Experimental Testing of Double Acting Ring Springs Type II

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Introduction

Double acting systems are being developed to accommodate upward and downward movements during severe earthquakes in centralised rocking concentrically braced frames (Figure 1a) The systems utilise Ringfeder®, a compression only friction ring spring (Figure 1b), which is designed to work as a double acting spring. The spring dissipates energy through frictions between inner and outer rings and provides self-centring afterwards.

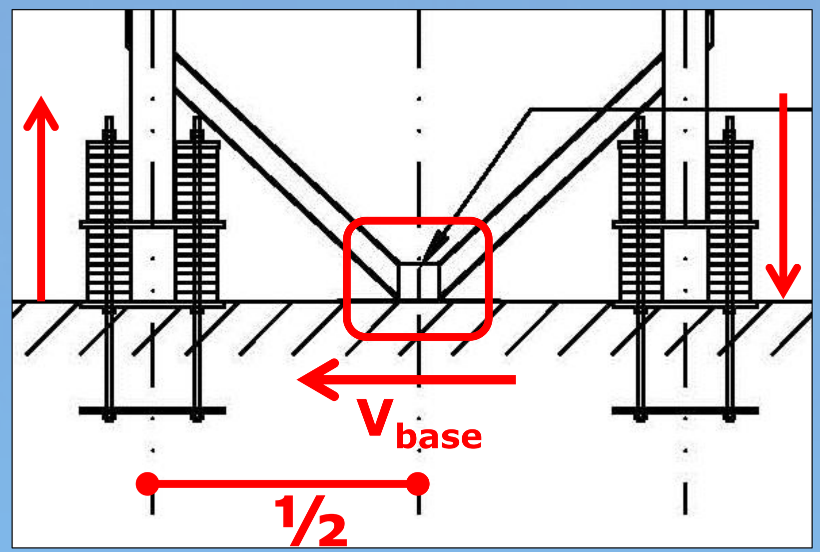

Figure 1. Design Concept
a) Centralised Rocking CBF; b) Ring Springs

Double Acting Ring Springs

Two designs of double acting ring springs systems have been developed and experimentally tested. Double acting ring springs type I (Figure 2a) have parallelogram hysteresis curves and double acting ring springs type II (Figure 2b) have flag-shaped hysteresis curves. Both of them showed stable and repeatable hysteresis loops at any loading rates [1,2].

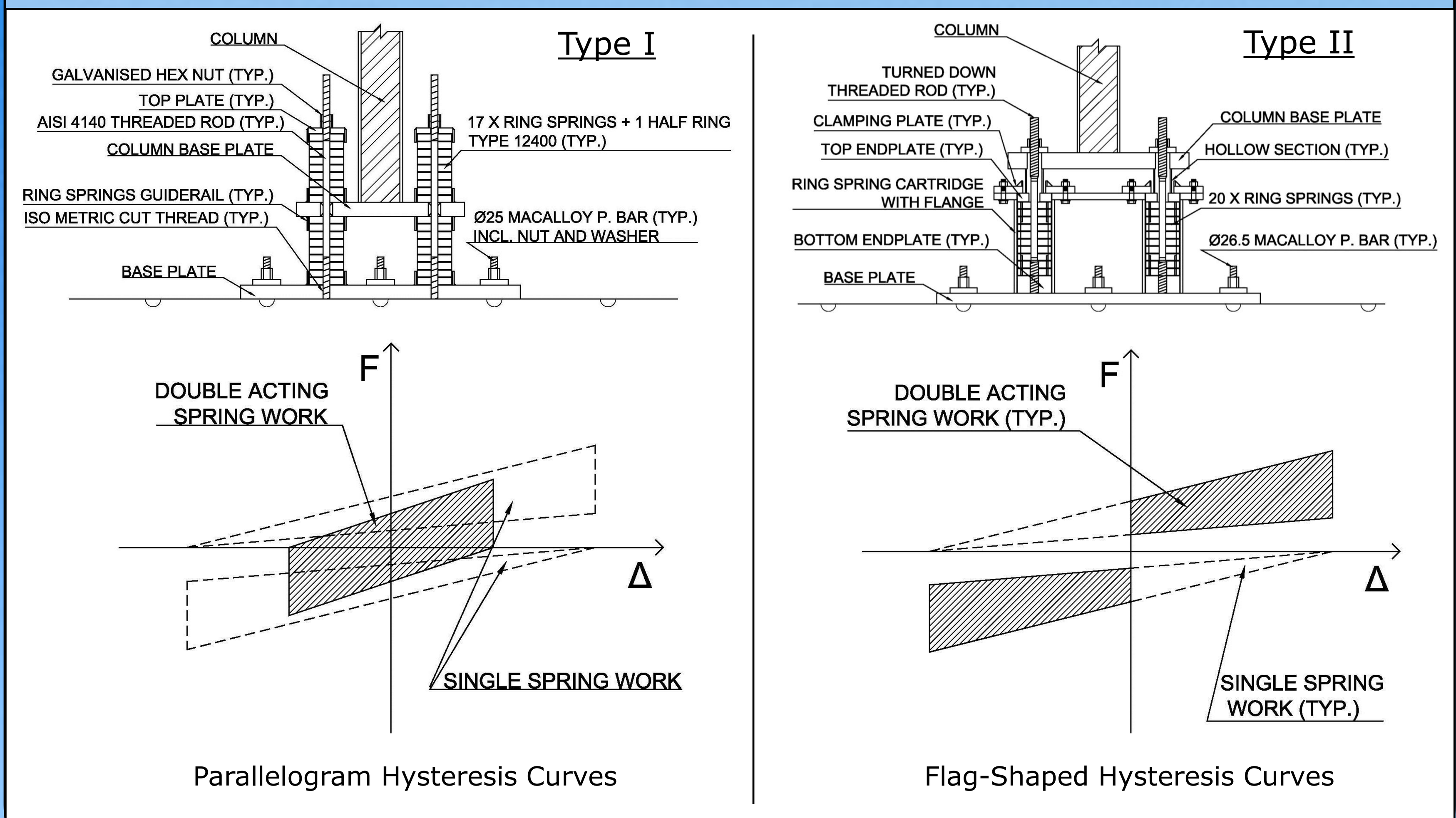

Figure 2. Double Acting Ring Springs Designs
a) Type I; b) Type II

Double Acting Ring Springs Type II Design

A stack of ring spring with end plates at both ends is placed inside a steel cartridge. A machined down threaded rod is centrally passed through the ring spring and top end plate and then the rod is fastened to connect between a column base plate and a bottom end plate. Then, it is sealed with a clamping plate which is bolted to the flanges of the cartridge (Figure 3a). Column base plate with a hollow section is free to uplift. Hence, this system is able to resist both compression and tension with the same stack of ring spring. In compression, the column base plate moves downward and compresses the ring spring through the top end plate (Figure 3b). In tension, the ring spring is lifted up in compression by the bottom end plate and the threaded rod which is connected to the column base plate moving upward (Figure 3c).

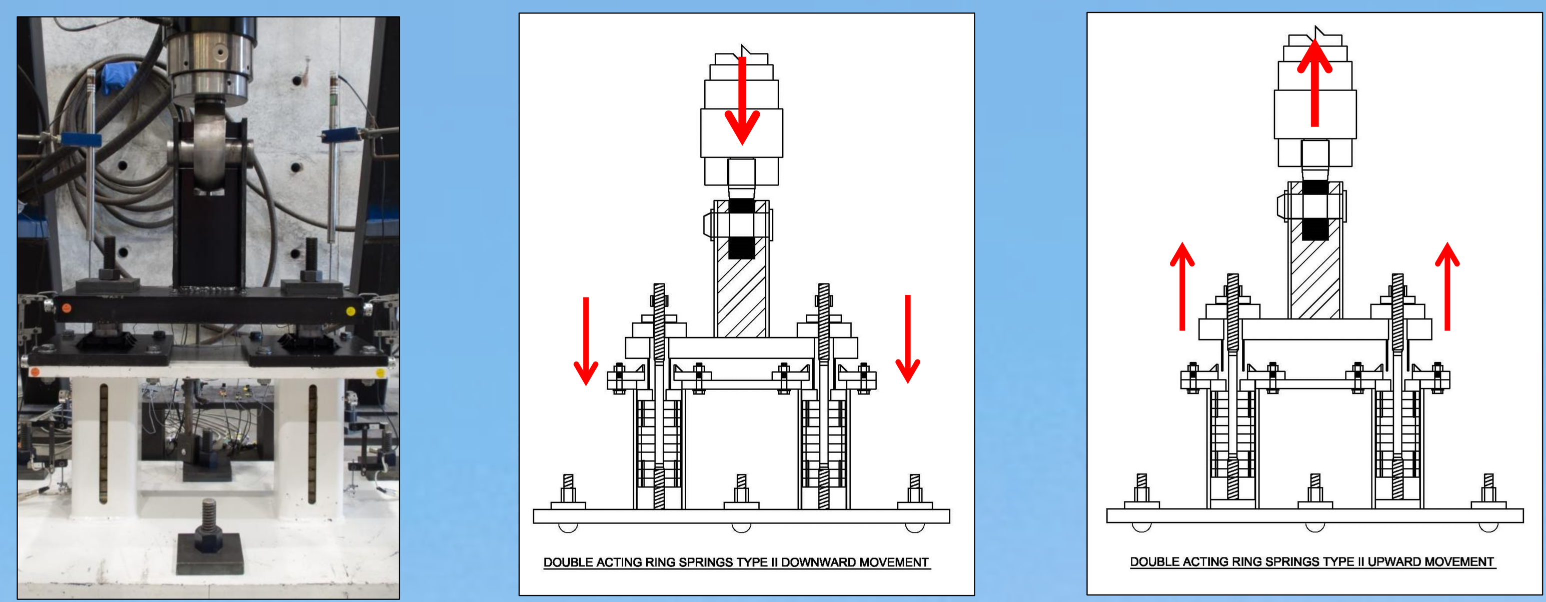

Figure 3. Double Acting Ring Springs Type II
a) Finished Assemblage; b) Downward Movement; c) Upward Movement

As the original ring spring work is a linear triangular hysteresis curve, the height of the cartridge is used to define the prestressing force by measuring the spring displacement. In this system, the ring spring is compressed to 50% of the total spring travel which gives a level of prestressed force at 50% of the ring spring capacity. The threaded rod is designed as a replaceable fuse (Figure 4) which yields after the maximum ring spring capacity is reached during upward movement. During downward movement, the column base plate is designed to yield.

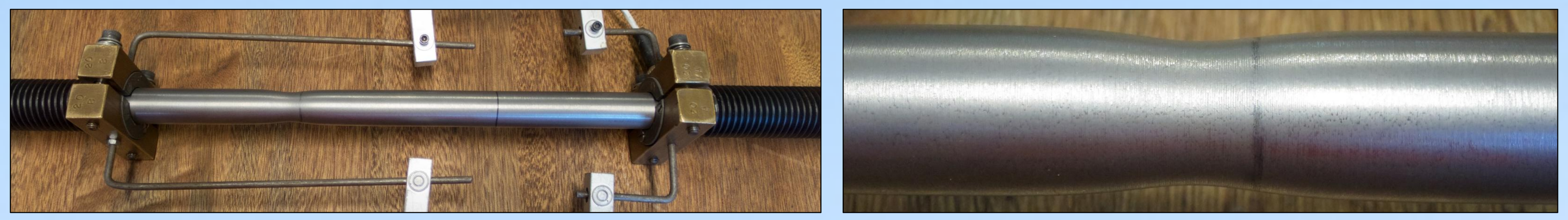

Figure 4. Machined Down Threaded Rod
a) Yielded Threaded Rod; b) Yielding Region

Test Results

Experimental testing of double acting ring springs type II have been carried out to observe the hysteresis curves, the initial force to initiate elastic spring of the system, the behaviour of the system after it is locked up, and the self-centring capability. The loading protocols used in this experimental testing and the test results are shown in Figure 5.

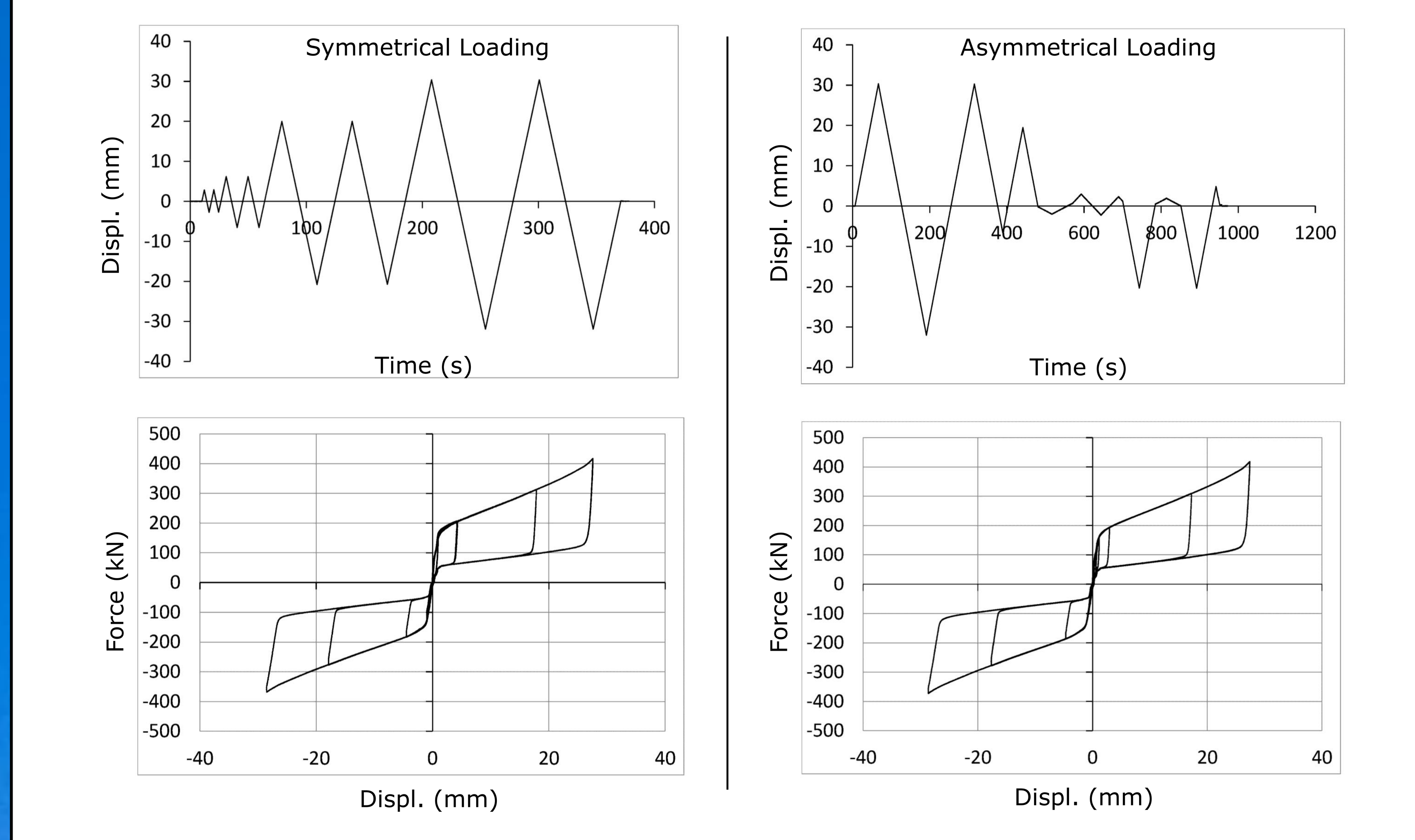

Figure 5. Loading Protocols and Hysteresis Curves
a)Symmetrical Loading; b) Asymmetrical Loading

Conclusion

Double acting ring springs type II which was loaded with symmetrical and asymmetrical loading with a range of loading rates from 0.05mm/s to 1.34 mm/s showed stable and repeatable flag-shaped hysteresis curves. It also returned to the original position after unloading. The test results showed good agreement to the spring manual calculation.

References

[1] Filiatrault A, Tremblay R, Kar R, "Performance evaluation of friction spring seismic damper", *Journal of Structural Engineering*, 126:491-499, 2000.

[2] Khoo HH, "Development of the low damage self-centring sliding hinge joint", *PhD Thesis, University of Auckland*, New Zealand, 2012.

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