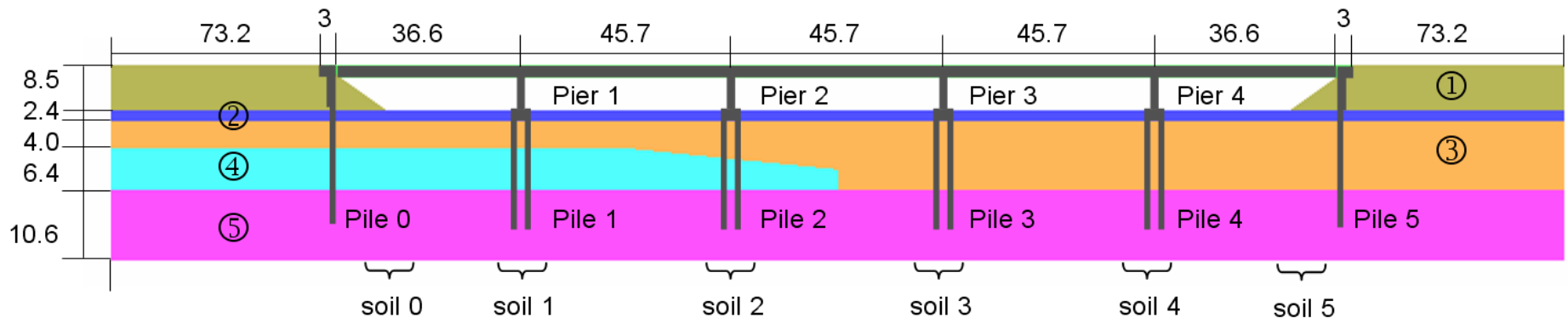# Experiences with PEER methodology

Example: Performance of a highway bridge in liquefiable soil

Five-span reinforced concrete bridge with prestressed box girder deck

Typical for Caltrans – designed by consultant to Caltrans

Experiences with PEER methodology

PEER integral

$$\lambda(\boldsymbol{DV}) = \iiint G(\boldsymbol{DV} \mid \boldsymbol{DM}) \big| dG(\boldsymbol{DM} \mid \boldsymbol{EDP}) \big\| dG(\boldsymbol{EDP} \mid \boldsymbol{IM}) \big\| d\lambda(\boldsymbol{IM}) \big|$$
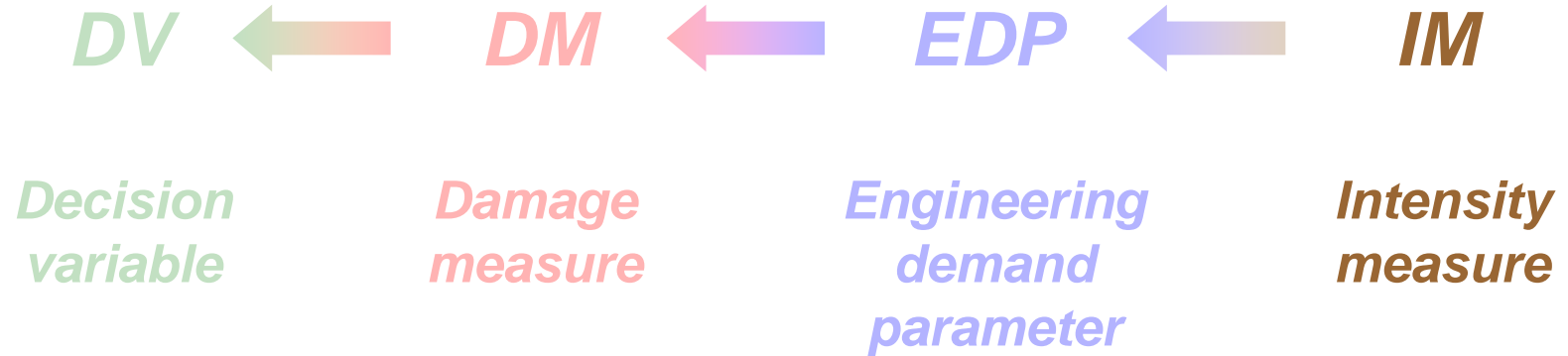
DV ← **DM** ← **EDP** ← **IM**

Decision variable   *Damage measure*   *Engineering demand parameter*   *Intensity measure*

Experiences with PEER methodology

PEER integral

$$DV \quad \longleftarrow \quad DM \quad \longleftarrow \quad EDP \quad \longleftarrow \quad IM$$

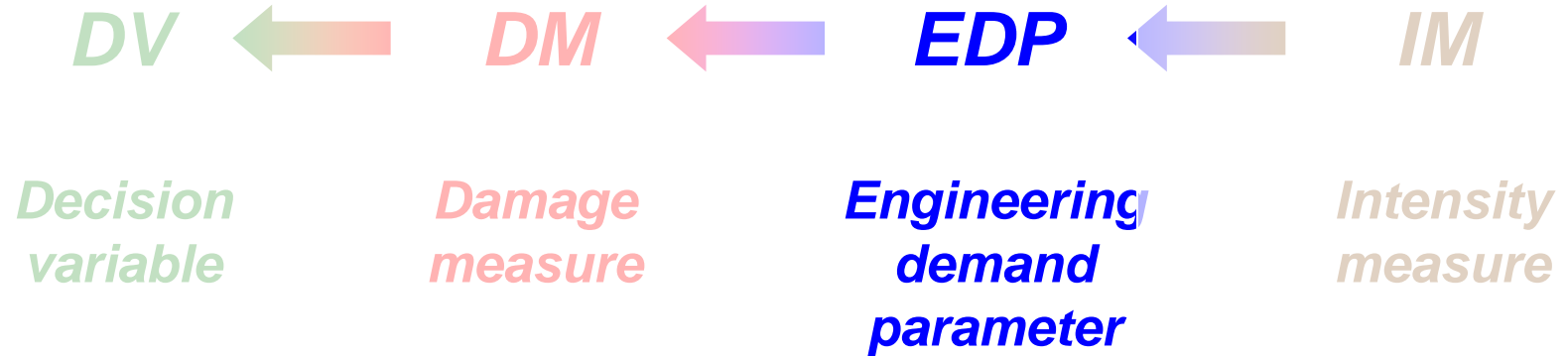| *Decision variable*	*Damage measure*	*Engineering demand parameter*	*Intensity measure*

Conventional *IM*s (*PGA*, S_a, etc.) may not be best

Vector *IM*s may allow better prediction of response

Experiences with PEER methodology

PEER integral

DV ⬅ *DM* ⬅ **EDP** ⬅ *IM*

Decision variable *Damage measure* **Engineering demand parameter** *Intensity measure*

Modeling entire system may be helpful

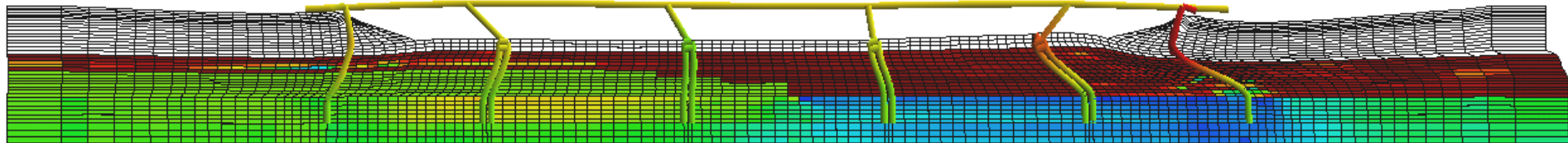Unanticipated system behavior may occur

PEER Performance-Based Framework

Example: Performance of a highway bridge in liquefiable soil

Five-span reinforced concrete bridge with prestressed box girder deck

Typical for Caltrans – designed by consultant to Caltrans

Displacements exaggerated by factor of 20

Liquefiable soil liquefies

Lateral spreading at both abutments – more on right than left
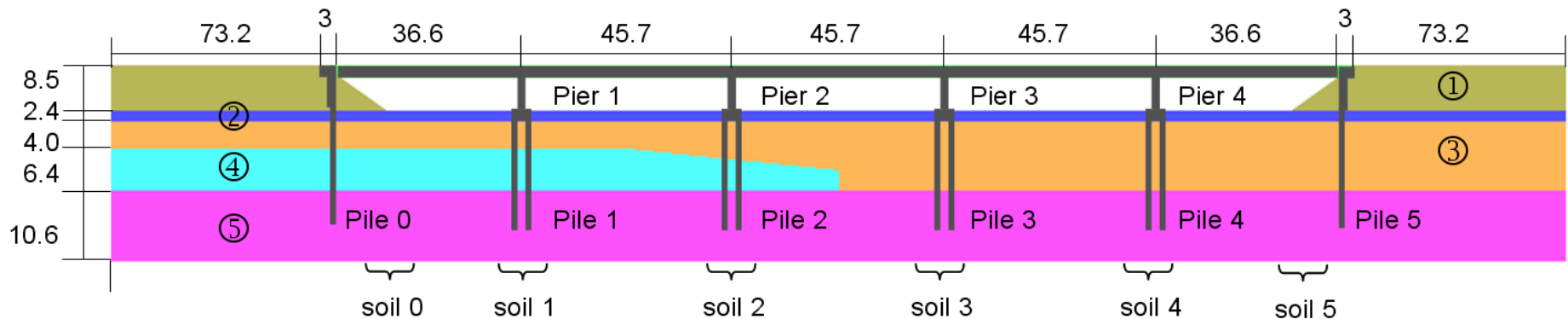
Bridge deck translates 20 cm to left

Drift ratio for left columns greater than right columns

PEER Performance-Based Framework

Example: Performance of a highway bridge in liquefiable soil

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Example: Performance of a highway bridge in liquefiable soil

Five-span reinforced concrete bridge with prestressed box girder deck
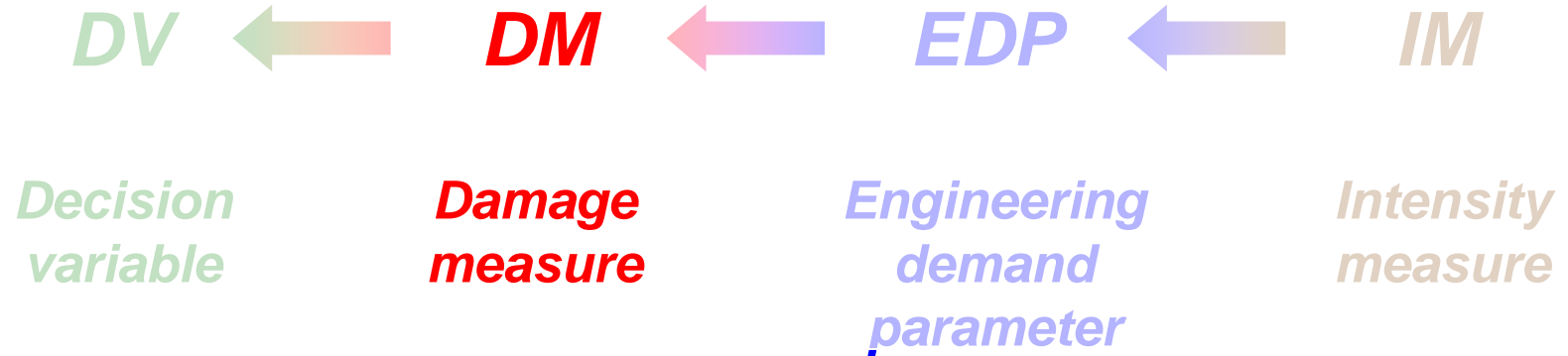
Typical for Caltrans – designed by consultant to Caltrans
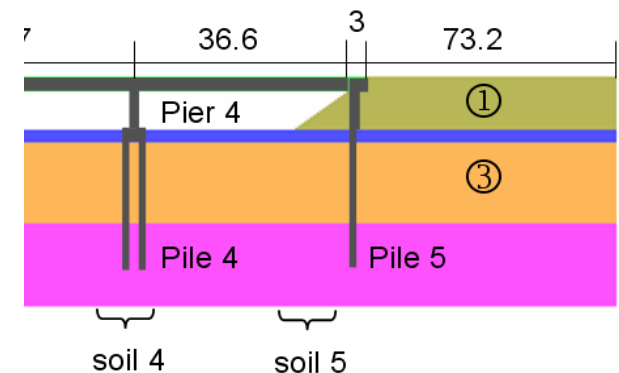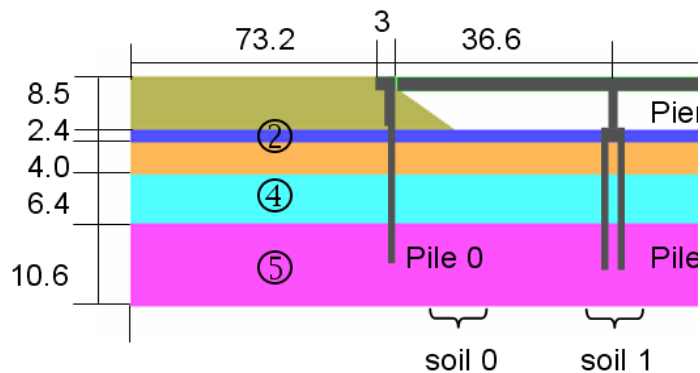
Can miss important damage mechanisms
by analyzing system in parts

Experiences with PEER methodology

PEER integral

DV ← *DM* ← *EDP* ← *IM*

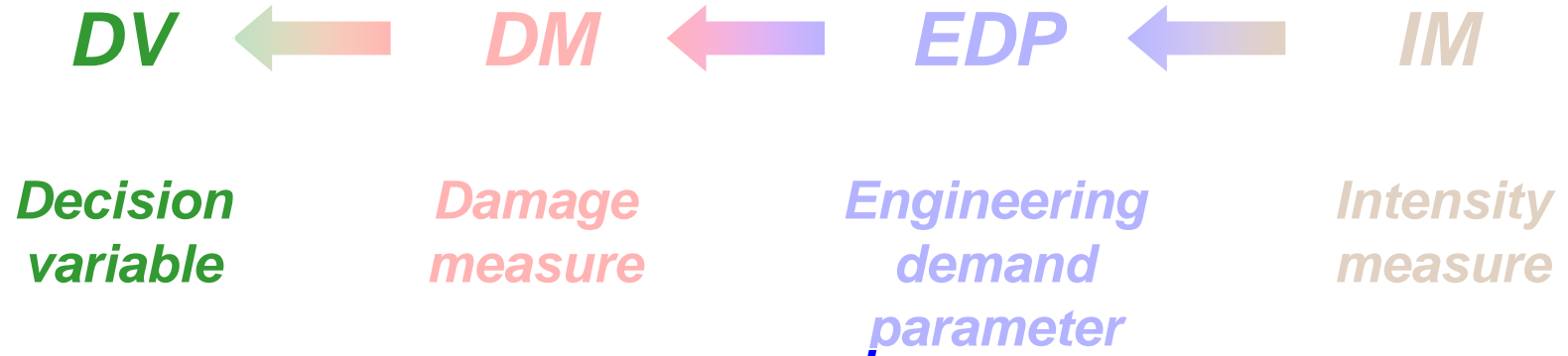**Decision variable** **Damage measure** **Engineering demand parameter** **Intensity measure**

Predicting damage given response is difficult

Need improved characterization of "allowable" displacements

Experiences with PEER methodology

PEER integral

$$DV \longleftarrow DM \longleftarrow EDP \longleftarrow IM$$

Decision variable   **Damage measure**   **Engineering demand parameter**   **Intensity measure**
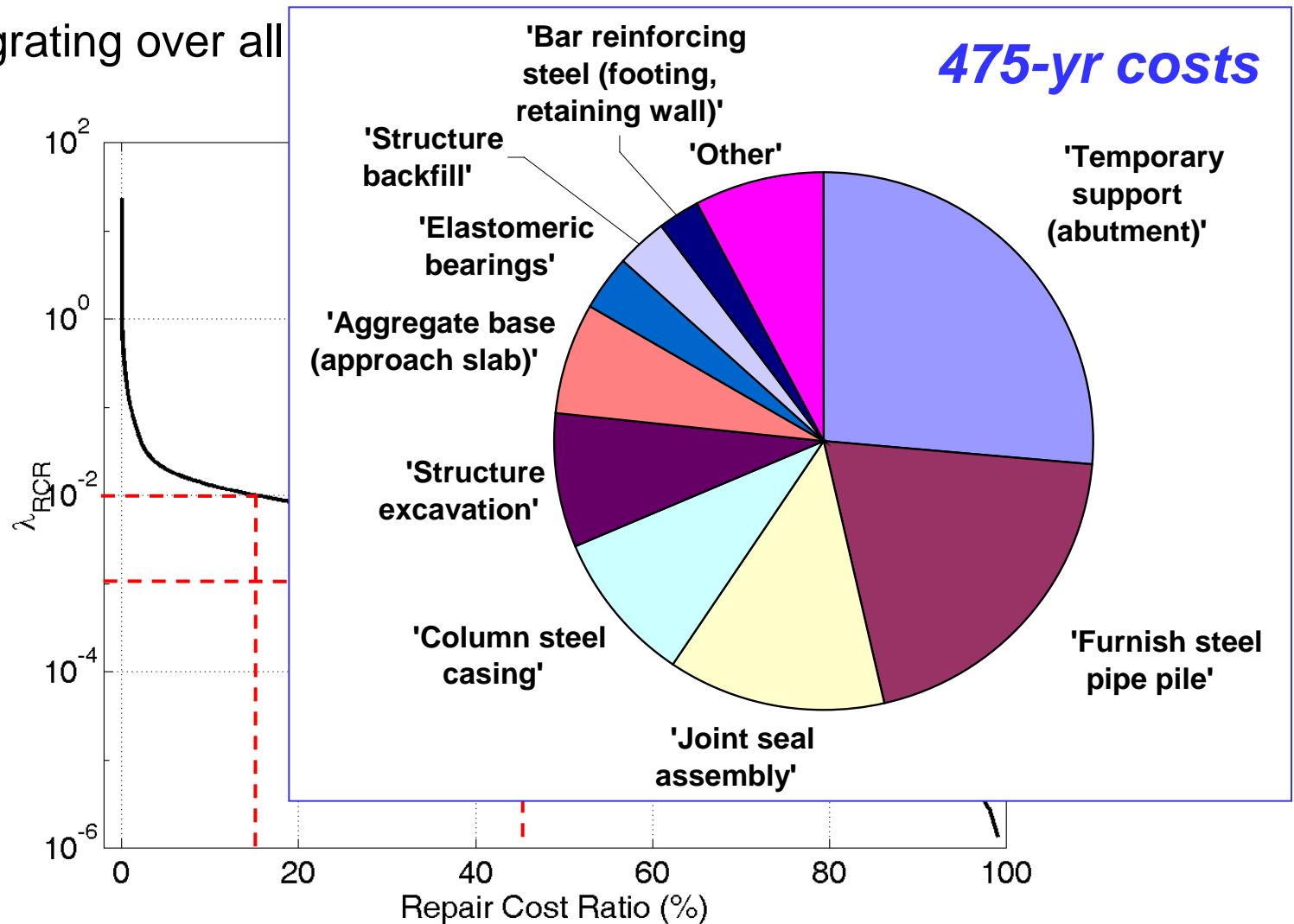
Predicting loss given damage is difficult

Need improved prediction of losses ($$$, downtime)

Experiences with PEER methodology

Example: Performance of a highway bridge in liquefiable soil

Integrating over all

Experiences with PEER methodology

Summary

$$\lambda(\boldsymbol{DV}) = \iiint G(\boldsymbol{DV} \mid \boldsymbol{DM}) \big| dG(\boldsymbol{DM} \mid \boldsymbol{EDP}) \big\| dG(\boldsymbol{EDP} \mid \boldsymbol{IM}) \big\| d\lambda(\boldsymbol{IM}) \big|$$

- PEER integral is powerful, useful tool

- Can also be pain in the (*choose body part*)

- Requires honest, objective assessment of uncertainties

- Main challenges are in implementation

  - Balance of rigor and convenience

  - Need to allow for judgment and experience

  - Need to recognize benefits of good engineering