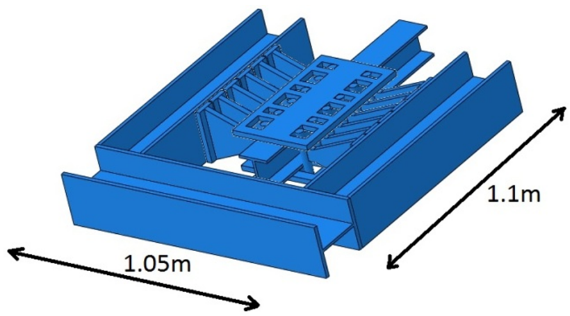
Due to considerable damages of the infrastructures caused by earthquakes and following high-cost reconstructions, the design and utilization of the repairable structures have been intensified recently.

In designing the repairable structures, a serious concern is that most of the structural systems use only single-performance fuse elements, and they, inevitably, are designed for the largest possible earthquakes. Consequently, for moderate earthquakes, the considerable damages of other structural members are very likely (Hosseini Hashemi & Alirezaei, 2015; Hosseini Hashemi & Moaddab, 2017; Zahrai & Vosooq, 2013). From another point of view, when an earthquake happens, seismic demand at the beginning moments is not high. Therefore, the activation of the highest available stiffness is not required and is not recommended. The main reason is that higher stiffness results in higher subsequent demand. Not addressing this issue is one of the major drawbacks of the single-performance systems.

In this regard, in current paper, a dual-performance repairable concentric brace is introduced (Figure 1). In this brace, upon the beginning of earthquake the first series of yielding plates (that are parts intended to absorb energy and are intentionally designed to be damaged by the earthquake force to protect main parts and to avoid their damage) react against the imposed forces and start to absorb energy, while the second series of plates are still inactive. If the displacement (drift) caused by the earthquake becomes greater than a certain amount, the second series of yielding plates will be activated too. In other words, the activated stiffness of the structure increases when the demand increases. Therefore, using the proposed system, for all levels of seismicity, a very well energy absorption is provided and intended structural elements will be protected. The yielding plates are easily replaceable and the structures can be repaired immediately.



a)



b)

Figure 1. a) A schematic of the proposed dual-performance repairable concentric brace, b) The detail view of dissipater part.

To evaluate the performance of proposed system, its finite element model is developed and analyzed (by use of ABAQUS CAE software). SAC cyclic loading protocol is used for obtaining hysteretic behavior of the proposed brace. Figure 2 shows this behavior based on the results of the numerical modelling. The jointing point of dissipater part and brace (indicated with a red spot in Figure 1) has been selected for derivation of the hysteresis curve. As the figure clearly depicts, the proposed brace is able to efficiently absorb energy at two levels of performance. According to the figure, there are four different slopes or two different trends for stiffness. First trend is the stiffness of the system resulted from elastic and following plastic deformation of the first level plates (center area of the figure) which is related to the beginning of loading protocol when the demand is low. The second trend is the result of the elastic and plastic reaction of the second level plates which follow the first level when the demand is high (lateral area of the figure). After a reduction in first level stiffness resulted from plastic deformation of the first level plates, an increase in stiffness happens due to the activation of the second level plates. Also, according to the finite element analysis, only the yielding plates experience plastic deformation and other elements are protected from permanent deformation and operate safely in the elastic region.

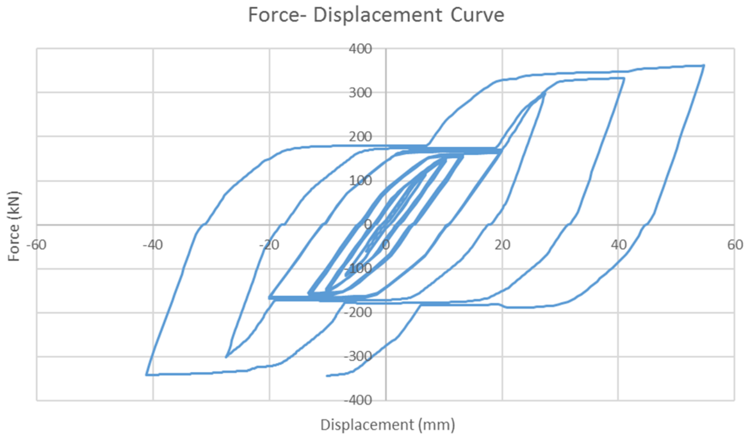


Figure 2. Hysteretic behavior of the proposed brace.

To conclude, the results of finite element analysis verify the proposed system acts in two levels of performance, all desired elements including force-control elements are protected from damage, energy absorption are more evenly distributed in all stories, the stiffness of the structure follows the seismic demand, only yielding plates experienced plastic deformation, and by replacement of the yielding plates the reparability objective is met.

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