Seismic Demands for Performance-Based Design of Bridges

Project #: 3122000

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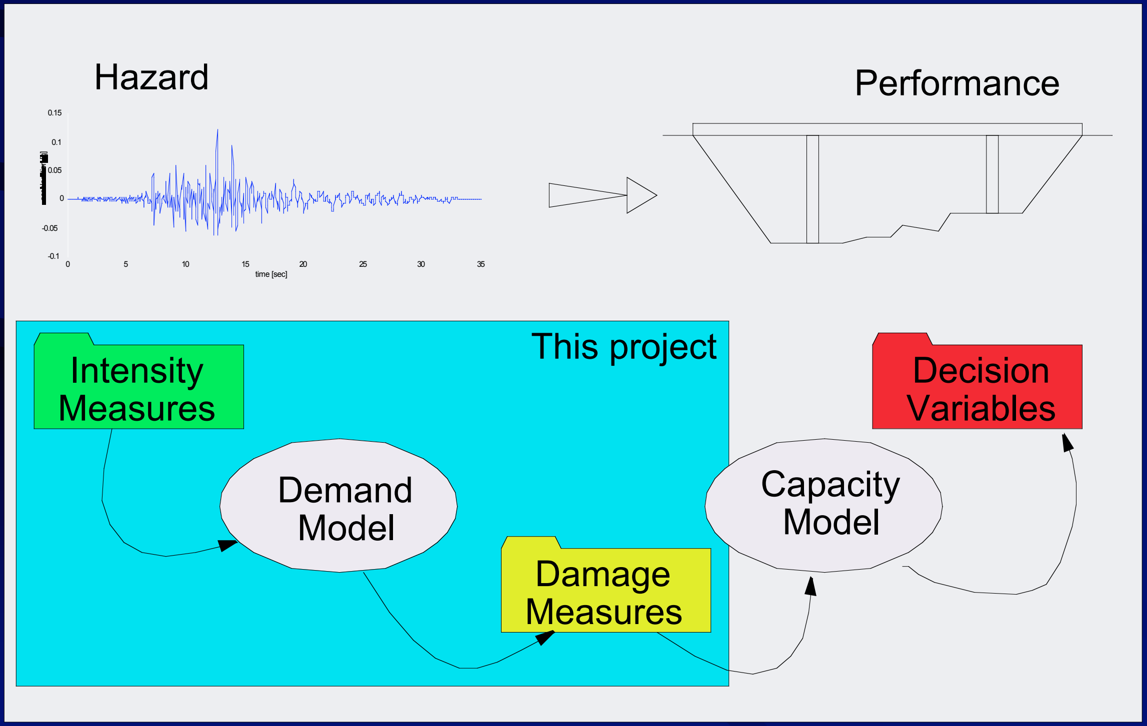
Project Objective

Develop a probabilistic demand model for typical new bridges in California



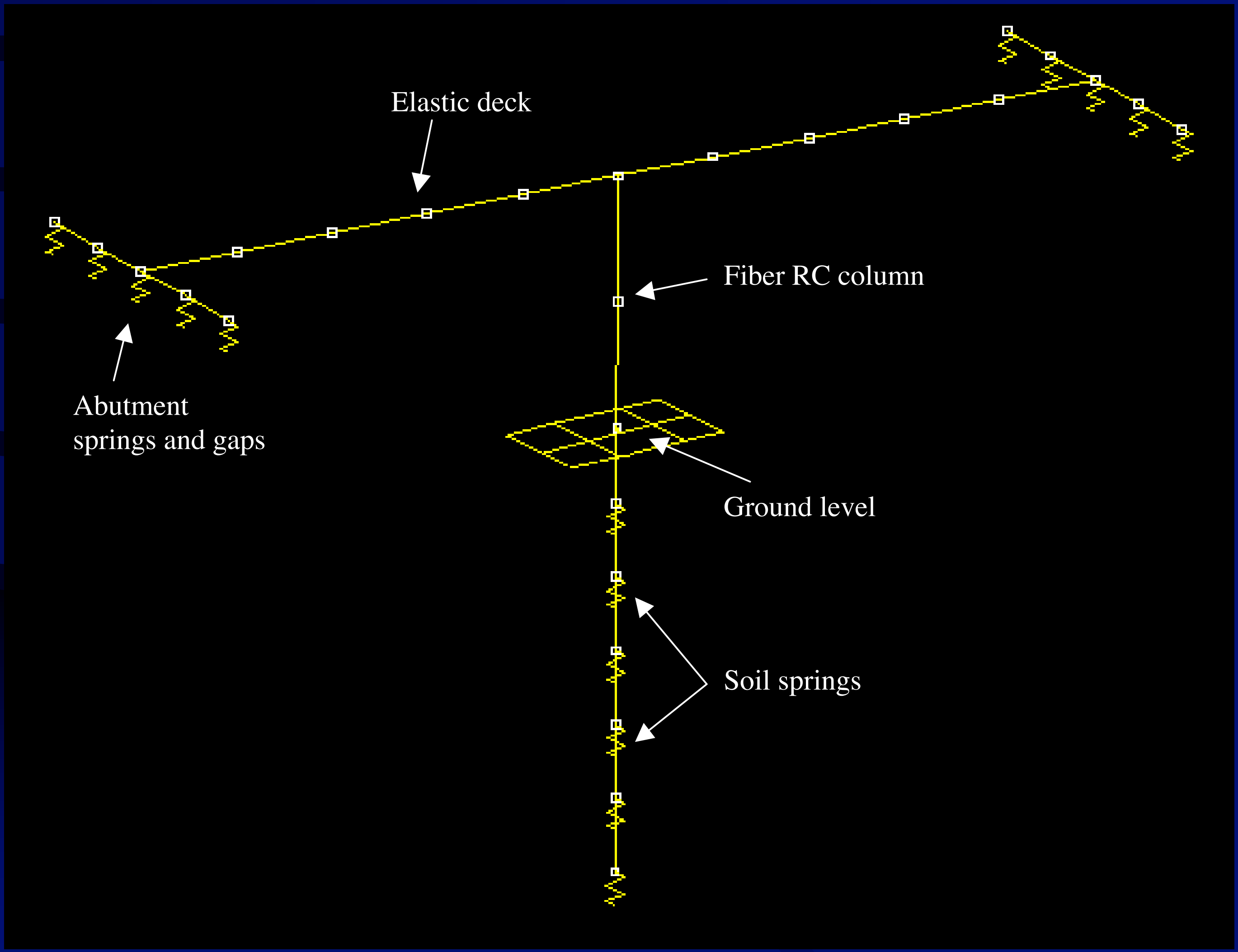
Seismicity: Intensity Measures

- Structure Independent Measures
  - Magnitude
  - Distance
  - Arias intensity (acceleration & velocity)
  - Cumulative absolute velocity
  - Cumulative absolute displacement
  - Frequency ratios
  - Strong motion duration
  - RMS acceleration
  - Characteristic intensity
  - PGA, PGV, PGD
- Structure Dependent Measures
  - Sa, Sv, Sd
  - $Sd,_{inelastic}$

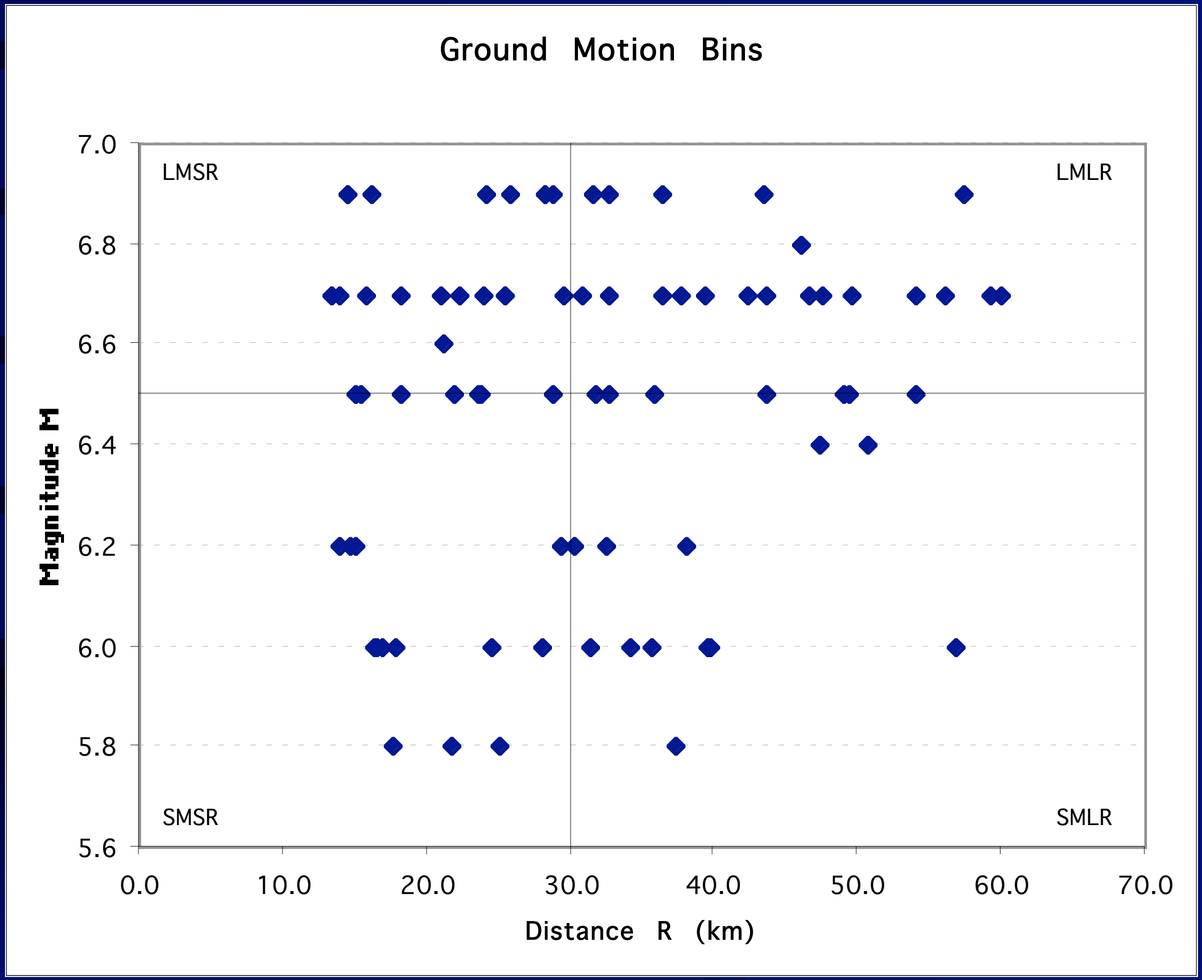
Demand: Damage Measures

- Steel strain ε_s
- Concrete strain ε_c
- Curvature ductility
- Displacement ductility
- Drift ratio
- Residual displacement index
- Plastic rotation
- Hysteretic energy
- Normalized hysteretic energy
- Maximum column curvature

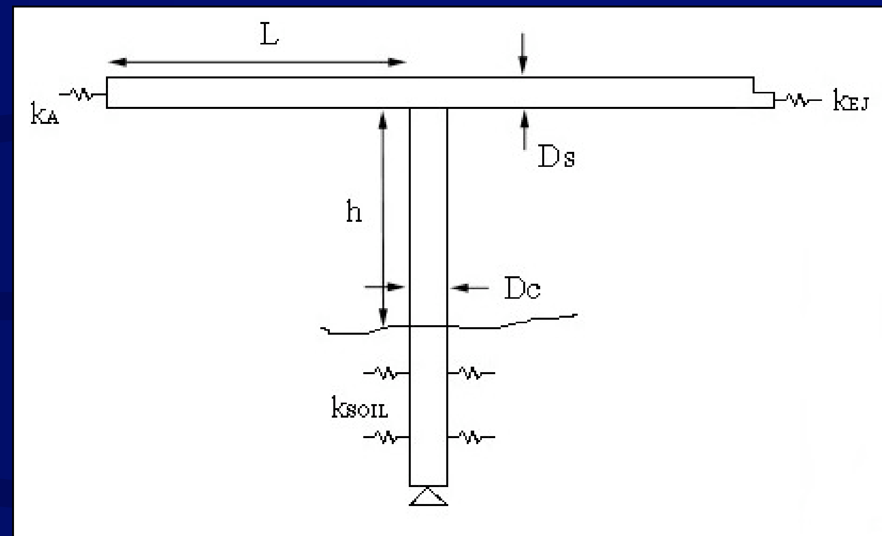
OpenSees Bridge Model



Ground Motion Portfolio

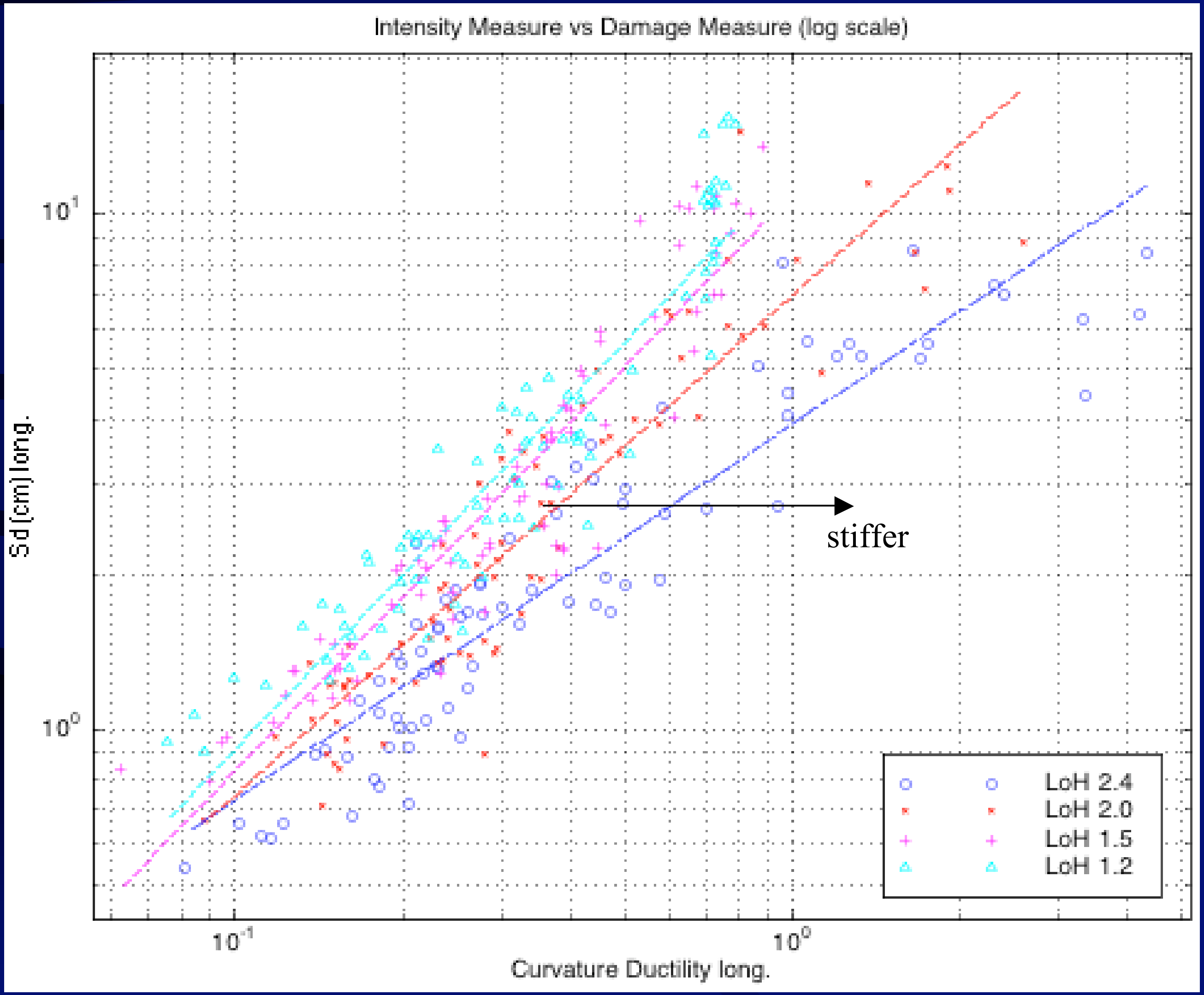


Bridge Portfolio



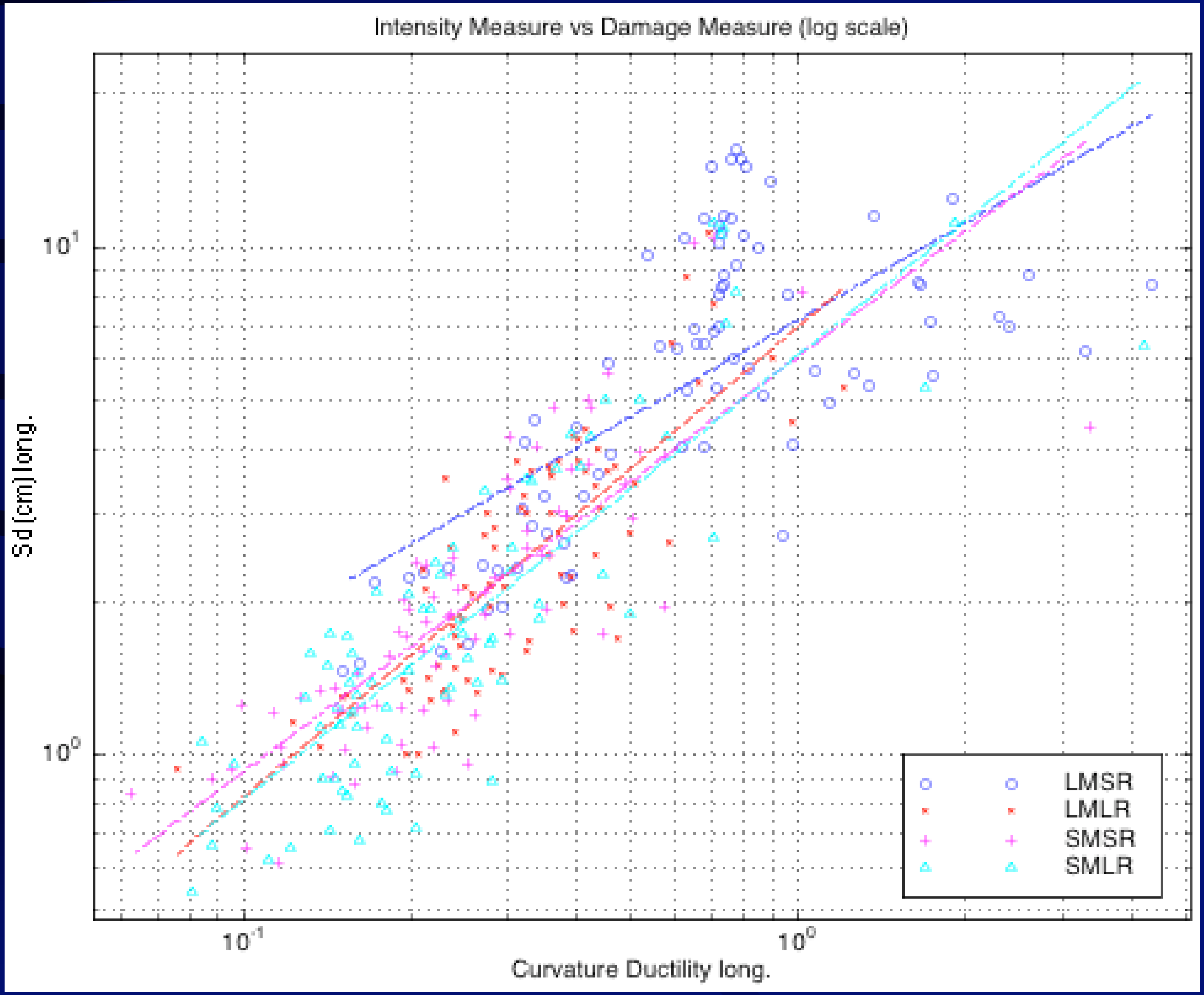
• Skew	degree of skewness	0-50º
• L	span length	60-180 ft
• L/h	span to column height ratio	1.2-2.0
• fy	steel strength	68-95 ksi
• f'c	concrete strength	3-8 ksi
• $\rho_{s,long}$	column longitudinal reinforcement	1-4%
• Dc/Ds	column to superstructure dimensions	0.67-1.33
• Ksoil	NEHRP soil group	B,C,D
• Wt	additional superstructure weight	0.1-50%
• $\rho_{s,trans}$	column transverse reinforcement	0.4-1.0%

Design Parameters - Sd vs



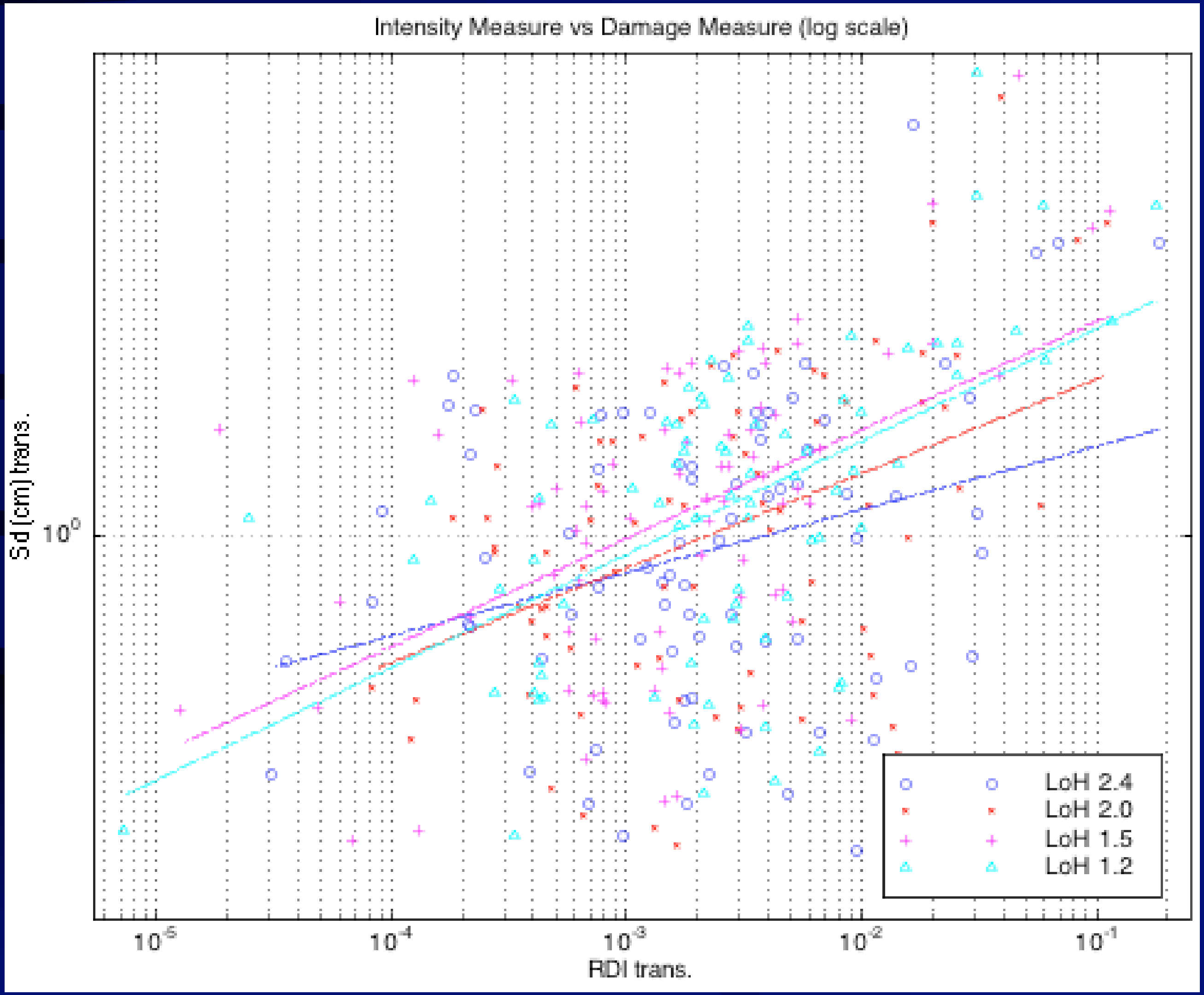
Increasing strength has negligible effect on performance.

Seismicity - Sd vs



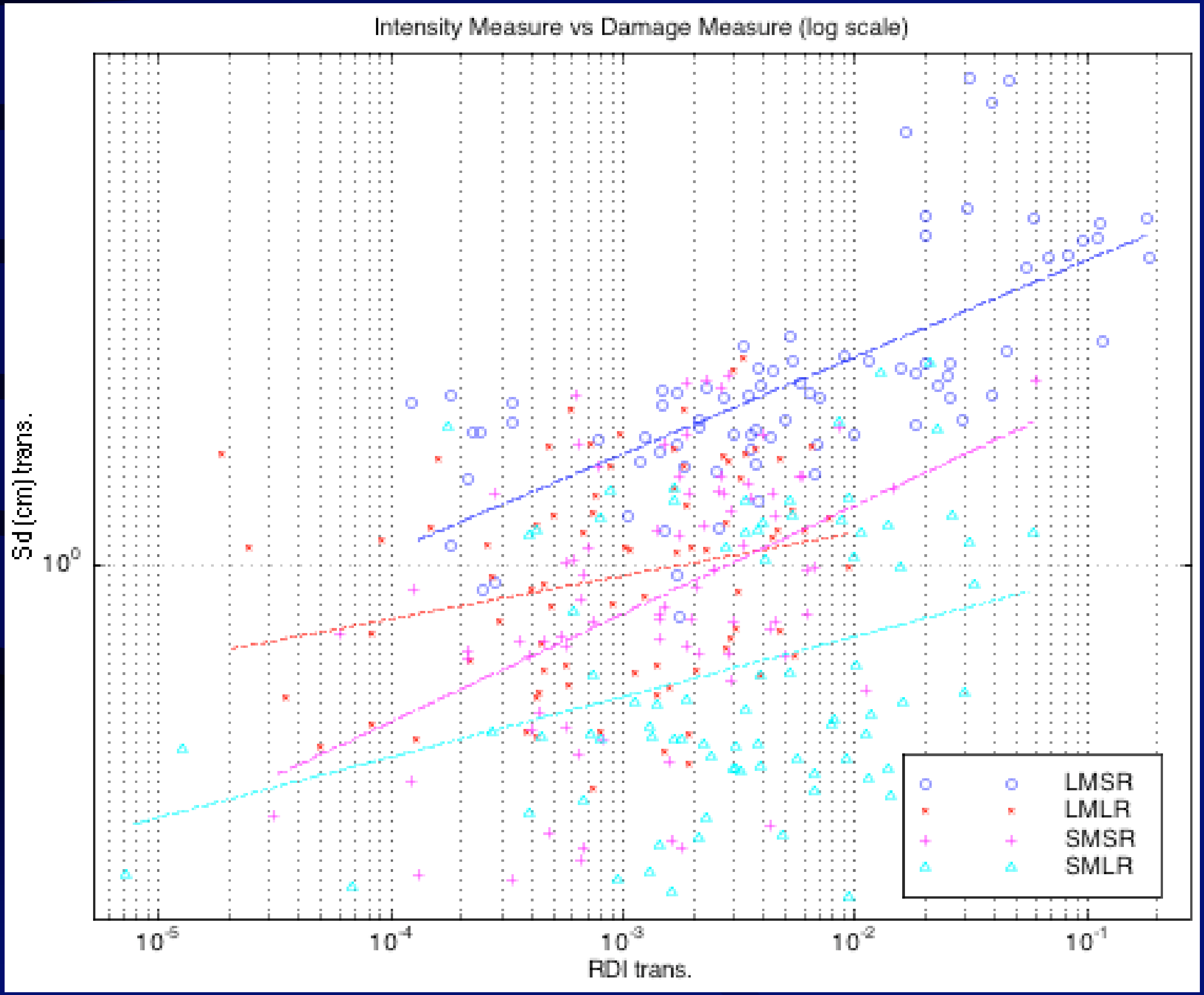
LoH

Design Parameters - Sd vs RDI



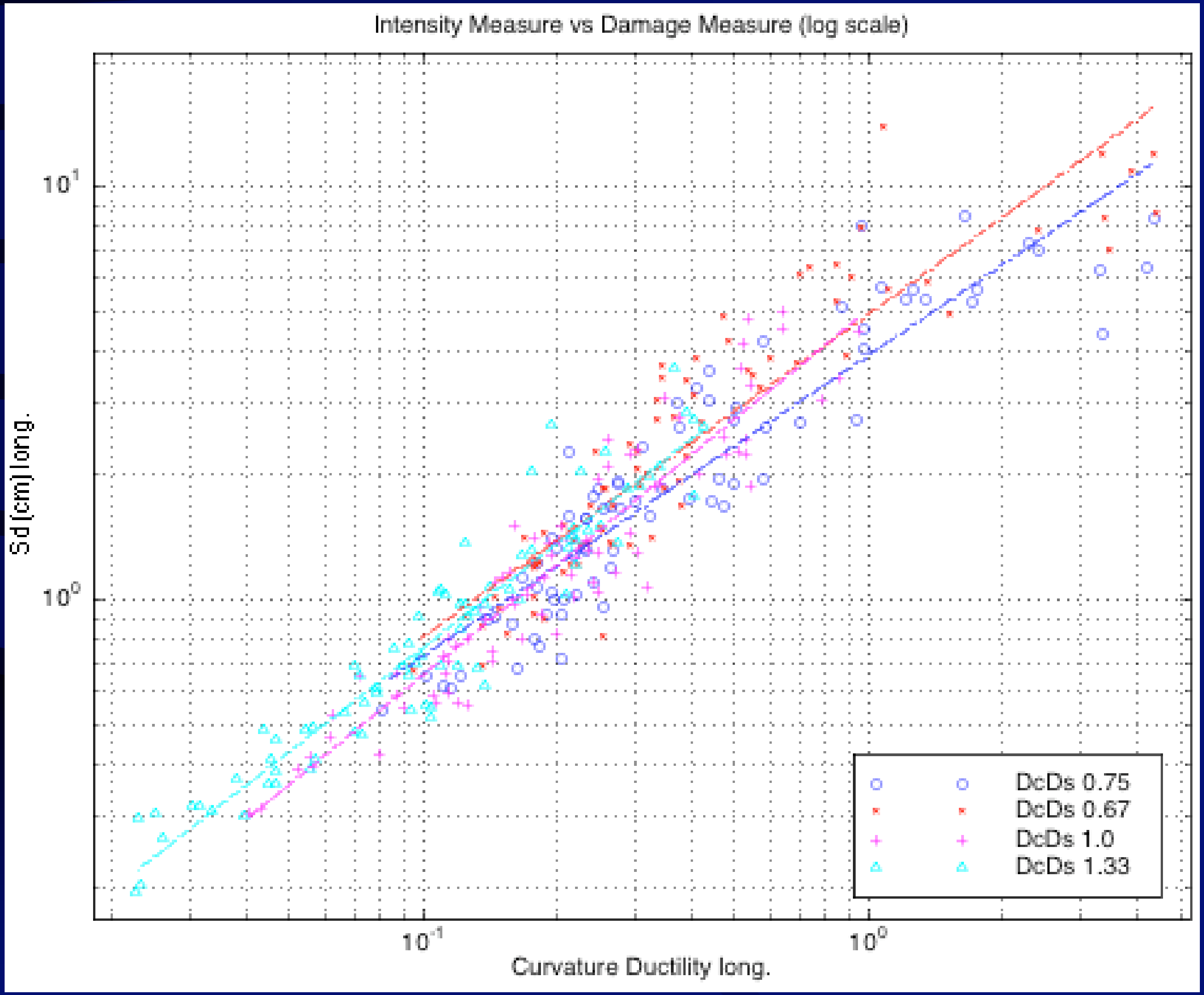
Poor DM choice

Seismicity - Sd vs RDI



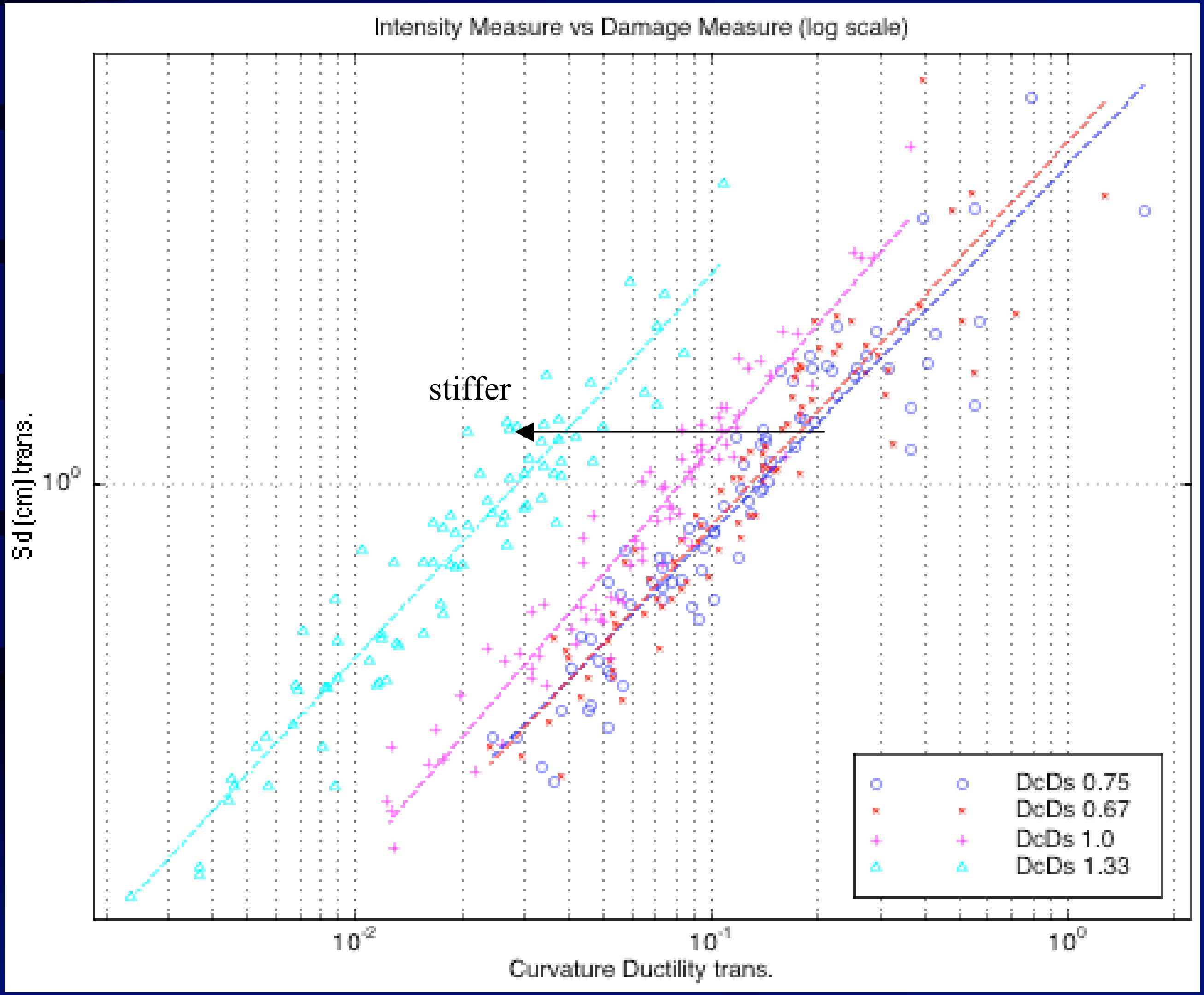
LoH - Poor DM choice

Design Parameters - Sd vs



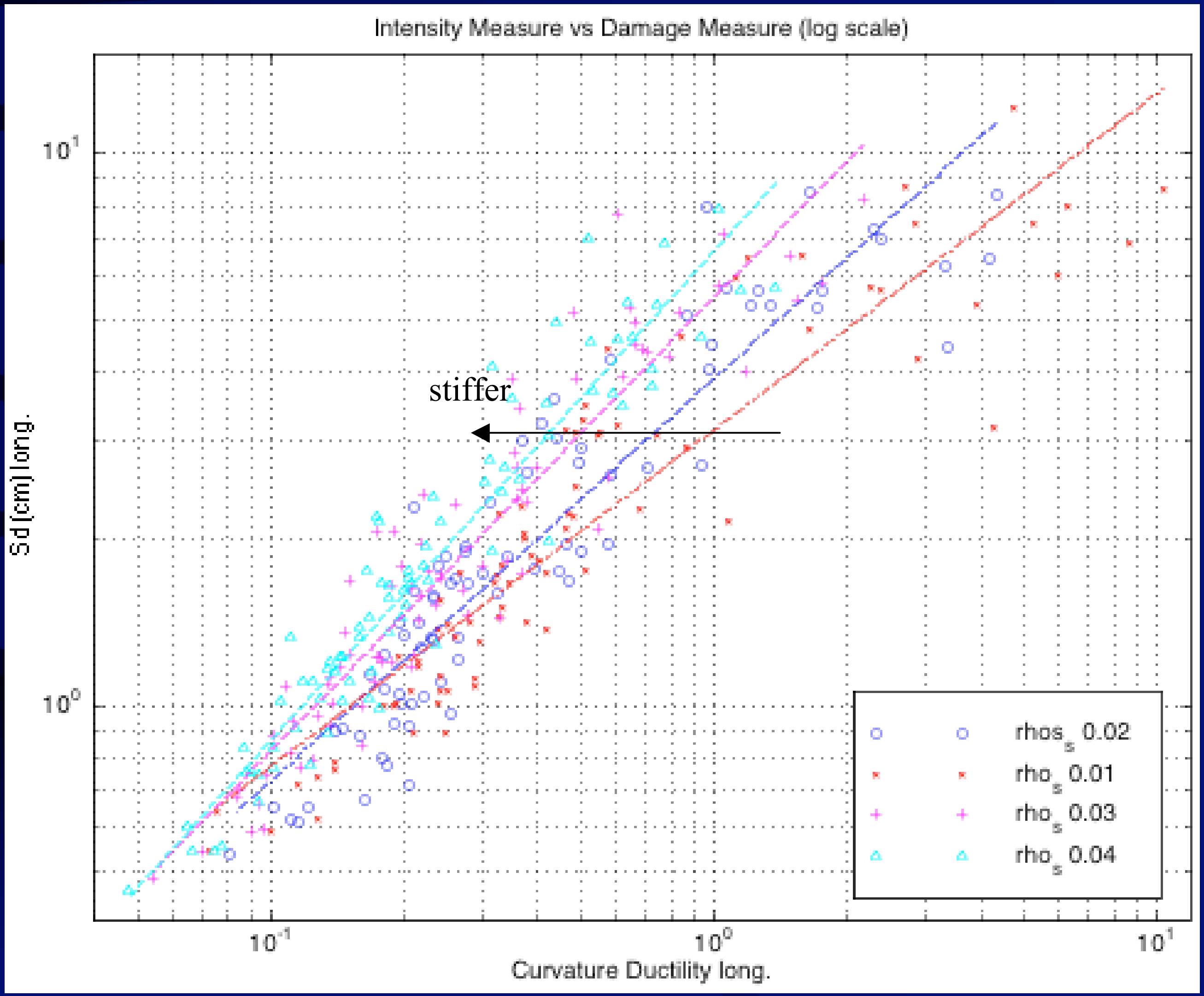
Design parameter does not affect performance

Design Parameters - Sd vs



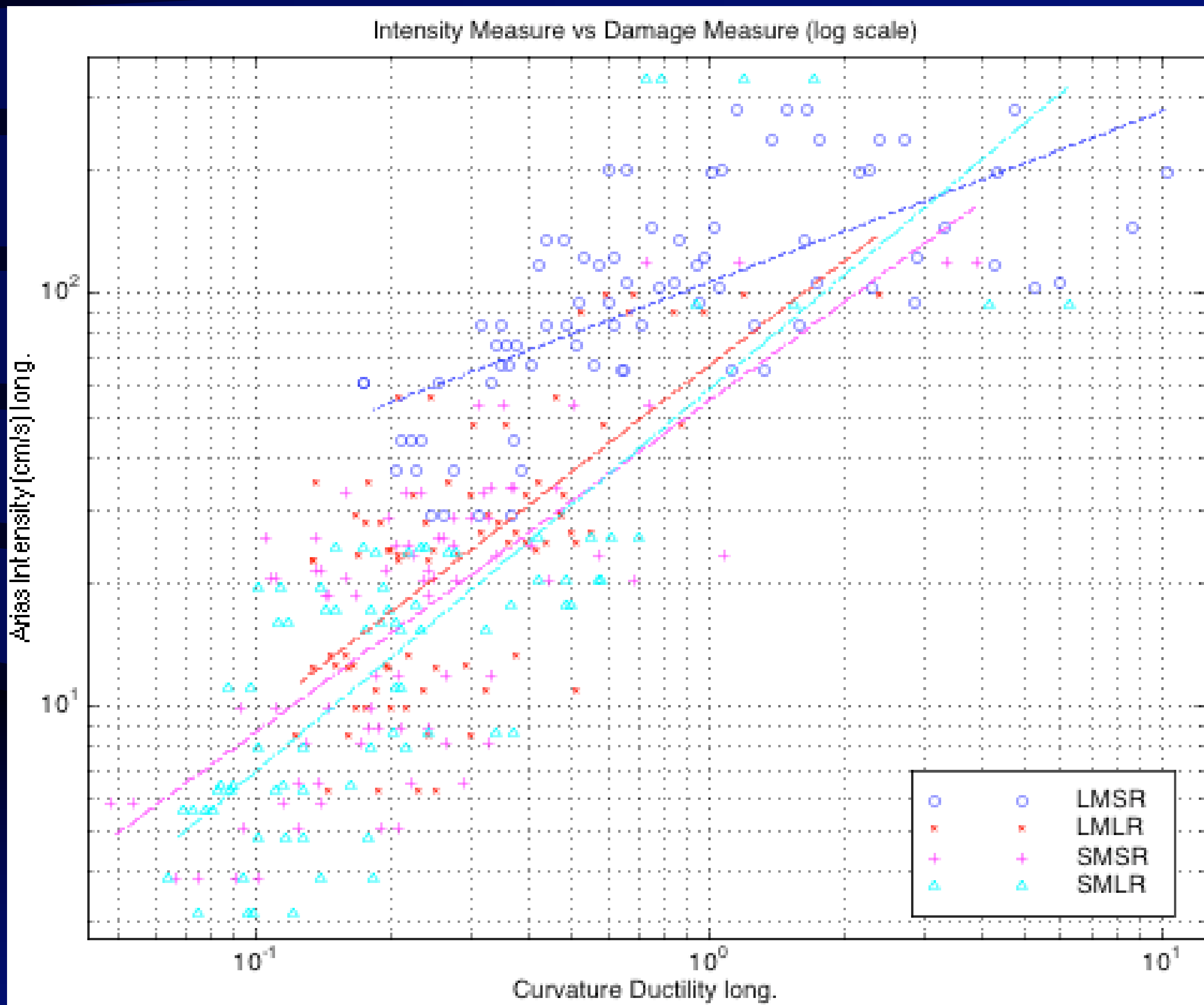
Increasing strength lowers demand. Slope similar for linear case

Design Parameters - Sd vs



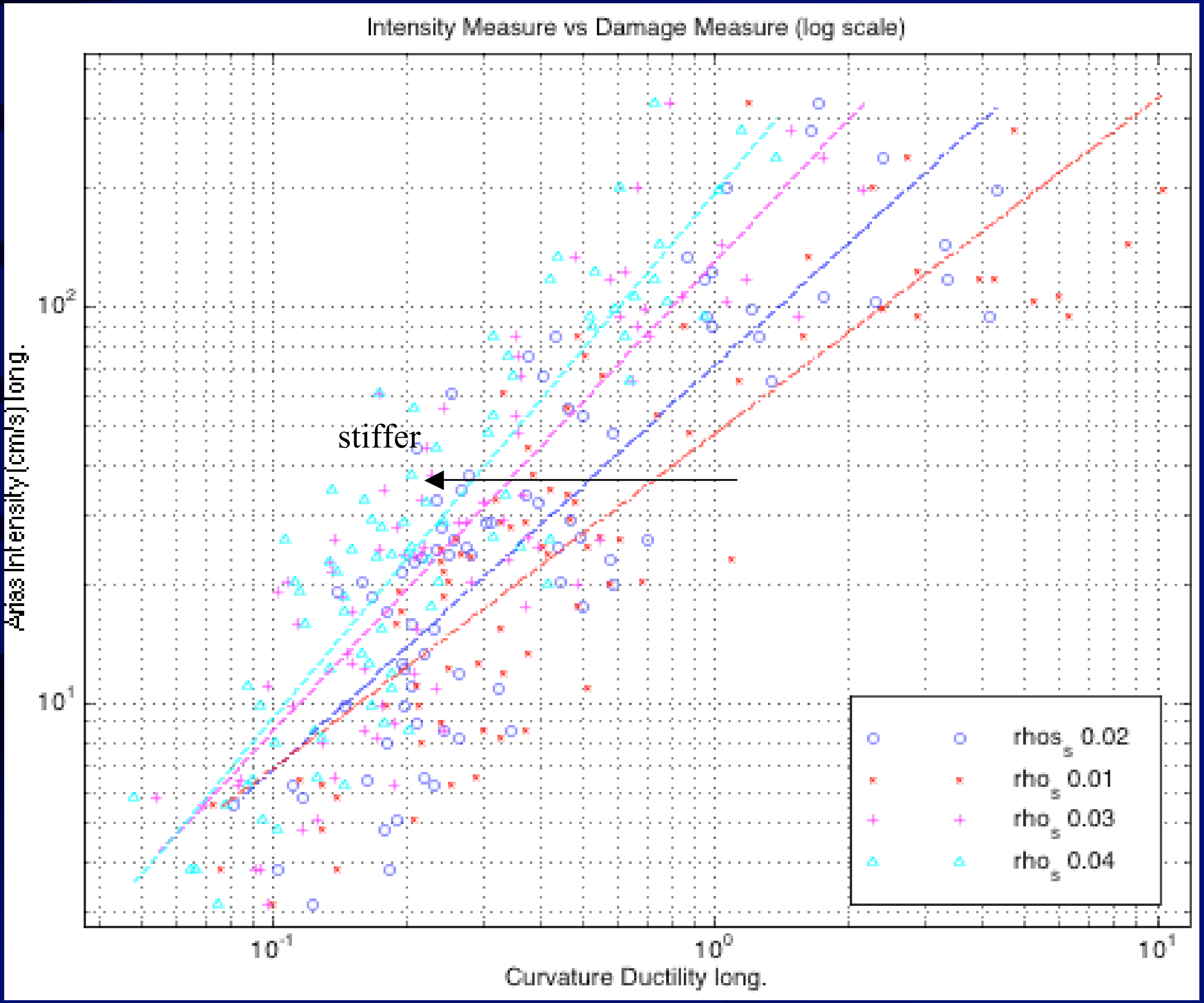
Increasing strength lowers demand. Slope increases with strength for nonlinear case

Seismicity - AI vs [illegible]



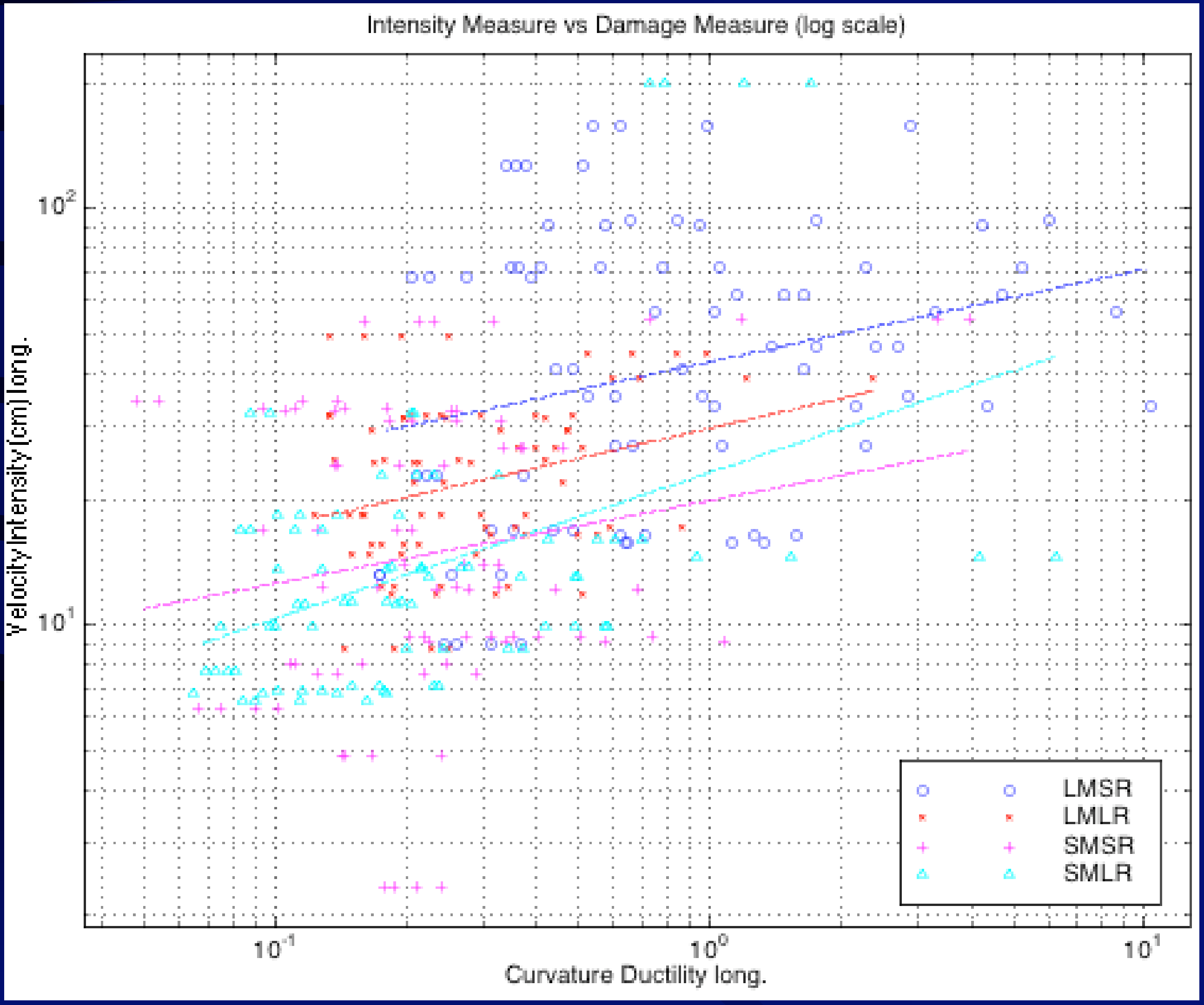
[illegible]s

Design Parameters - AI vs



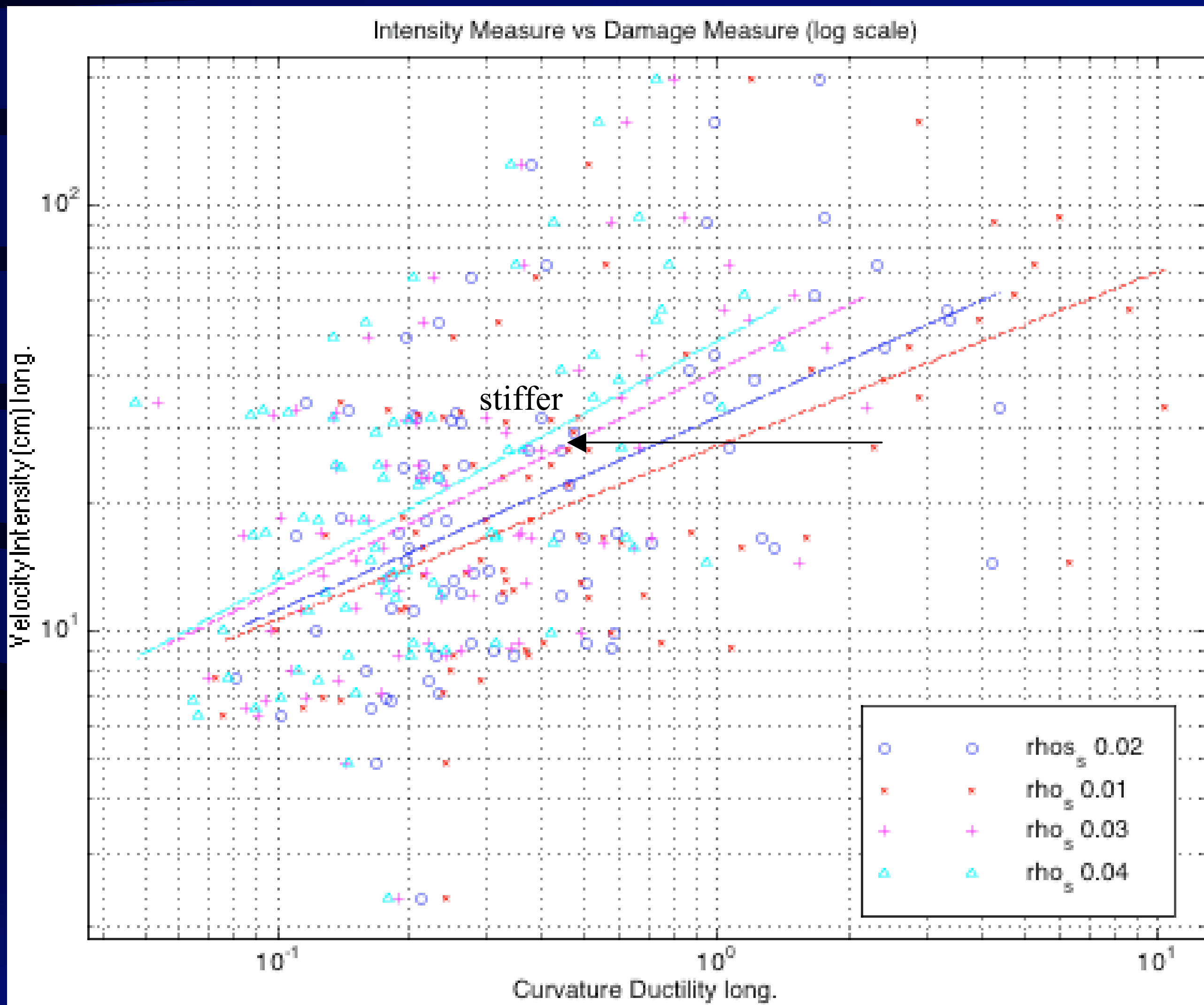
Increasing strength lowers demand

Seismicity - VI vs



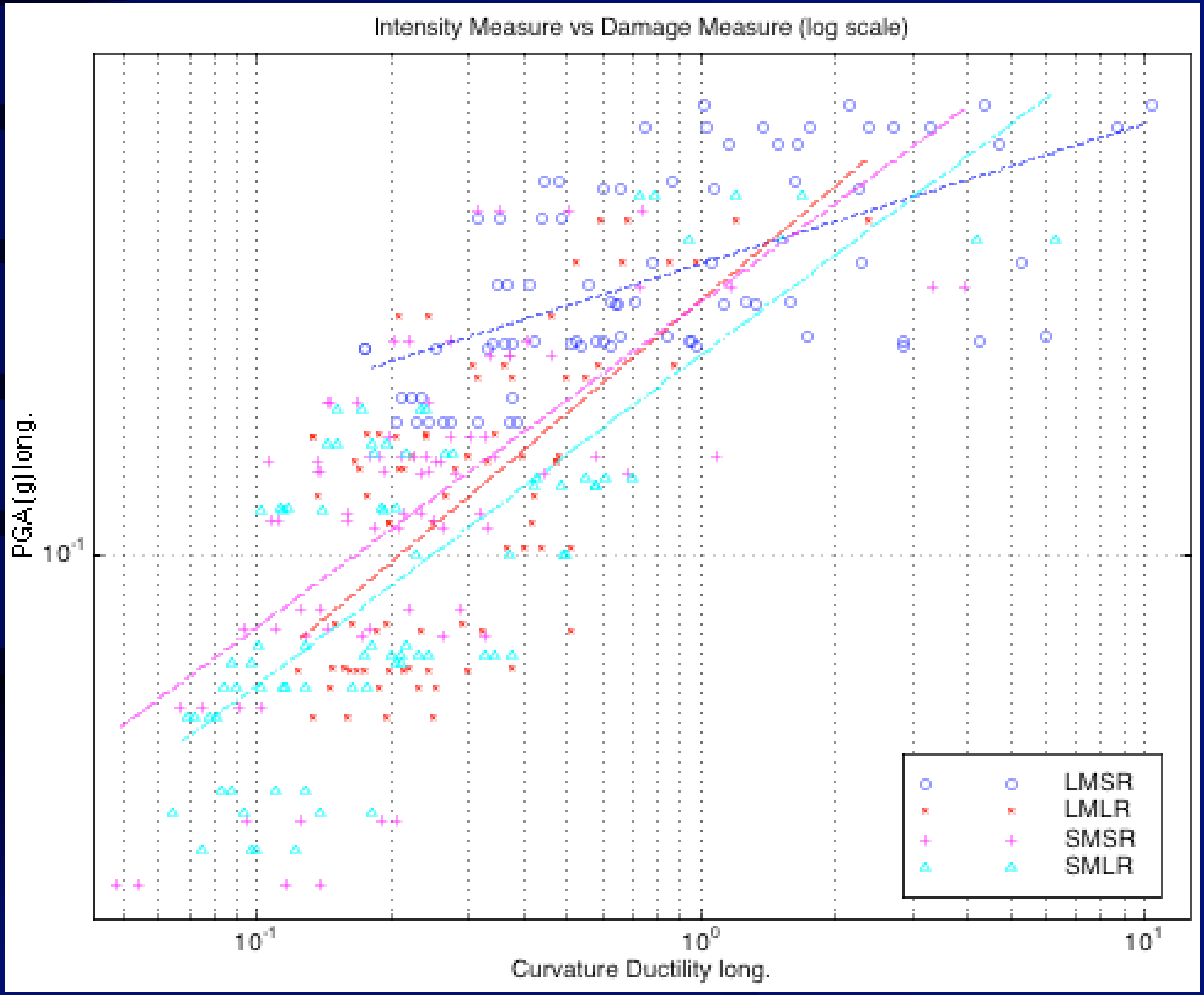
s

Design Parameters - VI vs □□



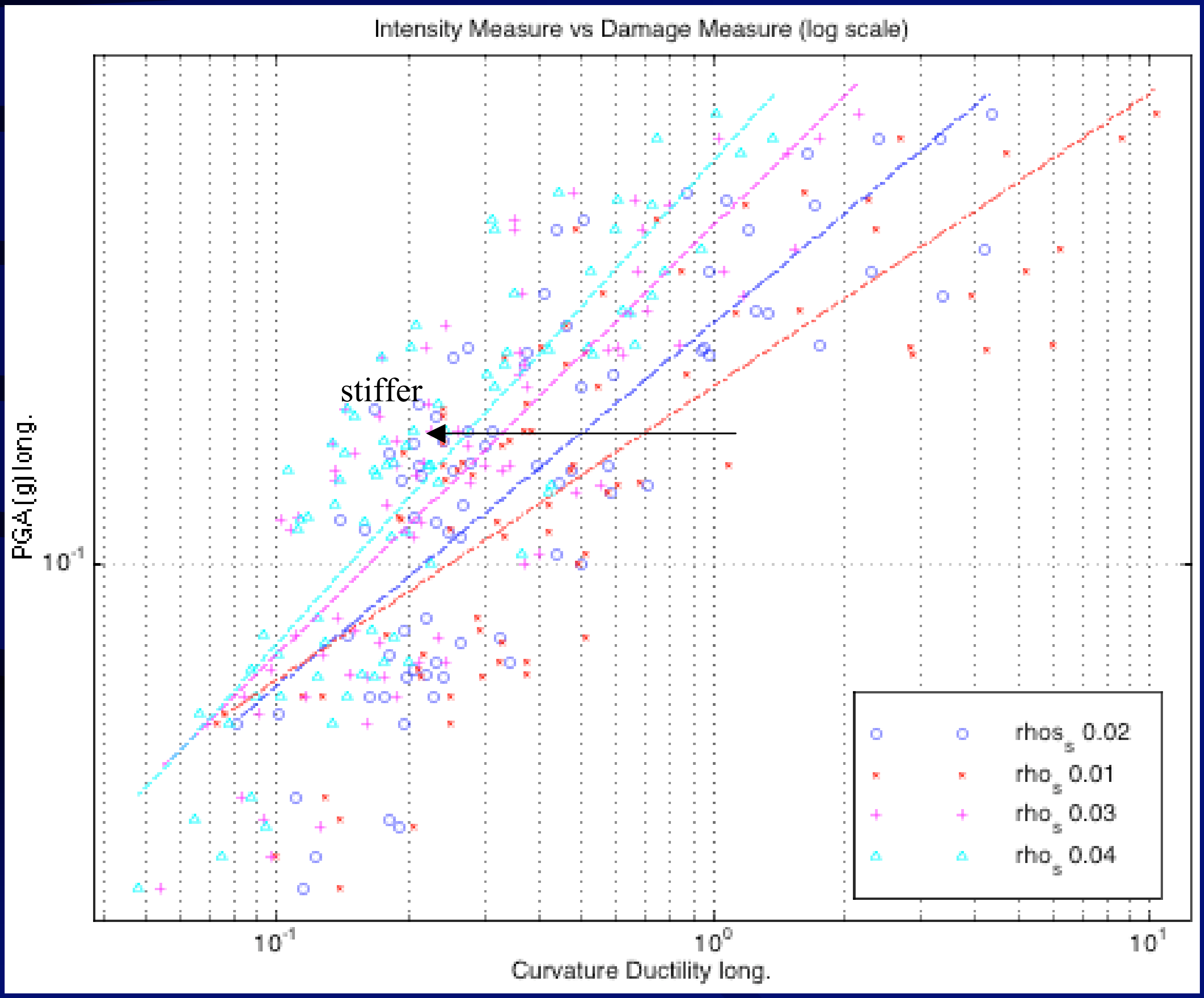
Increasing strength lowers demand, high scatter

Seismicity - PGA vs □□



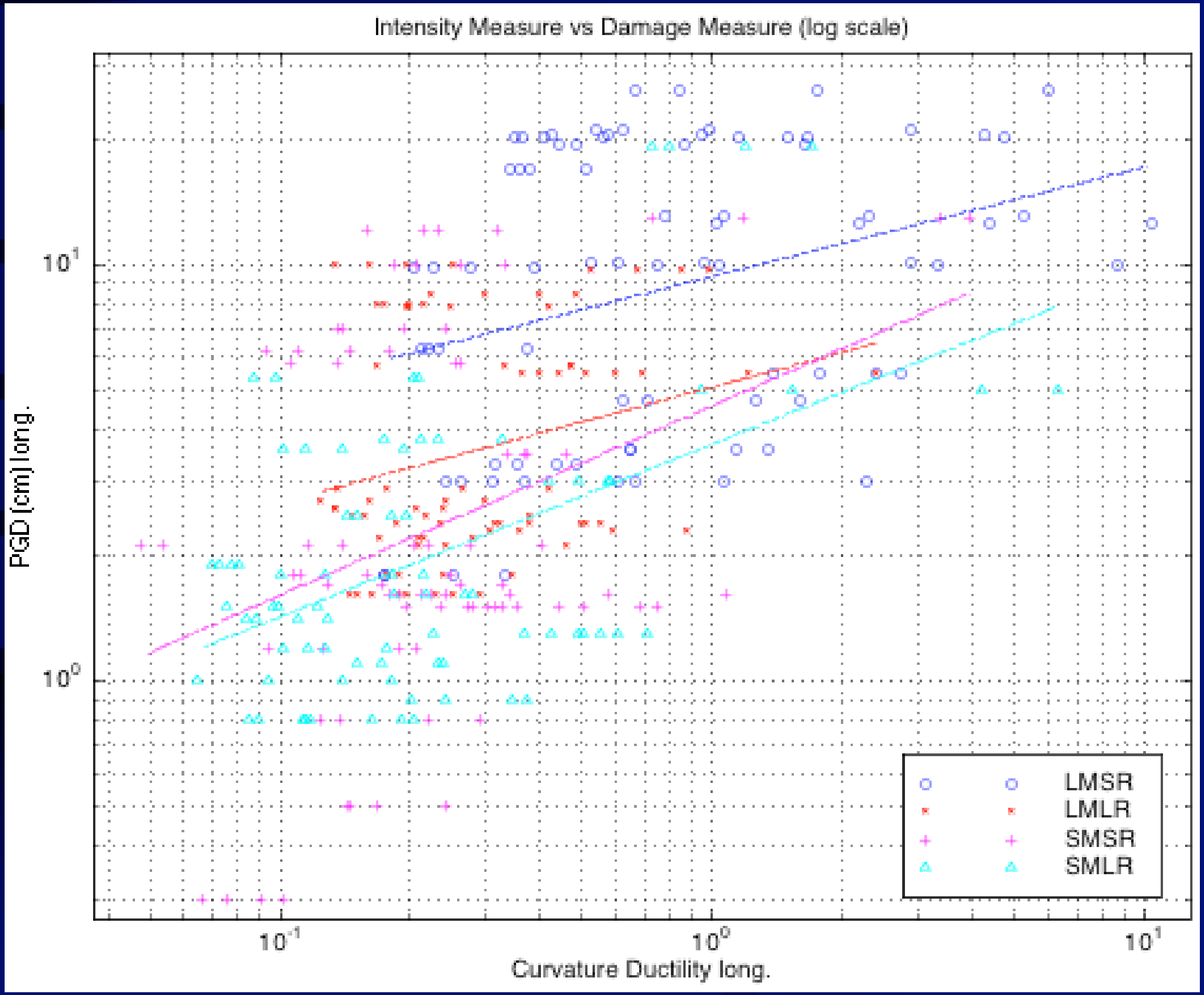
□s

Design Parameters - PGA vs



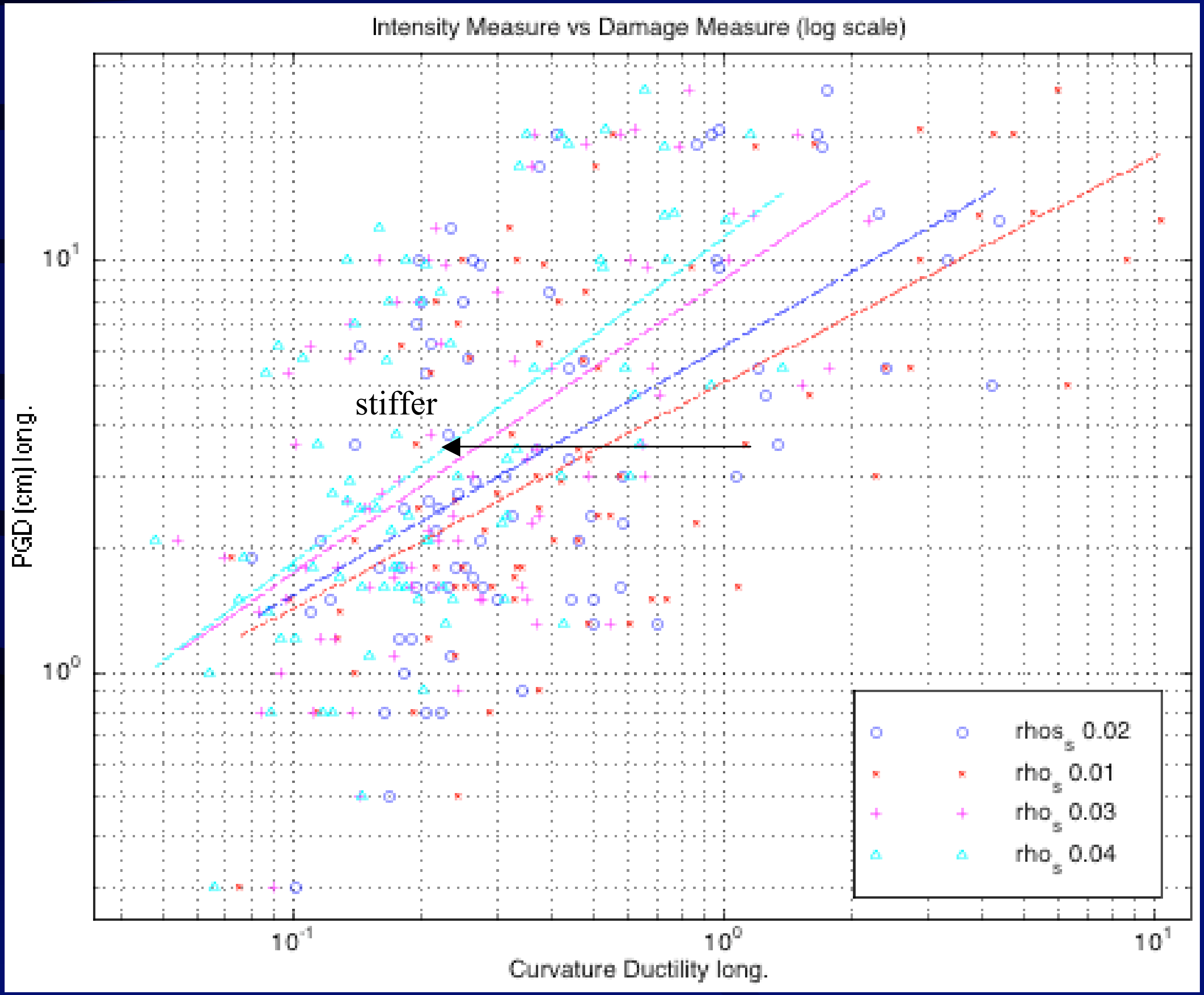
Increasing strength lowers demand

Seismicity - PGD vs [illegible]



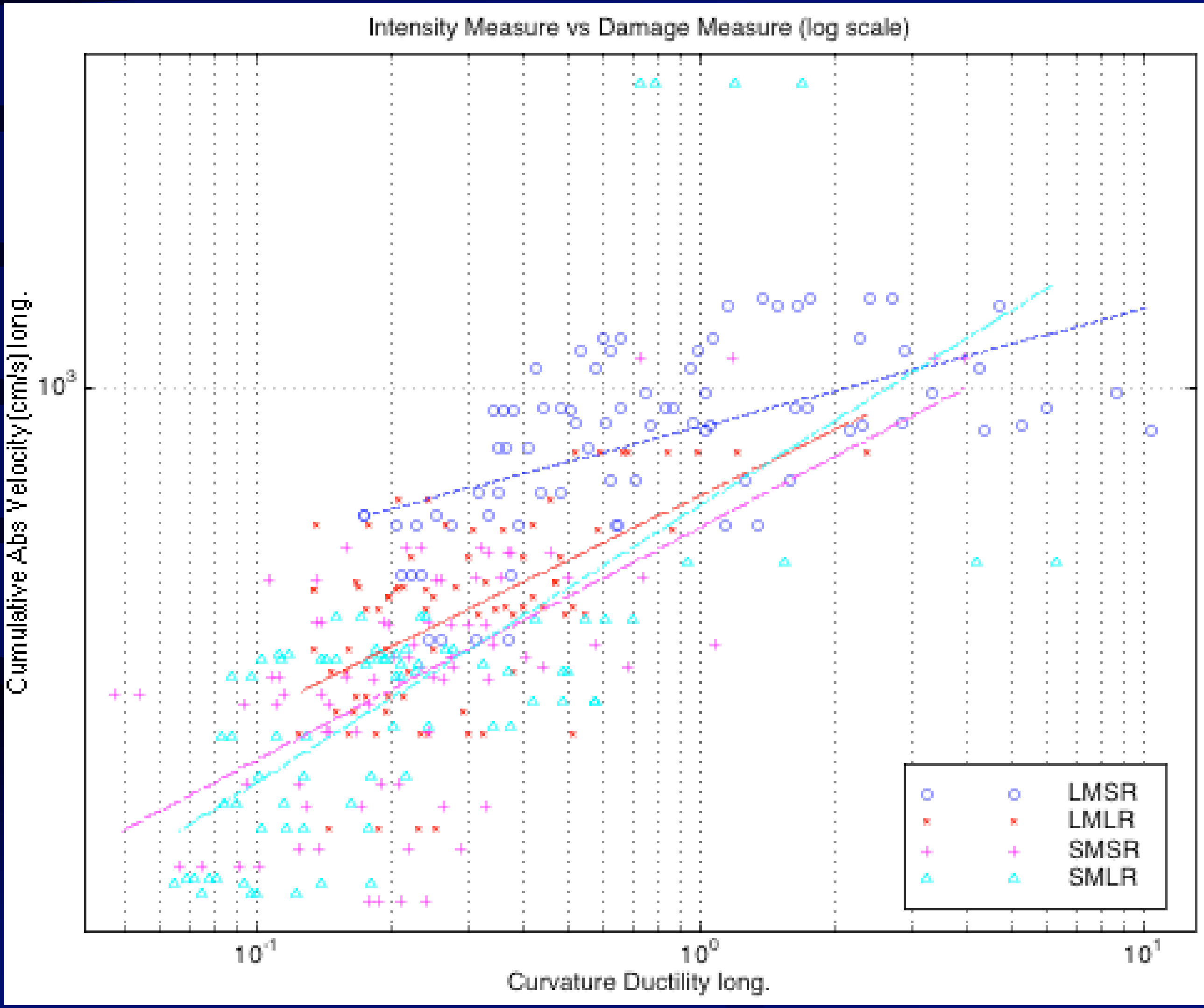
[illegible]s - poor IM choice

Design Parameters - PGD vs □□



Poor IM choice

Seismicity - CAV vs



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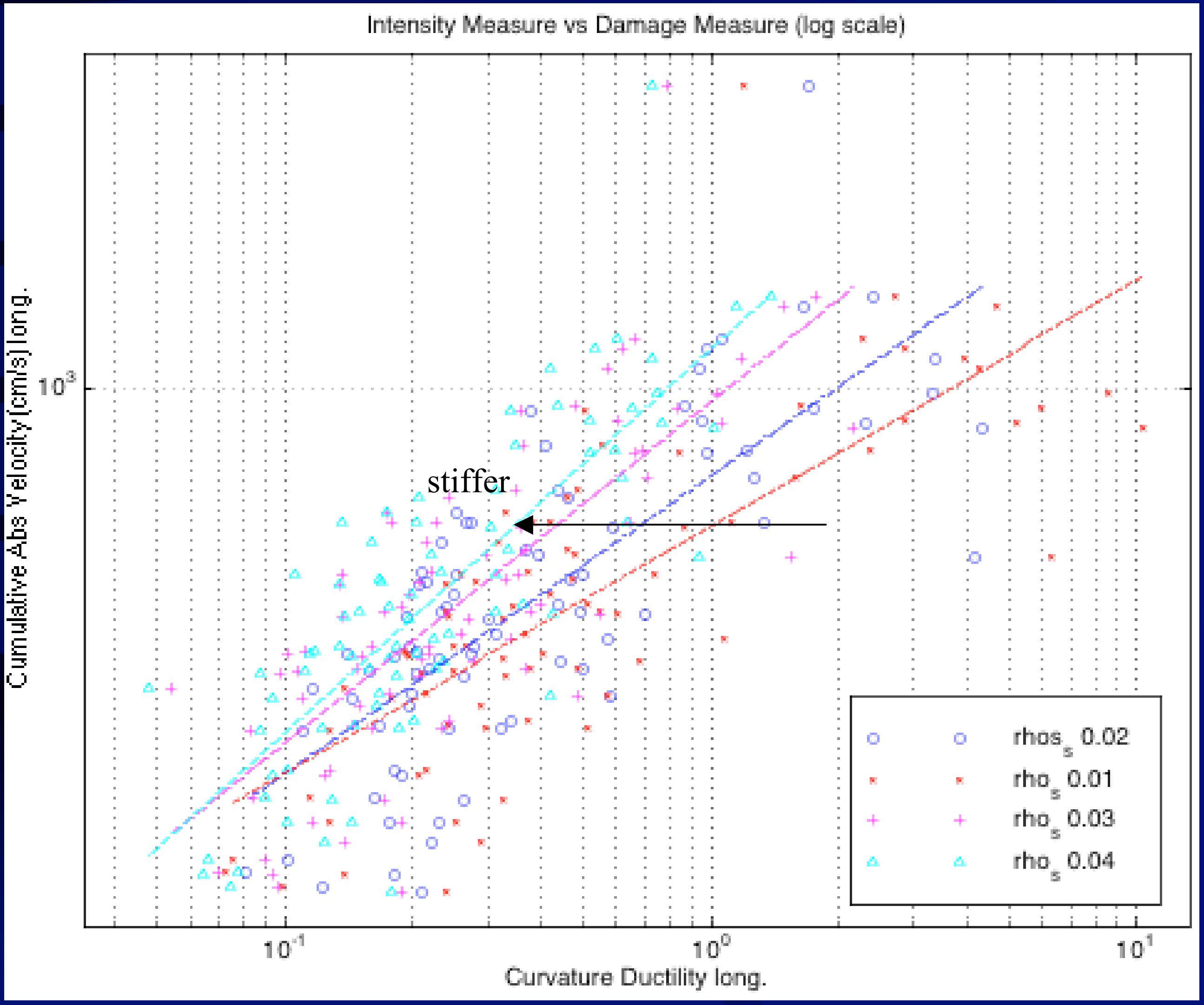
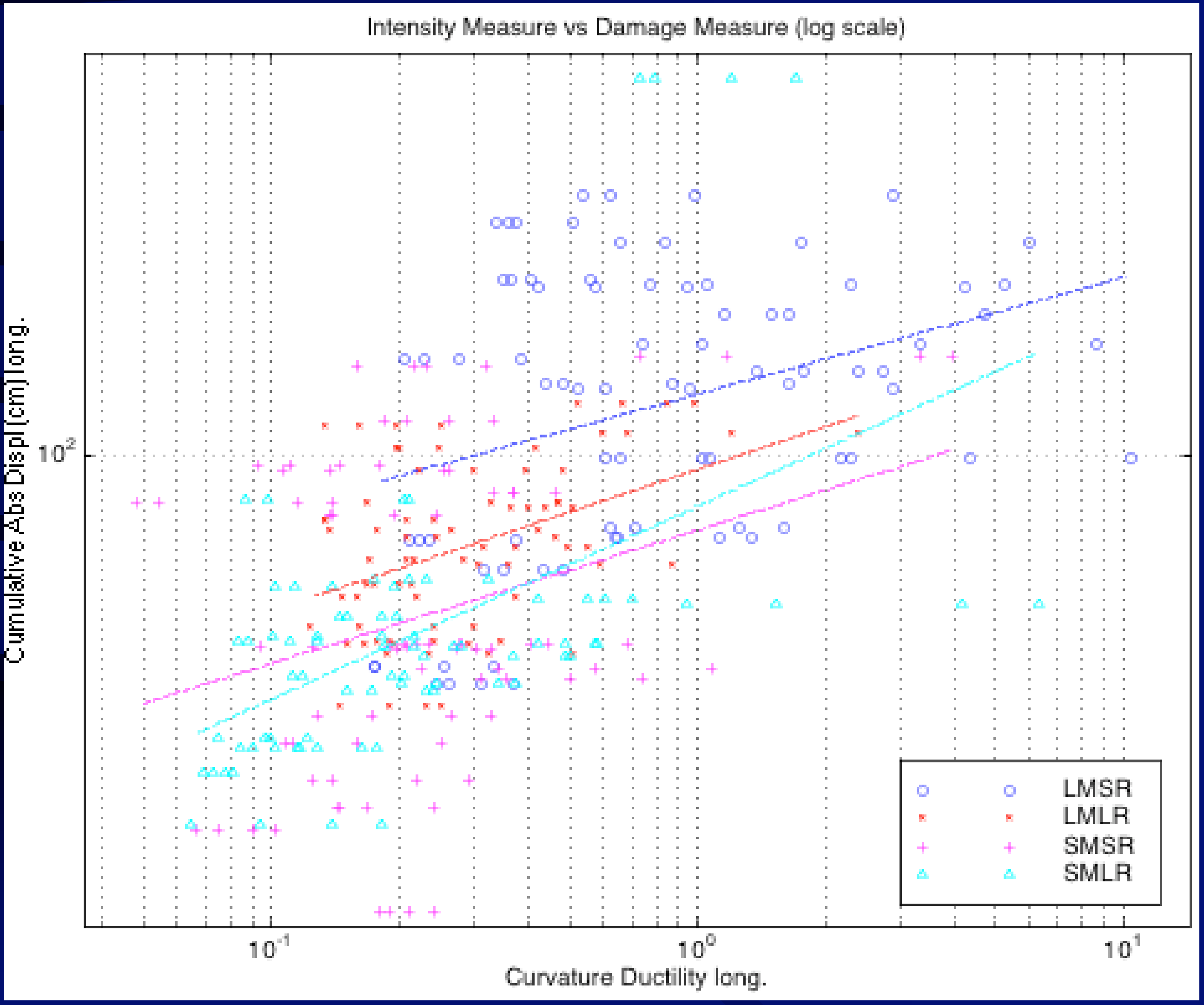
Design Parameters - CAV vs □□



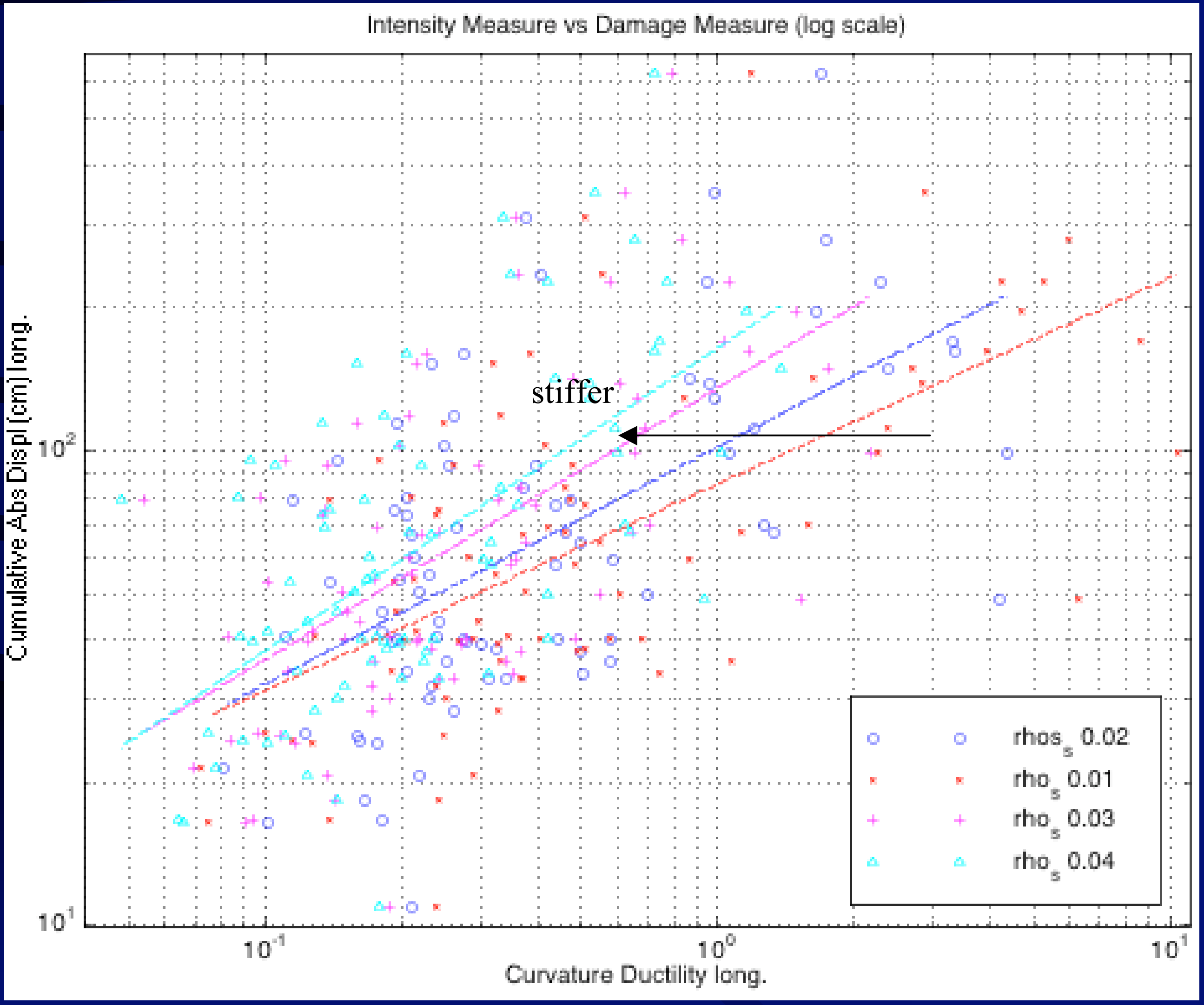
Increasing strength lowers demand

Seismicity - CAD vs



s - poor IM choice

Design Parameters - CAD vs



Poor IM choice

Current Status

- All ground motions and all bridge parameters successfully run
- Specific bridge has complete database of all IM-DM combinations
- Abutment dominated performance for short bridge creates long/trans data discrepancy

Immediate Future

- Evaluate all DM-IM combinations and trends
- Refine abutment model
- Address other bridge configurations with select few DM-IM pairs
- M, R dependence of DM
- Comparison with SDOF and simpler analysis techniques

Conclusion

- Formulate a demand model that fits into PEER performance-based design framework
- Allow designers to see the effects of:
  - seismicity
  - design parameters

  on seismic performance of a bridge