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DuraCore Combined System for Optimum Building Design

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Abstract: While most steel buildings in high seismic areas use either buckling-restrained braced frames (BRBFs) or special moment frames (SMFs), there are advantages to using combined systems in some cases. DuraCore (DuraFuse + CoreBrace) combines the best features of SMFs and BRBFs. DuraCore can reduce weights, as compared to SMFs, and can improve architectural flexibility and foundation demands as compared to BRBFs. DuraFuse engineers can help EORs explore possible benefits of a combined system on particular projects.

Background

In U.S. practice, steel buildings in high seismic regions typically employ either buckling restrained braced frames (BRBFs) or special moment frames (SMFs). Buckling restrained braced frames provide excellent stiffness and energy dissipation, but the braces sometimes interfere with architectural features and building layouts. Special moment frames accommodate architecture and have excellent ductility, but are inherently flexible and require heavy/deep beams and columns to satisfy drift requirements.

Building codes permit the use of dual and combined systems (SMFs + BRBFs), but most engineers have limited experience in using combined systems to their advantage. The fundamental challenge in using SMFs and BRBFs together is to proportion braces to help with meeting drift requirements without attracting so much force to the BRBFs that they become strength-governed.

Example

In an SMF building, moment frame bays at the first story had W24×176 columns and W24×146 beams. The bay width was 30 ft and the story height was 15 ft. The stiffness of one SMF bay was 361 k/in, and the steel weight of one SMF bay was 9660 lbs. Five bays were required to achieve a stiffness of 1800 k/in on each line, in order to meet drift requirements.

The member sizes in a single-bay chevron BRBF with

comparable stiffness to one SMF bay were much lighter. The brace core was 3 in.² and the steel weight of the BRBF bay was about one-fifth that of the moment frame bay with the same stiffness. By replacing one of the five SMF bays on each line with a BRBF, the weight of the lateral system decreased by about 10%.

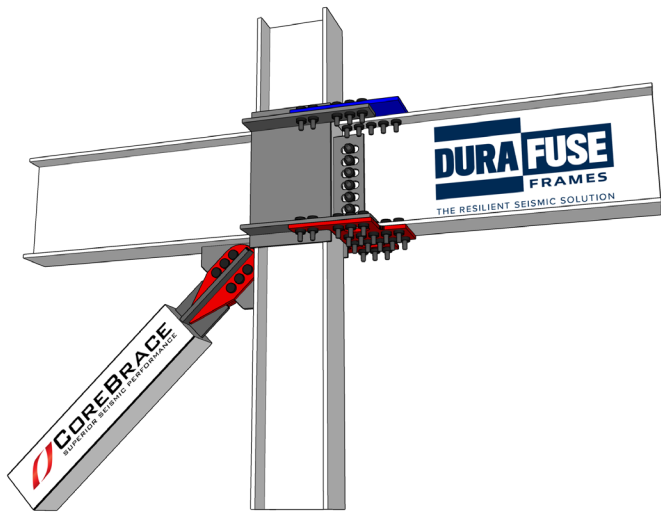
This solution maintained moment frames in the majority of bays, to limit architectural impacts, while using BRBFs where possible to economize on weight. Limiting the size of the brace in the BRBF bay prevented it from attracting too much force and eliminating the need for collectors and more substantial foundation under the braced bay.

DuraCore

DuraCore (DuraFuse + CoreBrace) leverages the best features of SMFs and BRBFs. DuraCore uses some DuraFuse Frames bays and some CoreBrace bays to obtain an optimum design (Fig. 1). The R factor is 8 for both systems, so they can be combined without penalty. DuraFuse Frames are the most resilient SMFs because they have a fuse plate that prevents beam and column damage during severe earthquakes. CoreBrace BRBs have superior seismic performance as compared to other BRBs or conventional braces.

DuraFuse engineers have experience in leveraging the benefits of DuraFuse Frames and CoreBrace so they can assist the EOR in finding the optimum solution for their building.

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Conclusions

Most engineers have limited experience in leveraging the benefits of a combined SMF and BRBF system. DuraCore (DuraFuse + CoreBrace) combines the best features of SMFs and BRBFs. DuraCore can reduce weights, as compared to SMFs, and can improve architectural flexibility and foundation demands as compared to BRBFs. DuraFuse engineers can help EORs explore possible benefits of a combined system on particular projects.

References

- Prinz, G.S., and Richards, P.W. (2012). "Seismic performance of buckling-restrained braced frames with eccentric configurations." *Journal of Structural Engineering*, ASCE, 138(3), 345-353.
- Richards, P.W. (2000). "Using BRBFs with eccentric configurations in combination with DuraFuse Frames." *Technical Bulletin 16*. DuraFuse Frames, West Jordan, UT.

Fig. 1 DuraCore combines the benefits of SMFs and BRBFs

Advantage of DuraCore over SMF buildings:

- Reduced frame weights since CoreBrace is used to help control drift

Advantages of DuraCore over BRBF buildings:

- Improved architectural flexibility – fewer braced bays; braced bays do not need to be aligned at each story
- Elimination of collectors and simplification of connection details
- Reduction of foundation demands under braced bays

Using BRBFs with Eccentric Configurations

When using DuraCore in a building, it can be advantageous to use CoreBrace BRBFs with eccentric bracing configurations. BRBFs with eccentric bracing were first discussed by Prinz and Richards (2012) and have seen some use in practice. When BRBFs have eccentric bracing, they can provide nearly the same unobstructed bay space as an SMF, while using much less steel than an SMF. The use of DuraCore with eccentric bracing is discussed in Technical Bulletin 16 (Richards, 2000).



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