Recent Developments of the Resilient Slip Friction Joint (RSFJ) Technology for Seismic Proofing New and Existing Buildings

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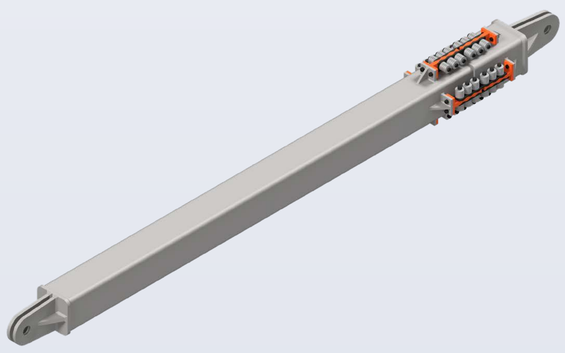
INTRODUCTION

The innovative Resilient Slip Friction Joint (RSFJ) technology has recently been introduced to the NZ construction industry. This damage avoidance technology not only provides life safety, but also minimizes the earthquake-induced damage so that the building can be reoccupied quickly. The RSFJ is a friction-based damping device with a special configuration that can produce a flag-shape hysteresis. It provides the required seismic performance regardless of the material used for the main structural components. It can be used in various applications including (but are not limited to) shear walls, tension-compression braces, tension-only braces and moment resisting frames. The philosophy of design is that the inelastic behavior of the structure is provided by the RSFJs and the rest of the structural members remain elastic. This study reports on the latest development of this technology including the analysis and design procedure.

RSFJ BRACE AND RSFJ TBRACE

As shown in Figure 1, The RSFJ brace includes RSFJs acting in tension and compression (providing energy dissipation and self-centring) attached to a conventional timber/steel section. The brace can be connected to the frame structure using the conventional solutions such as pinned, welded or bolted connections. The telescopic mechanism of the steel sections or tubes provides the required stability.



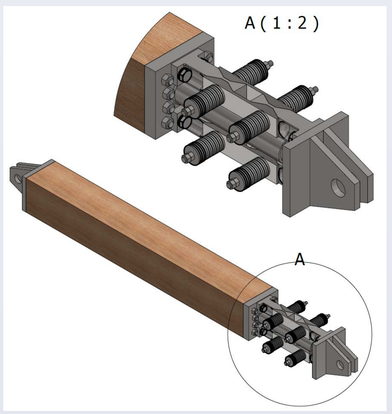


Figure 1. The RSFJ Brace

Figure 2 shows the RSFJ Tbrace concept where the RSFJ diagonal braces only work in tension so there will be no global buckling in the system. Rebars, Reidbars or rods can be used for the diagonal members resulting in an economical system which is very efficient for long-span applications and also for retrofitting the existing buildings.

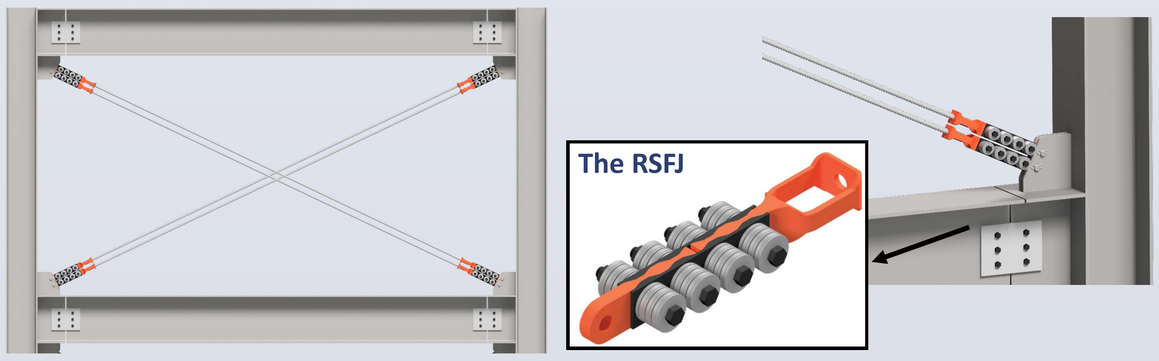
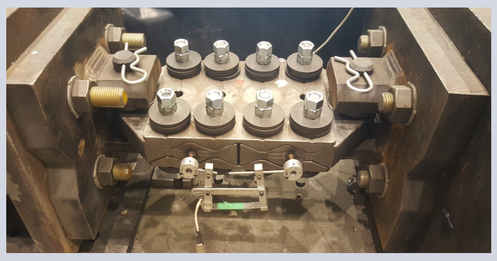


Figure 2. The RSFJ TBrace

COLLAPSE-PREVENTION SECONDARY FUSE

with the aim of collapse prevention in cases that the applied loads are larger than the design earthquake loads, a secondary fuse in the body of the RSFJ is considered. When the RSFJ reaches its maximum capacity and the ridges are locked, the clamping bolts (or rods) start to yield. The plastic elongation of the bolts provides additional travel distance for the joint allowing it to maintain a ductile behavior up to and even more than the collapse limit state of the structure (Figure 3). The stiffness of the RSFJ after the secondary fuse is activated can be specified with the equation below. The accuracy of this formula is verified by the experimental results.

$$k_{RSFJ,fuse} = 2k_{fuse,plastic}\left(\frac{sin^2\theta + \mu_s sin\theta cos\theta}{cos^2\theta - \mu_s sin\theta cos\theta}\right)$$



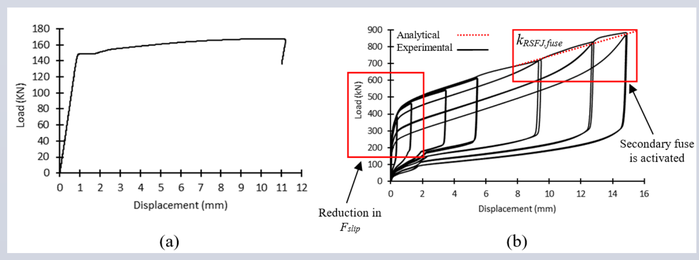


Figure 3. The Collapse-Prevention Secondary Fuse

PROPOSED DESIGN AND ANALYSIS PROCEDURE WITH EXAMPLE

The analysis and design procedures outlined here are recommended when using the RSFJ technology in structures. Iterations may be required to achieve the optimum design. In the left procedure, a non-linear time-history analysis is not required but the ductility factor used is limited to 2. In the right procedure, verification of the assumed μ is carried out through a non-linear time history analysis hence the ductility values are not limited.

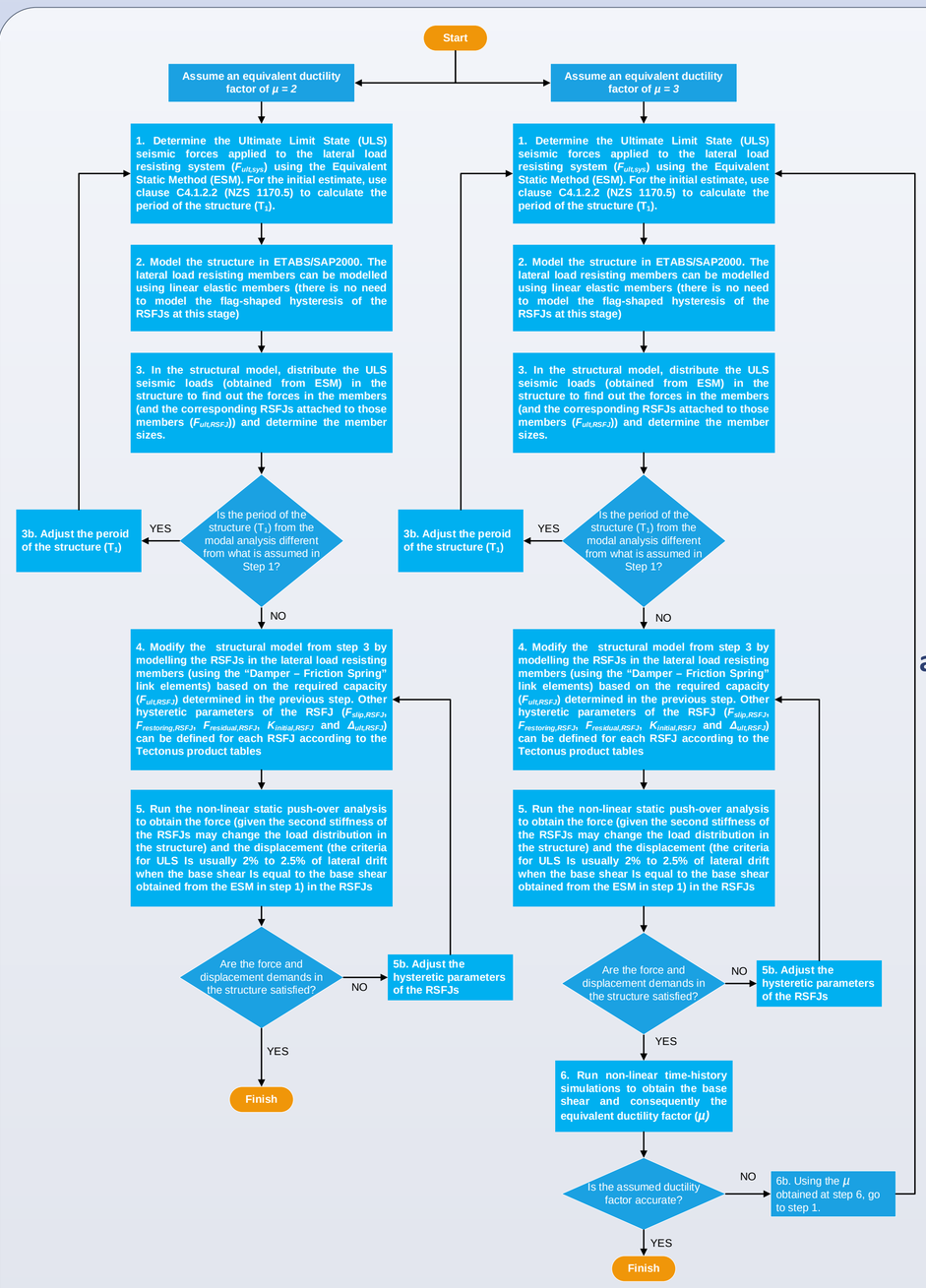
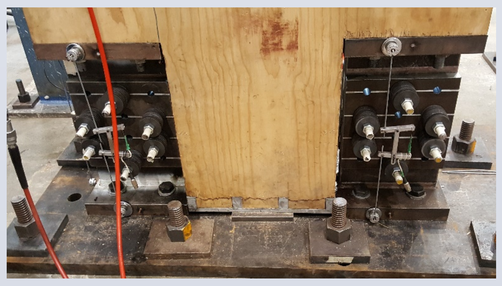


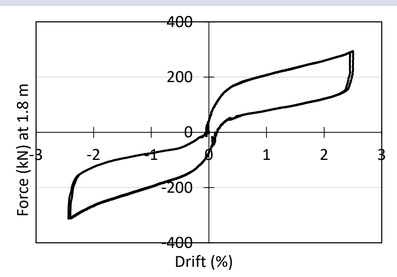
Figure 4. The recommended analysis and design procedures

BI-DIRECTIONAL TESTING OF A ROCKING LVL COLUMN WITH RSFJS

Figure 5 shows the configuration of the full-scale experimental test carried out on a rocking Laminated Veneer Lumber (LVL) column with RSFJ hold-downs which is related to the new Nelson airport terminal. As can be seen, a bi-directional test is performed to verify in- and out-of-plane performance of the column. As can be seen in the figure below, a stable flag-shaped hysteresis is achieved for up to 2.7% of lateral drift without relying on any external mechanism. The applied load protocol was two full cycles at the target lateral drift. Moreover, the out-of-plane test results shown in the figure demonstrates a nearly elastic behaviour up to 2.7% of lateral drift.



Bi-directional performance



Out-of-plane performance

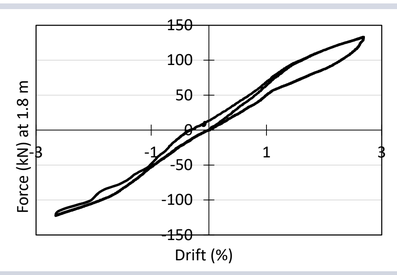


Figure 5. Bi-directional testing of the Nelson Column test

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