ENAC / PROJET DE MASTER 2020-2021
SECTION DE GÉNIE CIVIL

SEISMIC RETROFITTING OF EXISTING STEEL STRUCTURES WITH BUCKLING RESTRAINED BRACINGS

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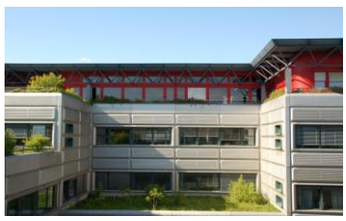
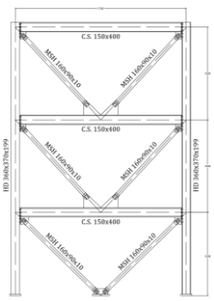
ABSTRACT

The objective of this project is the seismic retrofit of the EPFL GC building with buckling restrained braces (BRBs), and the proposition of a possible heightening. The structure does not comply with current seismic standards. The advantage of BRBs is that the structure becomes more flexible and at the same time more stable under seismic loads. In fact, BRBs do not experience buckling and their behaviour is hysteretic. With this new design, the number of connections and braces can be halved, decreasing the cost of the structure and eliminating weak points. As retrofit works are a good opportunity to modify the structure, a possible heightening of the building will also be studied, as it could be a solution for increasing the capacity of the EPFL campus. In this project, a representative concentrically braced frame will be analysed and retrofitted.



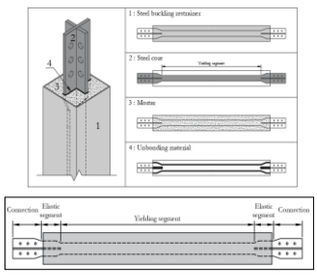
GC building façade (Daja, 2021)



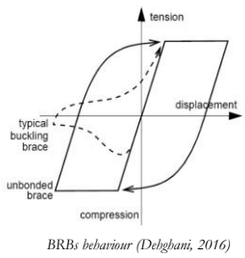
Actual CBF

BRBs

BRBs are a type of dissipative braces, that have the ability of avoiding buckling. Their stable behaviour allows to use them in diagonal configuration, so that the braces and connections of the frames are halved. BRBs are composed of a inner steel core, which yields to dissipate energy during an earthquake, a steel restrainer for avoiding buckling in compression and a mortar infill.



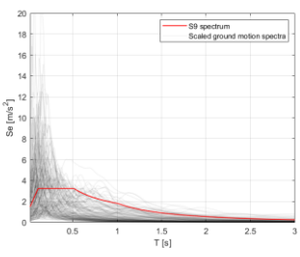
BRBs components



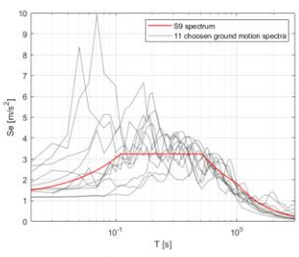
BRBs behaviour (Dehghani, 2016)

GROUND MOTION SELECTION

Two hundred representative ground motion records of a possible 475 years return period earthquake in Switzerland are chosen. They are scaled to better represent the S9 microzonation response spectrum around the fundamental period of the structure. The 11 scaled records with the smaller error with respect to the S9 spectrum are selected.



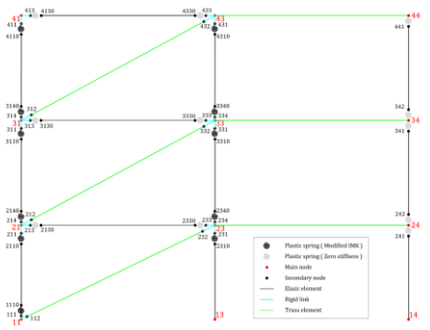
Ground motion records



Selected scaled records

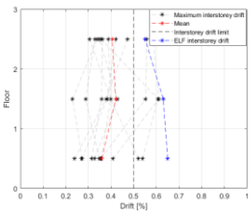
MODEL

A nonlinear model is built with the software OpenSees to perform time history analysis. The hysteretic behaviour of the BRBs is described by an apposite material model. The rest of the frame is defined with elastic elements and plastic springs, where we expect the maximum rotational efforts. A leaning columns system is built to consider the P-Delta effect.

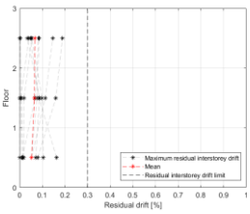


RESULTS OF TIME HISTORY ANALYSIS

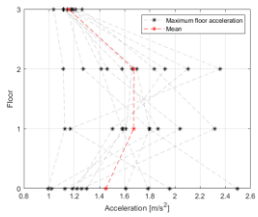
Interstorey drift, residual drift and acceleration are evaluated for the 3-storey and the 5-storey frames. In both cases, the results are below the chosen limits. Non-dissipative element such as beams and columns are the most critical point as they must be designed based on the maximal strength of BRBs and not only on seismic force demand. All the verifications of the non-dissipative elements are satisfied.



Interstorey drift



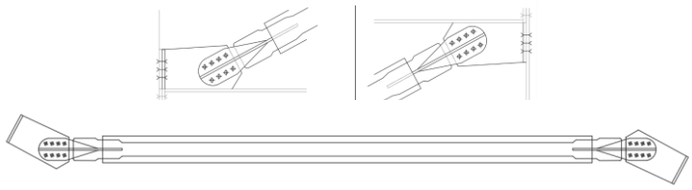
Residual drift



Floor acceleration

CONNECTIONS

In the actual state, connections are the weakest point due to the buckling of the braces. With BRBs, this problems is avoided. BRBs will be assembled with the rest of the structure, that is not modified.



CONCLUSION

Both the retrofit and the heightening are demonstrated to be feasible. Even in a low seismicity zone, where the dissipative potential of BRBs can not be totally exploited, this solution is effective, stable and elegant. Buckling and connection problems are avoided.

This solution has also economical advantages, as due to the diagonal configuration, the number of braces and connection is halved. Moreover, because of the stable behaviour of BRBs, stiffeners are not required on gusset plates.