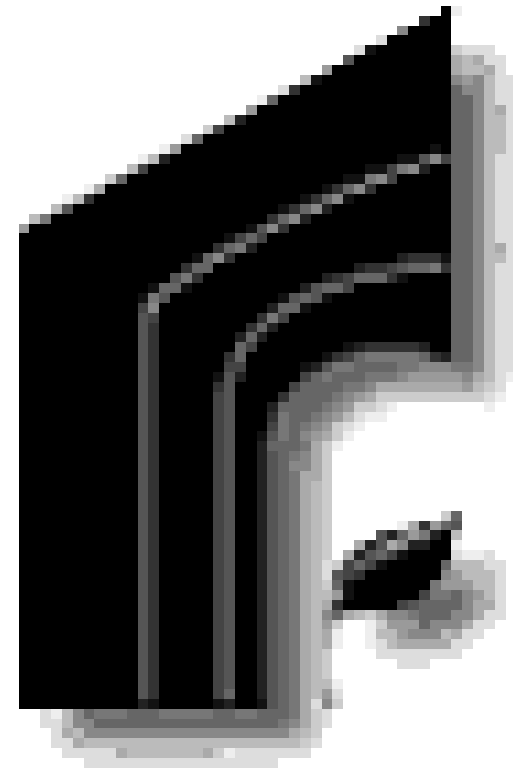


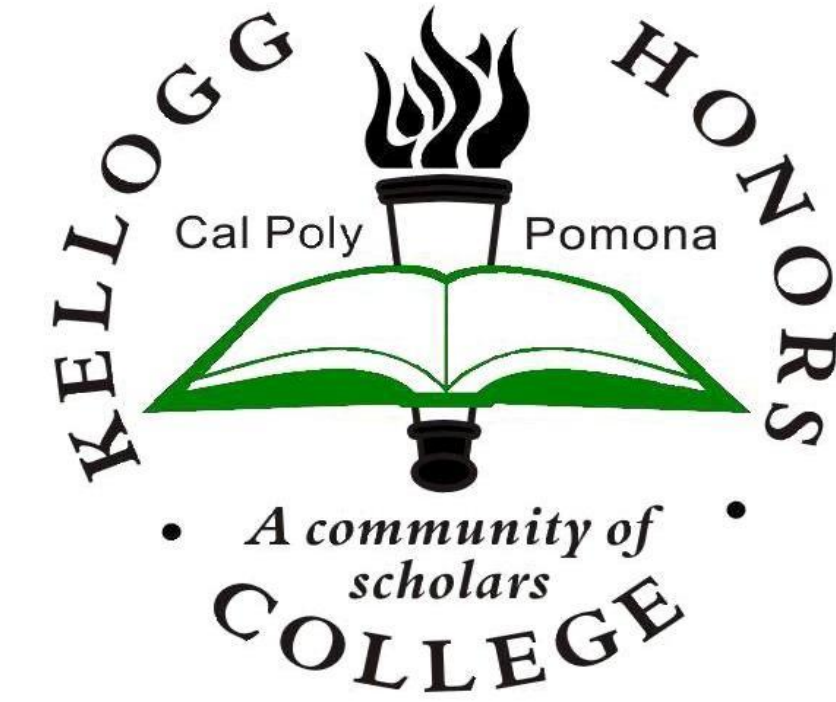
INCREMENTAL DYNAMIC ANALYSIS FOR NON-LINEAR SEISMIC ENERGY DEMAND ESTIMATION



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Kellogg Honors College Capstone Project

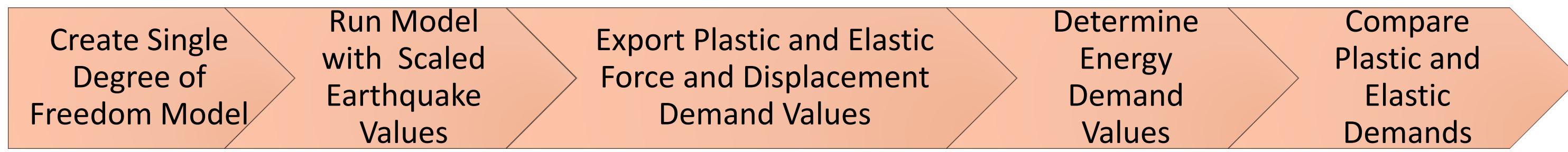


OBJECTIVE

Goal

Investigate the feasibility of using Incremental Dynamic Analysis curves to estimate seismic energy demand in comparison to traditional displacement demand.

Method



INTRODUCTION

Commonly Used Methods

- Force Based Design (FBD)
- Displacement Based Design (DBD)

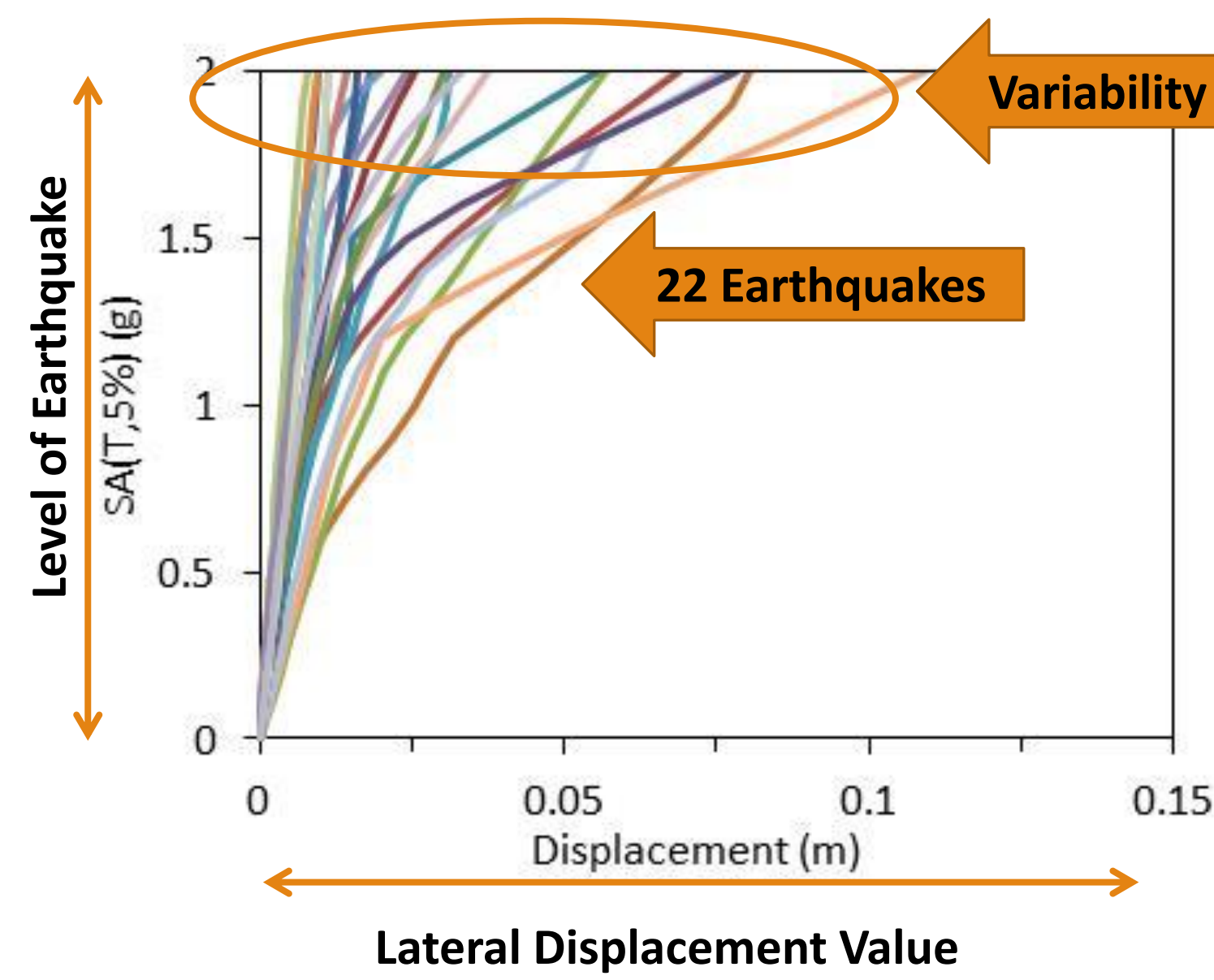
Current Limitations

- FBD is inherently **inaccurate** due to the adjustment factors used to estimate inelastic behavior
- DBD **assumes** an elastic-perfectly plastic behavior

Proposed Alternative

- Energy Based Design (EBD)
- Accounts for **both** the force and displacement demand values
- No assumptions** are made about the inelastic behavior of the structure
- Incremental Dynamic Analysis** to determine the energy demand

Incremental Dynamic Analysis (IDA)

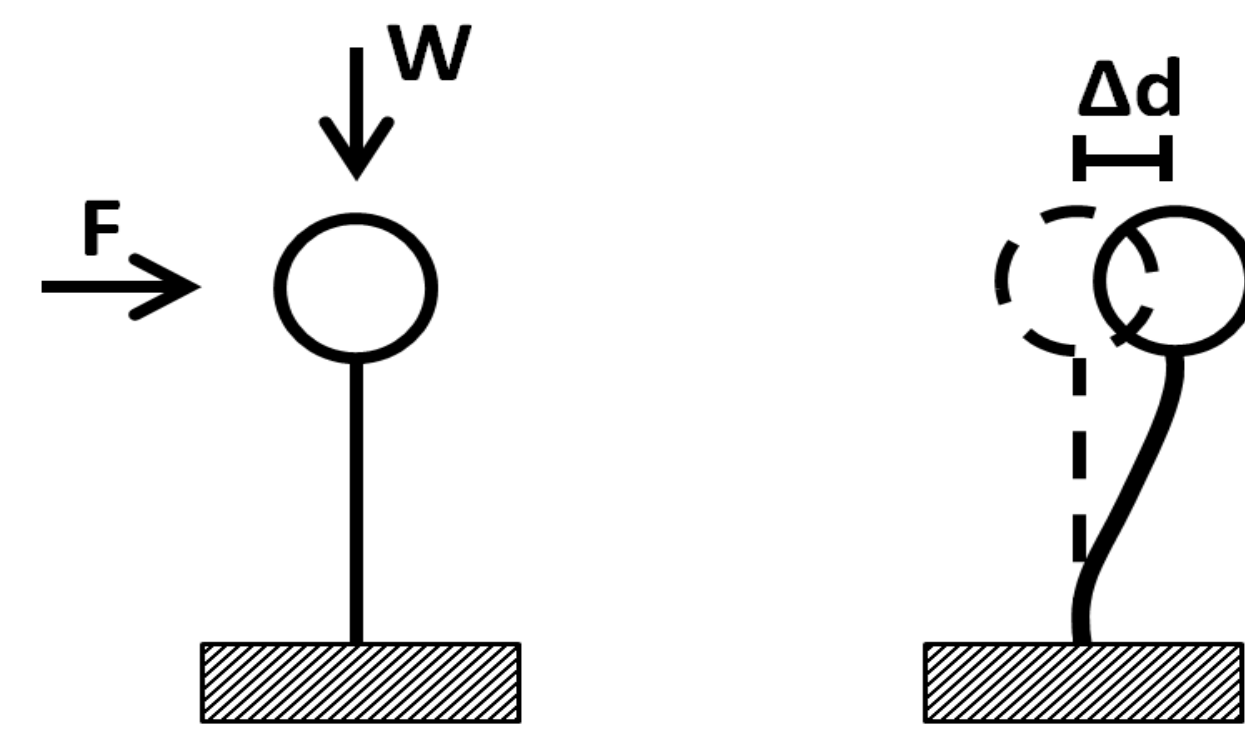


- Proposed by Vamvatsikos in 2002
- Used to determine displacement demand and capacity
- Never before applied to energy

OVERVIEW

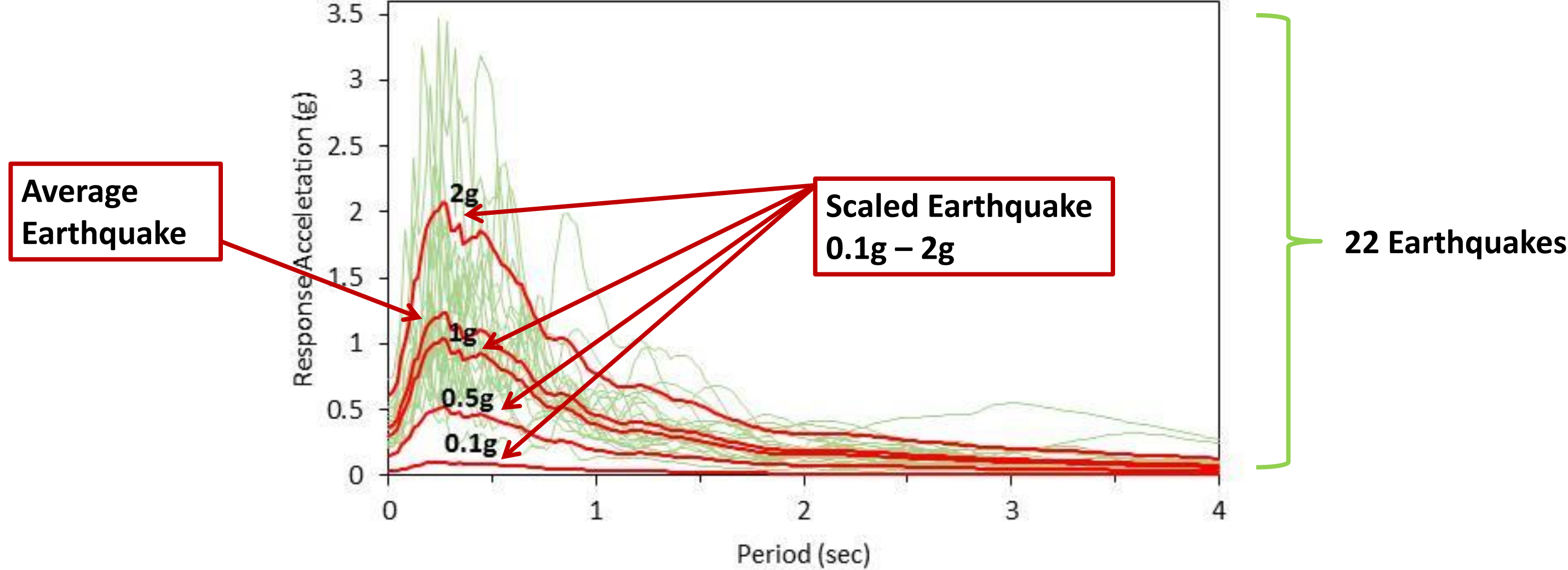


- Typical reinforced concrete highway bridge bent used for case study

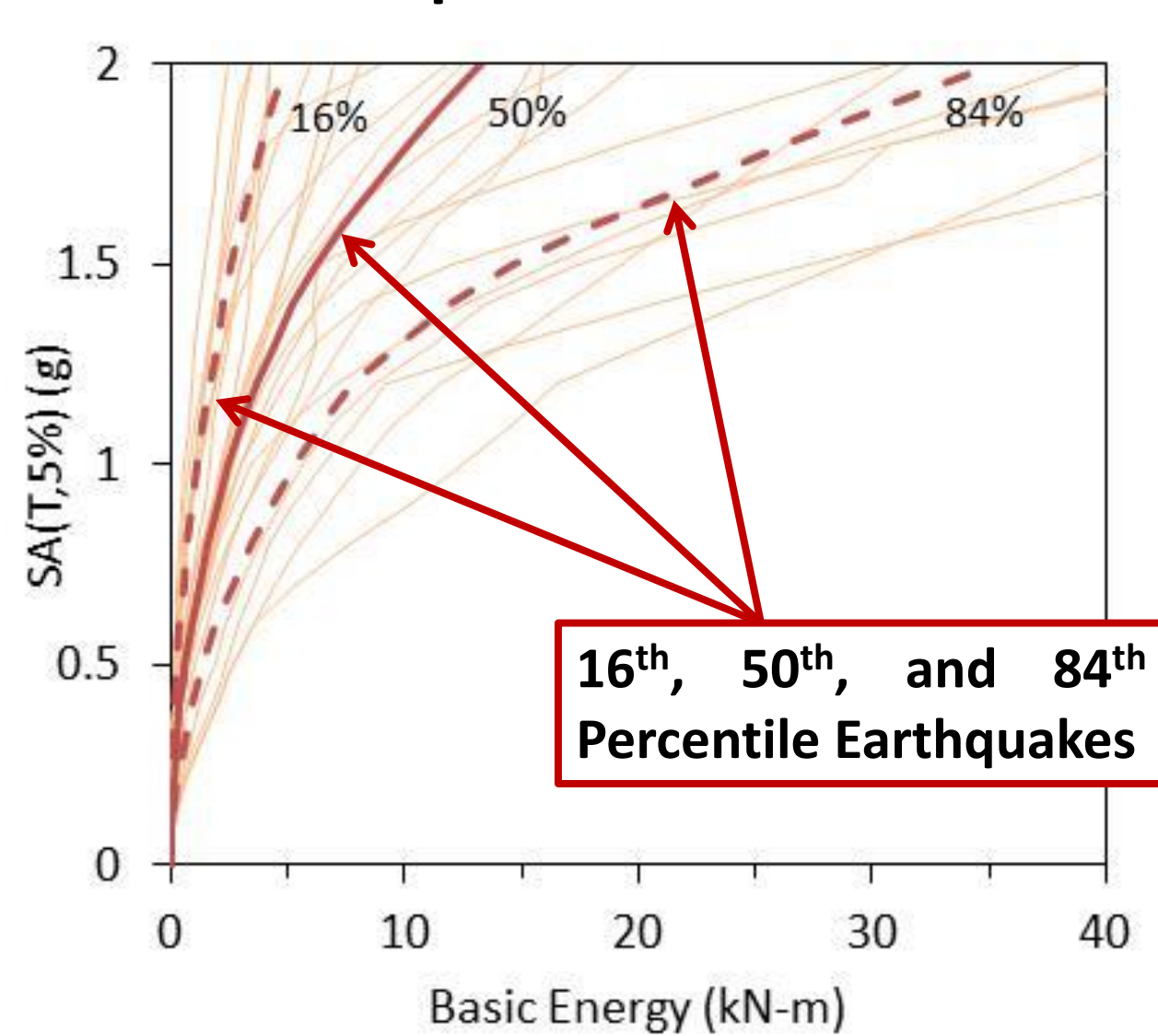


- Idealized as a lumped mass single degree of freedom (SDOF) system
- Supports a weight (W) of 1240 kN

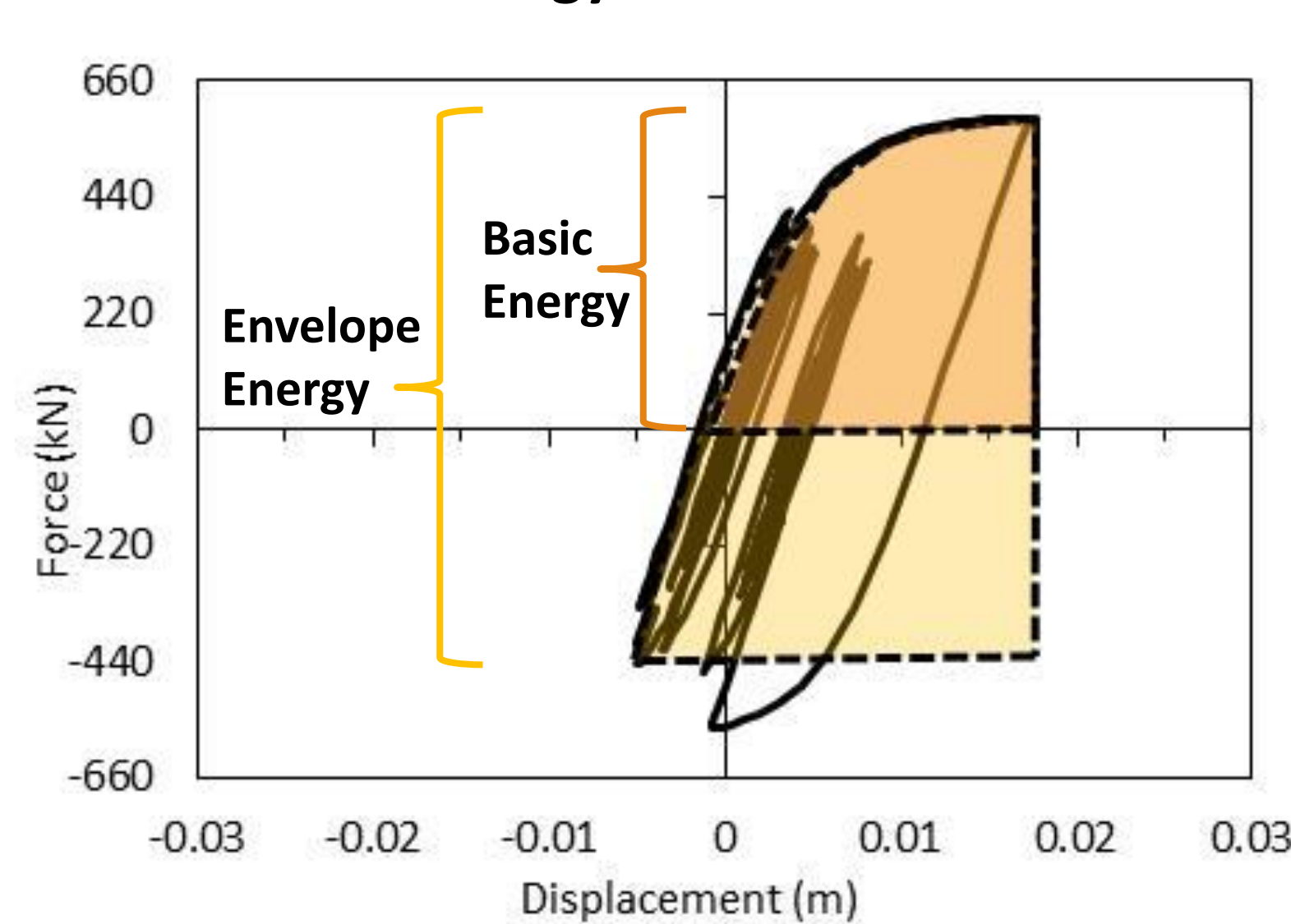
Spectral Response Acceleration Graph



Sample IDA Curve Results

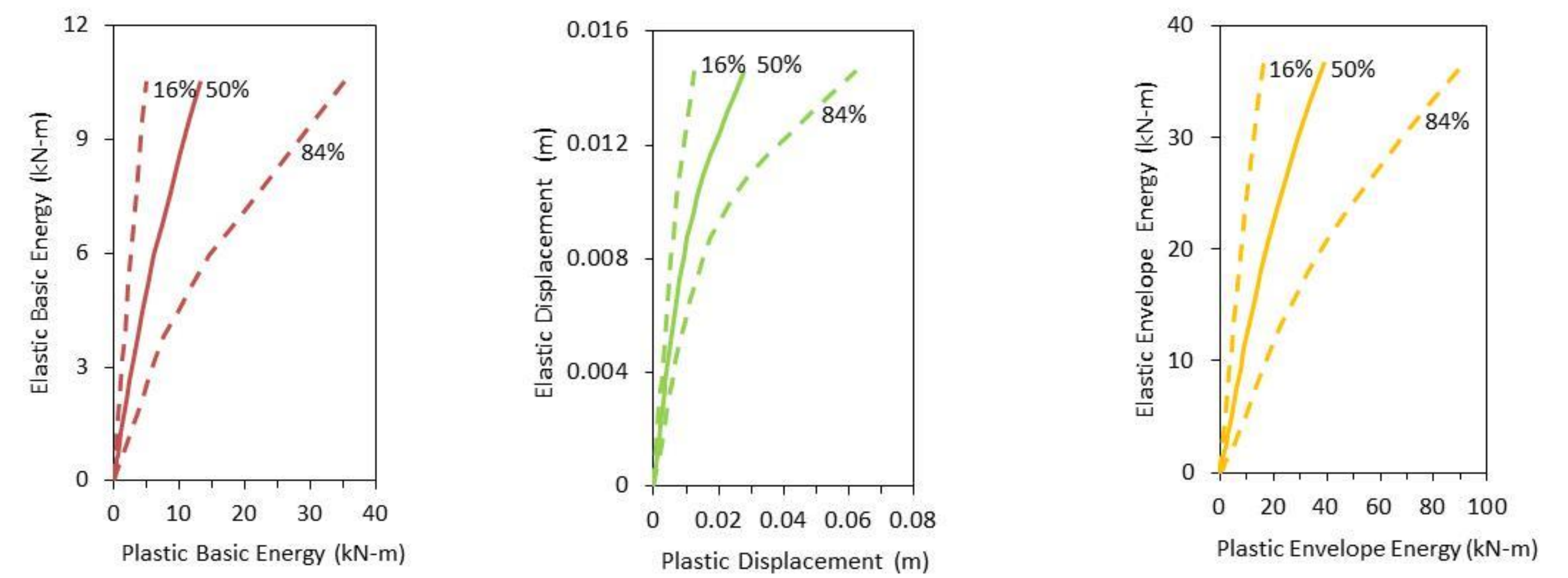


Energy Demand



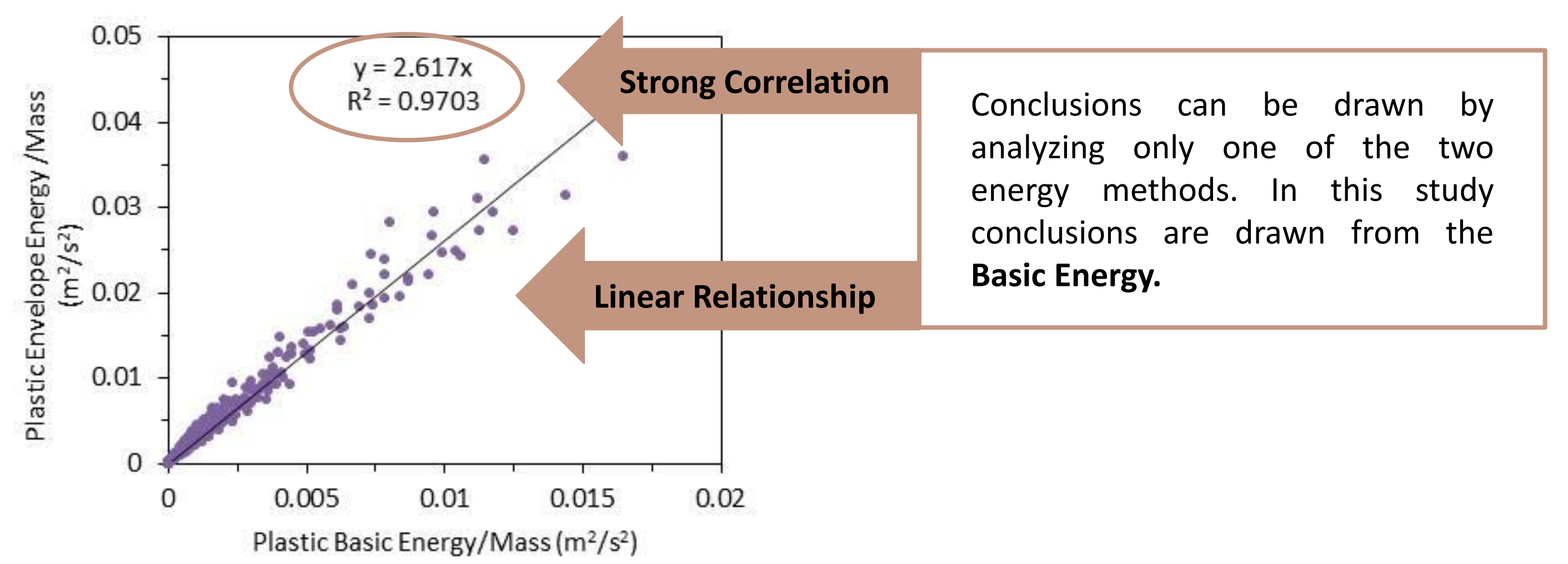
RESULTS

IDA Elastic and Plastic Demand Correlation Comparison



The IDA curves above are used to directly compare the elastic to plastic demands. A linear correlation would indicate that the plastic demand can be predicted using the elastic demand.

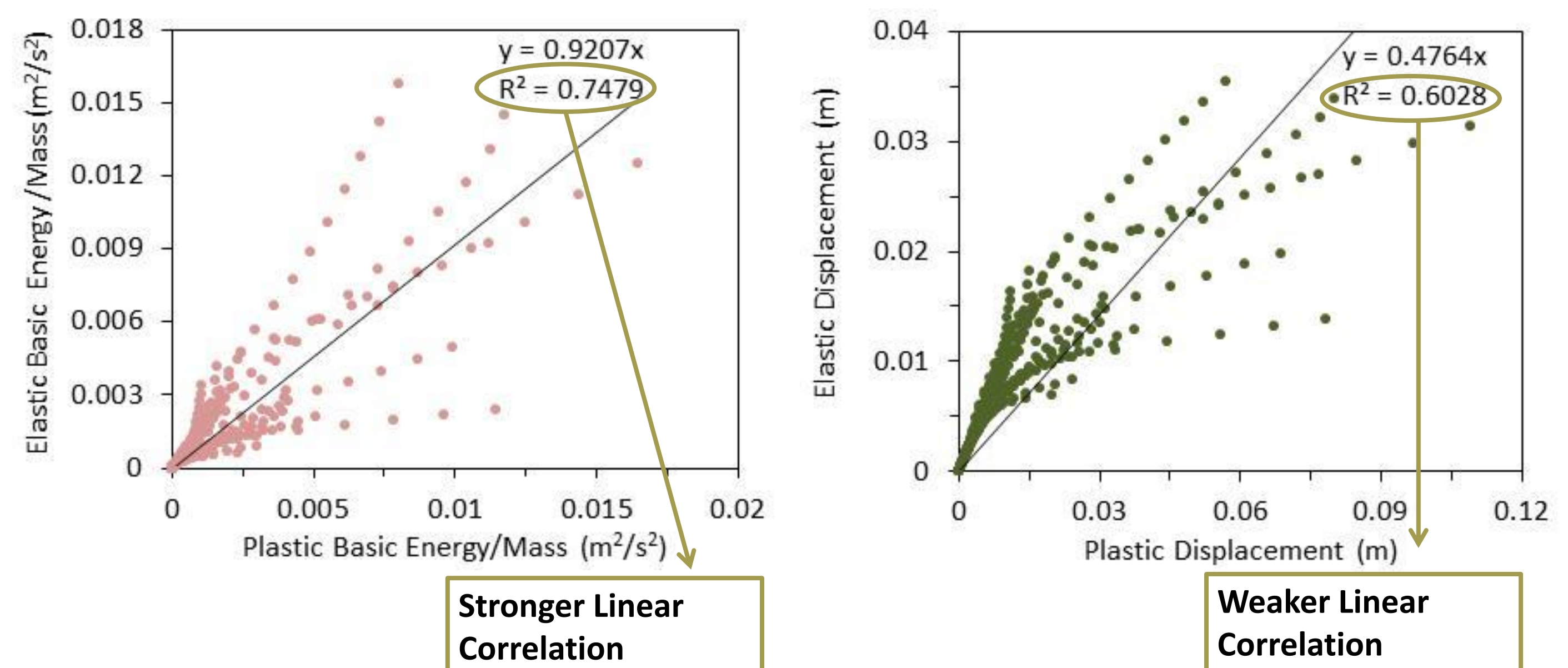
Plastic Envelope and Basic Energy Correlation Comparison



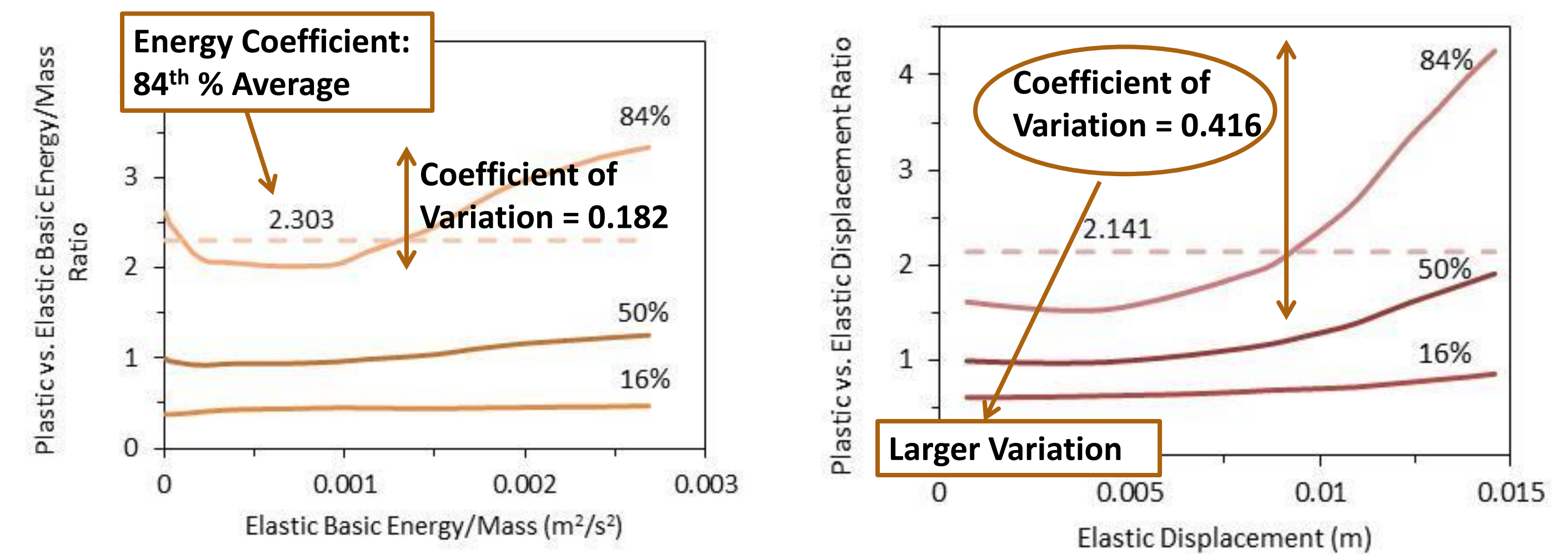
Conclusions can be drawn by analyzing only one of the two energy methods. In this study conclusions are drawn from the **Basic Energy**.

CONCLUSION

Energy vs. Displacement Elastic and Plastic Demand Correlation Comparison



Energy and Displacement Coefficient



Final Thoughts:

From this study, it can be seen that EBD is a viable alternative to traditional design procedures. The elastic and plastic energy demands have a stronger linear correlation in comparison to elastic and plastic displacement demands. In using a coefficient to convert elastic demand into plastic demand, displacement based methods were shown to have larger variation. Both these results indicate that the plastic demand can more easily be estimated using EBD methods.

Further investigations should be conducted on different highway bents. This would serve as a means to verify conclusions drawn from this study. EBD should also be investigated in different materials. It would be beneficial to study the practicality of EBD based on different material properties.

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