Entertainment Structures Group
A Division of Steven Schaefer Associates, Inc.

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This article is not intended to be a thorough treatment of the topic of structural evaluation. Local, state and national building codes should be consulted. The author cannot be responsible for any evaluation based solely upon this article.

SEISMIC FORCES ON COUNTERWEIGHT GUIDE SYSTEMS

Design and analysis of standard counterweight systems has raised questions regarding the need for seismic bracing of the guides[1] used in these installations. Based on our experience in the theater rigging industry, and our engineering experience with the design and operation principles for these types of systems, we support the opinion that seismic bracing of the guide system is not necessary. There are several major points that we believe contribute to the current standard practice:

- The guide system serves only to guide the vertical movement of the counterweight arbors. Vertical support for the arbors is provided by a series of wire ropes attached to the top of the arbor, which counter-balances scenery located above the stage. Consequently, the counterweight arbors are in a pendulum-type arrangement and are completely independent of the guide system.

- Seismic bracing of the guide system would brace only half of the dead load in the rigging system. The other half of the dead load is at the opposite end of the wire rope supports, at the horizontal pipe battens that support scenery, lighting, and electrical equipment hanging above the stage (the “counterbalance” for the arbor weight). While the batten rigging has the same seismic load as the counterweight arbors, seismic bracing of the battens is not considered, since these battens also act as pendulums during a seismic event.

- During a seismic event, the flexibility of the tee bar wall prevents the counterweight arbors from developing a seismic force that is transmitted into the building. The flexibility of the tee bar wall allows the counterweight arbor to de-couple from the building frame for lateral forces, and to perform as a pendulum during a seismic event. This de-coupling occurs through a combination of yielding in the arbor guide shoes and/or the guide members themselves. Since neither of these components provide vertical support for the arbor, yielding of these components has no effect on vertical movement during a seismic event. This pendulum will have a fundamental period much longer than the rigid structure of the building. Therefore, little or no seismic force would be transmitted from the counterweight arbors into the building, and little lateral motion would be expected in the counterweight arbors. While the deformations experienced by the guide system would likely require repair or replacement following the seismic event, that damage would not affect the vertical load support system for the arbors, and is therefore acceptable.

- Every counterweight arbor is also tethered to the building, from its bottom, by an operating handline. This line is pre-tensioned by the floor block, which is a guide pulley located at or near the stage floor. This partial restraint dampens arbor movement during a seismic event.

- One of the most seismically restricted areas in the United States is southern California, which also happens to be a popular theater and entertainment industry locale. That area has many operating theaters that have experienced a significant amount of seismic events. Yet, seismic bracing is still not required by the governing building code.

We hope this information is beneficial in determining the purpose of the guide system, as well as the industry's standard approach for lateral bracing of these system elements.

[1] The term "guides" or "guide system" refers to the rigid members used to vertically guide the counterweight arbors, typically having a T- or J-shaped cross-section.