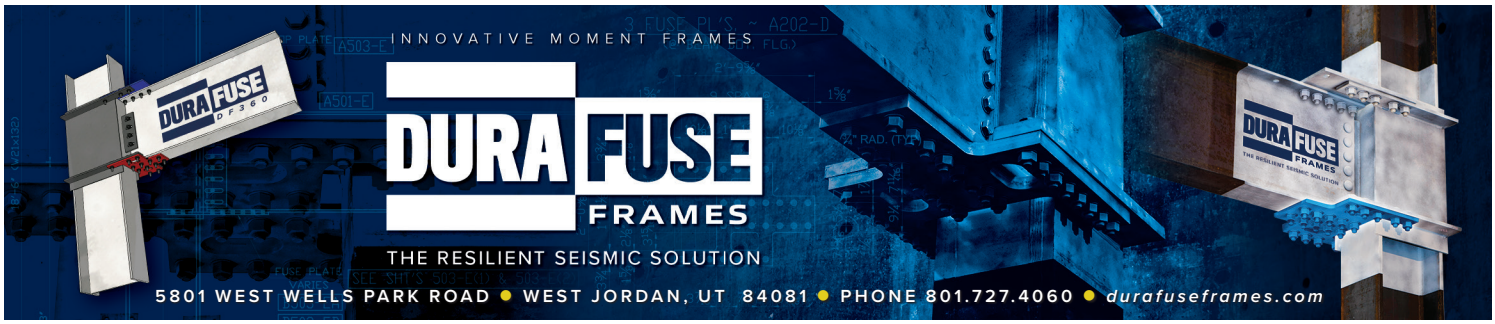

03/20

TECHNICAL BULLETIN 3

How to Use the DuraFuse Features in RAM Frame

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Abstract: RAM Frame software has the option to model moment frame connections as DuraFuse connections. The software accurately models the elastic stiffness of frames with DuraFuse connections and performs the seismic checks that are pertinent to the members and joints. Detailed connection design that is not required for stiffness calculations or member checks is performed outside of RAM.

Introduction

DuraFuse Frames are innovative moment frames that provide enhanced joint stiffness and dramatically improved repairability after severe earthquakes.

DuraFuse has been incorporated into the RAM Structural System software. The purpose of this Technical Bulletin is to show how to assign DuraFuse connections and perform seismic checks in RAM Frame.

Assigning DuraFuse Connections

In the Analysis mode of RAM Frame, DuraFuse connections can be assigned to the beam by selecting **Assign – Beams – Frame Beam Connection Types**...

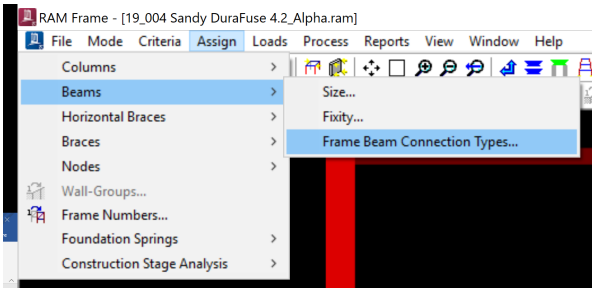

Fig. 1. Assign Frame Beam Connection Type

DuraFuse can be assigned to either or both ends of each beam, depending on the condition (Fig. 2). To apply to a single beam, select “Single”. To apply to several beams, select “Fence” and to apply the connection to all beams select “All”.

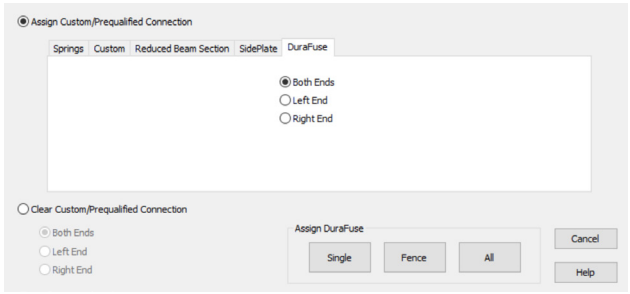

Fig. 2. Assign DuraFuse Connection

Once a beam is chosen, the DuraFuse graphic will be displayed at the appropriate beam end(s) to indicate that DuraFuse has been assigned.

Fig. 3. Assigned DuraFuse Connection to Beam Ends

The design methodology can be specified by selecting **Criteria – DuraFuse**. Then SMF or OMF can be specified for design.

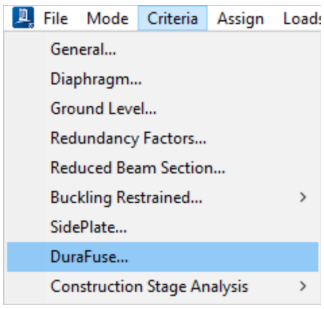

Fig. 4. DuraFuse Design Criteria

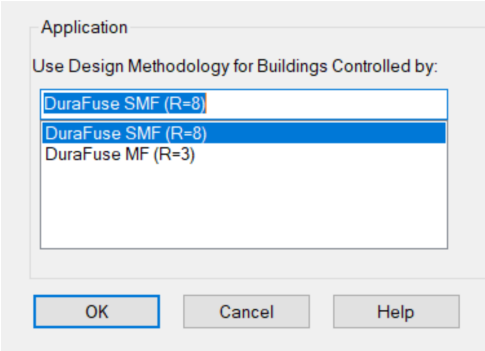

Fig. 5. DuraFuse Design Methodology

Once DuraFuse has been assigned, the analysis can be performed as usual. A separate technical note and RAM Frame documentation explain what RAM is doing "under the hood" once the connection has been assigned.

Note: The general criteria rigid end zone dialogs do not apply to DuraFuse connections.

Checking Frame Stiffness

Drift checks are performed in the same way as with standard moment frame connections. The analysis is run with desired load cases. Then, once analysis is complete, several points or a single point can be checked using the "Drift at Control Points" buttons. The drift report is displayed by clicking "View Results" from the dialog shown next. A typical drift report is shown in Fig. 7. These drifts can also be exported into an excel file by selecting **Reports – Text File**, shown in Fig. 8.

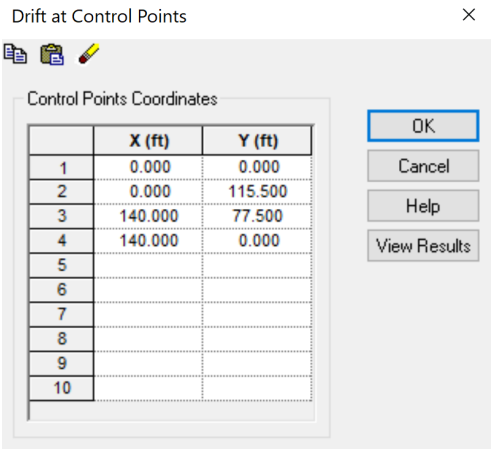

Fig. 6. Drift at Control Points

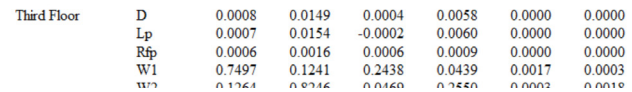

Fig. 7. Typical Drift Report

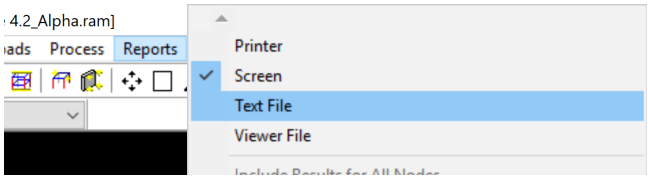

Fig. 8. Print Report to Excel File

Displacements at nodes or stories can also be reported by selecting **Reports – Story Displacements** or **Nodal Displacements**.

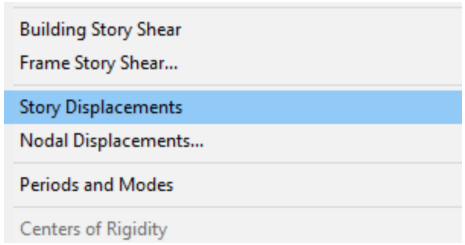

Fig. 9. Story or Nodal Displacements

Seismic Member Checks

After the analysis has been completed, seismic member checks can be performed by going to the Steel mode (Fig. 10), indicating the applicable design code (Fig. 11), entering the appropriate load combination information (Fig. 12), and switching to "Seismic Provisions" (Fig. 13). Then, assign the appropriate frame type to the applicable lateral frames by selecting **Assign – Frame Type** (Fig. 14). Several options are available, but only Special Moment Resisting Frames and Ordinary Moment Resisting Frames apply to DuraFuse connections (Fig. 15).

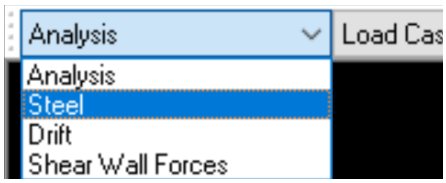

Fig. 10. Switch to Steel Mode

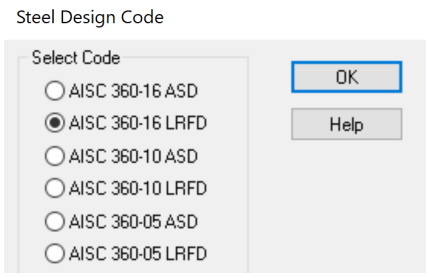

Fig. 11. Applicable Design Code

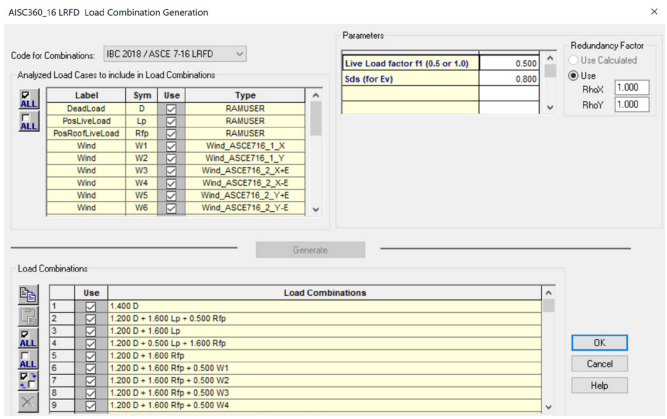

Fig. 12. Applicable Load Combination Information

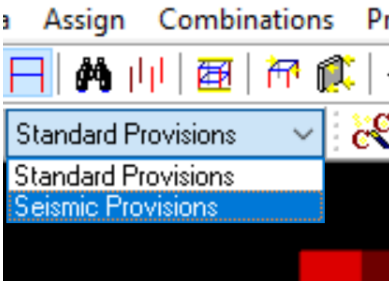

Fig. 13. Seismic Provisions Mode

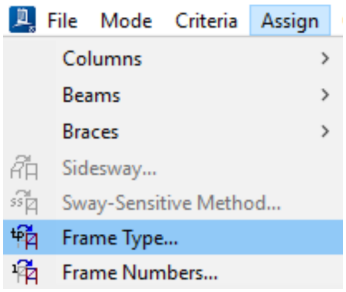

Fig. 14. Assign Frame Type

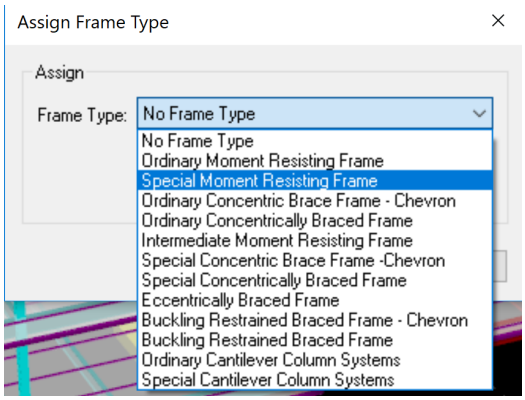

Fig. 15. Applicable DuraFuse Frame Types

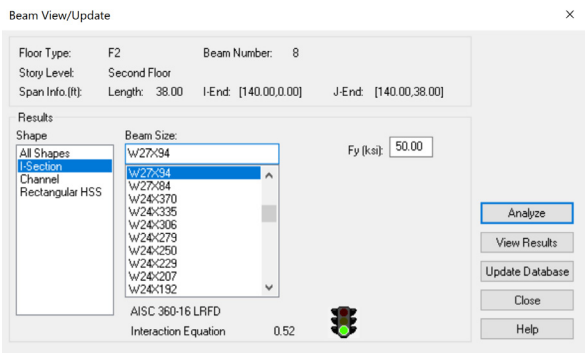

Fig. 16. Beam View/Update Dialog

Select the "Member Code Check" button to run the seismic checks. The report for a particular beam or column is generated by using the "View Update" button and selecting a beam or column. When the "View Results" button is used (Fig 14.) the Member Code Check report will display.

Column seismic requirements are the same as for other connections and include the following checks with reference to the seismic code AISC 341 (2016):

- **D1.4a Required Strength**
- **D2.5b Column Splice Required Strength**
- **E3.4c Unbraced Connections**
- **E3.5a Compactness**

DuraFuse beam seismic requirements vary from other connections (UES, 2019). The following list outlines the DuraFuse beam checks performed and reported in RAM.

- **E3.4b Stability Bracing of Beams; need only meet AISC 360 requirements. Bracing per D1.2b not required**
- **E3.5a Compactness; need only meet AISC 360 requirements. Compactness per D1.1 not required**
- **E3.6b Beam-to-Column Requirements**

Seismic Joint Checks

The seismic joint checks can be performed in a similar way to the member checks by selecting the "Joint Code Check" button while in the Seismic Provisions mode, using the "View Update" button, selecting a DuraFuse joint, using the "View Results" button and viewing the Joint Code Check report.

The following list outlines the DuraFuse joint checks performed and reported in RAM, organized by the location of the check in AISC 341 (2016).

- **E3.4a Strong Column Weak Beam**
- **E3.4c Stability Bracing at Beam-to-Column Connections**
- **E3.6c Connection Required Shear Strength**
- **E3.6e(1) Panel Zone of Beam-to-Column Connections**
- **E3.6(2) Panel Zone of Beam-to-Column Connections: Thickness**
- **E3.6f Continuity Plates; not required for DuraFuse connections**

Weight Takeoff

Another feature in RAM Frame is the ability to generate weight take offs. In the "Analysis" mode, under **Reports – Takeoff**, the weights for the moment frame beams, columns, and DuraFuse cover plates are reported. For each floor, the beams, columns, and number of DuraFuse connections are given. At the end of the report, the total weight take-off for the building is summarized. Fig. 15 shows a typical summary for the cover plate weight of all DuraFuse connections on a building.

DuraFuse Connections:

Number of Joints with Connection: 30

Number of DuraFuse Beam Ends: 38

Weight of DuraFuse Cover Plates (lbs): 13588.26
UnitWt (psf): 0.23

See DuraFuse for full connection weight

Fig. 17. DuraFuse Connection Weight Takeoff

If you need assistance in modeling, or are ready to move forward with connection design, contact DuraFuse Frames (801) 727-4060.

Conclusion

RAM Frame software has the option to model moment frame connections as DuraFuse connections. It is easy to assign the connections and the software accurately models the elastic stiffness of DuraFuse Frames for drift checks. RAM Frame also performs the seismic checks that are pertinent to the members and joints, including strong column weak beam and stability bracing checks. Finally, RAM Frame calculates cover plate weights. Detailed connection design that is not required for stiffness calculations or member checks is performed outside of RAM by DuraFuse Frames, LLC.

References

AISC (2016), *Seismic Provisions for Structural Steel Buildings*, ANSI/AISC 341-16, American Institute of Steel Construction, Chicago, IL.

UES (2019), "DuraFuse Frame Technology," *Uniform Evaluation Service ER-610*, Uniform Evaluation Service, Ontario, CA.