Seismic Resilience of a Carbon Black Plant and the Importance of its Industry Specific Components

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Motivation

Economic Loss

Community

Human Lifes

RESILIENCE

Environment
Carbon Black
Process Flow

STORAGE
SALES

MILLING

WASTE GAS
ENERGY PRODUCTION

REACTION

TANKS
Milling Tower

Equipment:

• Supports at 1\textsuperscript{st} floor surrounding Buildings
• Braced in X direction
• Moment Resisting Frame in Y direction
• 30 ton Top Tank (300m\textsuperscript{3} 100g/l)
• 10 ton Bottom Tank
• Connection with a Bolted Flange Joint
Push Over

Push Over X
• The Tower shows a **good stiffness distribution** over its height.
• A significant Load resistance can be achieved

Push Over Y
• A **weak story** shows failure first.
• Responsible for **system and component failure**
Damage States

- **Damage State 1**: Loss of Containment LOC Bolted Flange Joint. **Drift: 0.2 %**
- **Damage State 2**: Plastic deformation of Bolted Flange Joint. **Drift: 0.5 %**
- **Damage State 3**: Minor Structural Damage and Equipment failure
- **Damage State 4**: Major structural Damage occurs
- **Damage State 5**: Collapse of the Structure
Seismic Hazard

- Priolo Gargallo
- Very high seismizity
- Hazard curve shows the likelihood of observing an EQ with specific IM
Cloud Analysis

• Probability of reaching each Damage State
• 140 Ground Motions

Response Spectrum of Ground Motions
Cloud Analysis

Interstory Drift $Sa_{0.75 \text{ Hz}}$  $R^2 = 0.9$

- DS1: 0.25 %
- DS2: 0.5 %
- DS3: 1.5 %
- DS4: 2.75 %
- DS5: 5.5 %
Assessment

Fragility Sa(0.75Hz)

DS1: 0.25 %
DS2: 0.5 %
DS3: 1.5 %
DS4: 2.75 %
DS5: 5.5 %
\[ P_L (DS) = 1 - (1 - P(DS))^{LC} \]

\[ P(DS) = \int P(EDP|IM)^2P(IM)dIM \]
Resilience

Reduce:

- Area of Loss
- Risk of Failure
- Capacity Loss
- Repair Time

$$R_{LOSS} = \int_{t_E}^{t_R} [100 - C(t)] dt$$
Conclusion

• Resilience provides additional options to the Stakeholder for Loss mitigation

• In Depth Risk analysis of the components crucial to the Resilience calculation