

IT5

Nonbuilding Structure - Nonstructural Component Subgroup

J. G. (Greg) Soules, P.E., S.E.

April 5, 2018



Update on 25% Mass Ratio Rule of Sections 13.1.1 and 15.3

- Good News – Determined logic used to arrive at mass ratio limit of 25%.
- Bad News - Determined logic used to arrive at mass ratio limit of 25%.
- “Minor” change in mass ratio definition in ASCE 7-02 invalidated original rule.



25% Weight Rule

- Introduced in 1988 UBC.
- No commentary exists for rule.
- Rule is intended to identify when supported component significantly impacts the response of the supported structure.
- Nuclear industry uses a small % as the trigger for a coupled analysis (elastic design & a 10% tolerance error on frequency).
- New Zealand uses 20% and the definition of mass ratio used in current ASCE 7.

Why does the 25% rule matter?

- Primarily a nonbuilding structure issue.
- Triggers a coupled analysis for a large flexible nonbuilding structure/nonstructural component supported by another structure.
- R value used in coupled analysis is lesser of the two values.
- If supported component is rigid, analysis is not coupled and is similar to that used in Chapter 13.

Hadjian (1986) - Bechtel

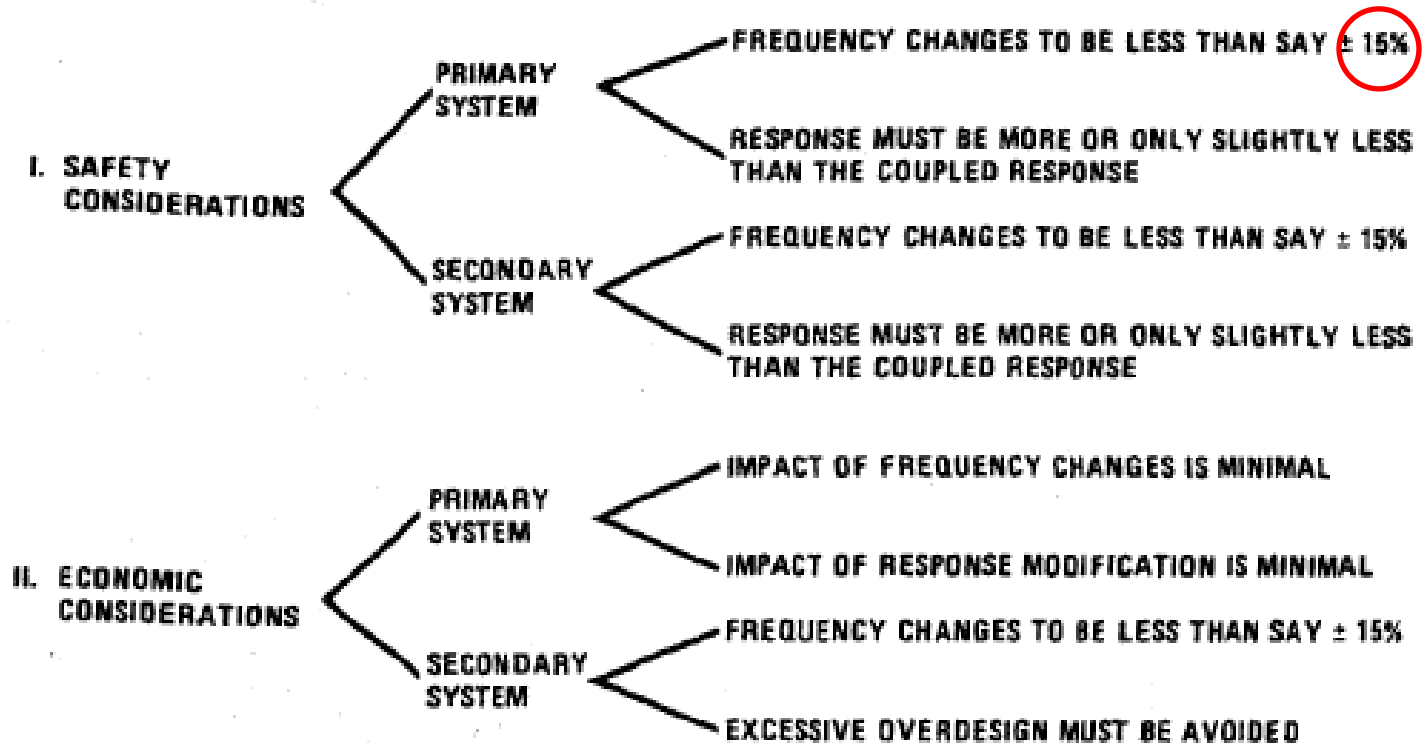
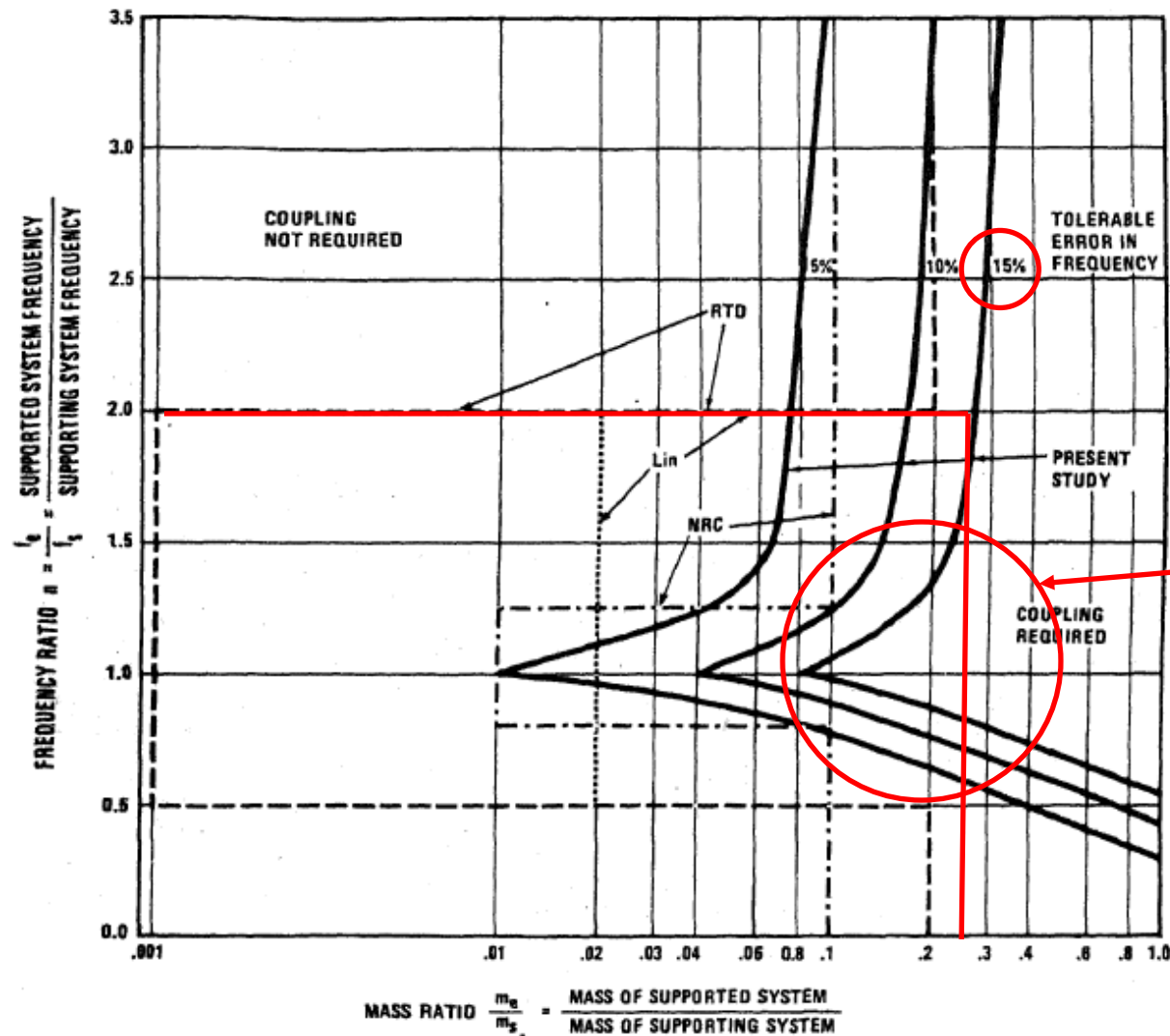


FIGURE 1. SPECIFICATIONS FOR UNCOUPLING.

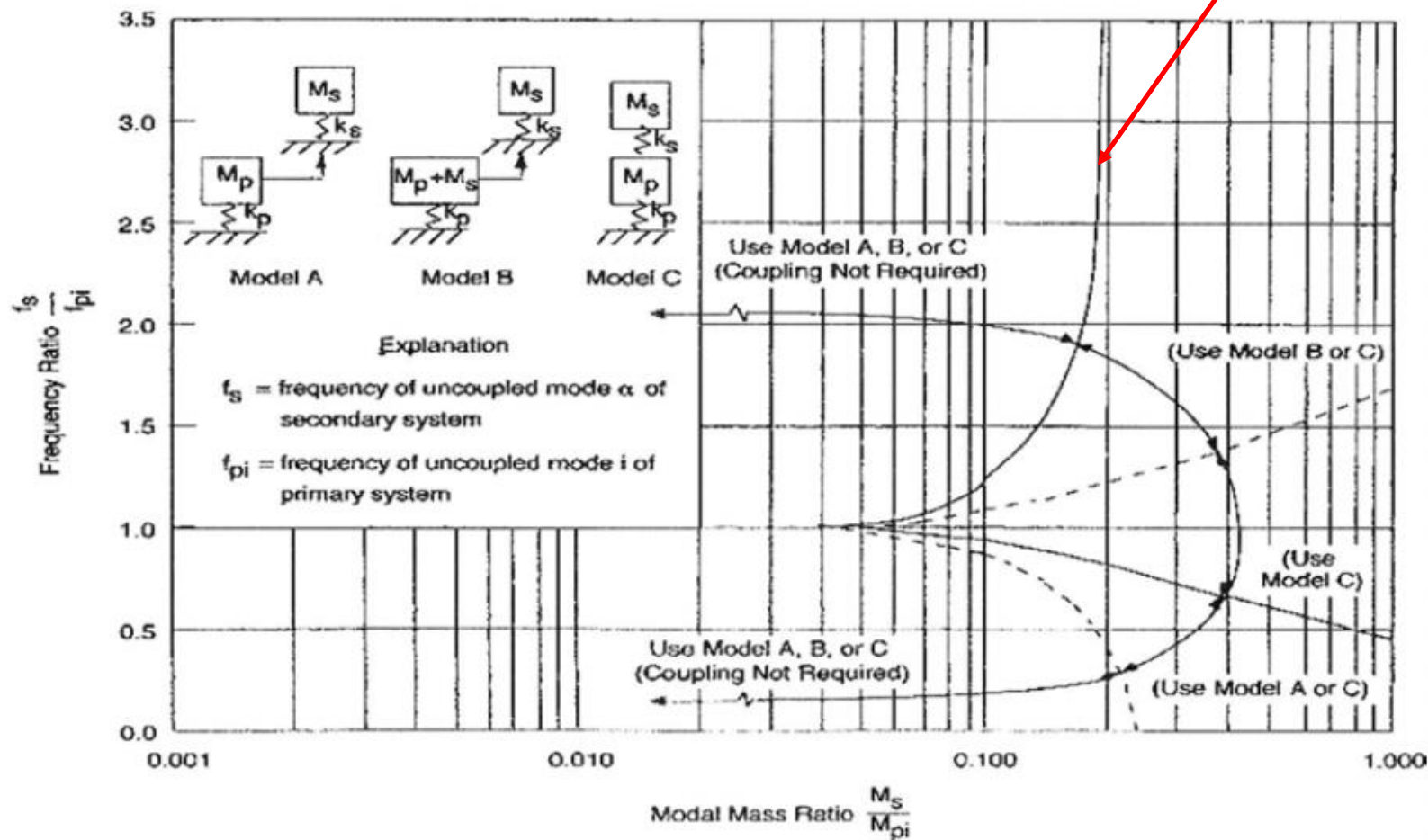
Hadjian (1986) - Bechtel



Assumed inelastic action of support will tend to keep frequency ratio well away from 1.0.

ASCE 4-16

Curve from Hadjian
based on 10% error.



Mass Ratio

- The original rule was written essentially as shown below from 1988 until 2002:
- **“In Seismic Zones 3 and 4, structures which support flexible nonstructural elements whose combined weight exceeds 25 percent of the weight of the structure shall be designed considering interaction effects between the structure and the supported elements.”**
- This matches the mass ratio used in the Hadjian paper.

Mass Ratio

- In ASCE 7-02, the requirement was changed to read:
- **“If the weight of a nonbuilding structure is 25% or more of the combined weight of the nonbuilding structure and the supporting structure, the design seismic forces of the nonbuilding structure shall be determined based on the combined nonbuilding structure and supporting structural system.”**

Mass Ratio

- 1988 UBC Mass Ratio
 - $m_{\text{component}}/m_{\text{support}} = 0.25$
- ASCE 7-16 Mass Ratio Rule
 - $m_{\text{component}}/(m_{\text{support}} + m_{\text{component}}) = 0.25$
 - Equivalent 1988 UBC = $0.25/(1 - 0.25) = 0.33$
- Corrected ASCE 7-16 Mass Ratio Rule
 - $m_{\text{component}}/(m_{\text{support}} + m_{\text{component}}) =$
 - $0.25/(1 + 0.25) = 0.20$ (matches New Zealand code)

Path Forward

- IT5 will develop ballot correcting mass ratio trigger to 0.20 in Chapters 13 and 15.
- Commentary will be expanded to describe source of rule and assumptions made in original analysis (e.g. single point attachment)
- Additional Changes:
 - Chapters 13 and 15 rules will be standalone.
 - Clarification that rule does not apply to distributed systems such as pipe racks and conveyor systems.



References

- Hadjian, A.H. (1986). *On the Decoupling of Secondary Systems for Seismic Analysis*, *J. Pressure Vessel Technology* 108(1), 78-85 (Feb 01) doi:10.1115/1.3264755
- ASCE (2016). “Seismic Analysis of Safety-Related Nuclear Structures”, *ASCE 4-16*, Reston, VA

