Analysis of Electromagnetic Fields in Urban Environments

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Electromagnetic fields in urban environment

- Electric transmission lines
- Electrical substations
- Rail/Metro systems
- Commuter buses
- Cell towers
Construction industry electrocution

• Leading cause of death (CCRT) – 40 / year
• Average of 411 workers electrocuted each year
• Highest frequency of occurrence among major industry sectors
Construction industry

• Fatal electrocution
  – Body part of electrical circuit
  – Overstimulate nervous system
  – Damage internal organs

• Indirect
  – Burns
  – Falls
Chicago Skyway Bridge

• Workers experienced electrical shock while repairing bridge span
Historic Examples of Worker Shock from Induced Currents

- 1990 Maersk Constellation, Hawaii
  - Workers shocked on cranes and cables
  - Source: AM radio station

- 2001 Kosciuszko Bridge, NYC
  - Workers shocked on man lift
  - Source: AM radio station
  - Demolition of “protective shield” of gas tanks
Chicago Skyway Bridge

- No direct high energy electrical power connection
- No local AM radio stations
- High power electrical transmission lines close to bridge
COMSOL model

- *Magnetic Fields* (mf) physics interface to solve Maxwell’s 2\(^{nd}\) equation:

  \[ \nabla \times \mathbf{H} = \mathbf{J} + \frac{\partial \mathbf{D}}{\partial t} \]

- Three phase power cable represented by *Edge Current* boundary condition

- Simplified geometry of bridge and surrounding structures
COMSOL model: Results

Magnetic field distribution

Electric potential distribution

Current density distribution

\[ I_1 = 738 \text{ mA} \]
\[ I_2 = 8 \text{ mA} \]
\[ I_3 = 15 \text{ mA} \]
Induced Current: Bridge structure

- Time varying magnetic field of power line induces currents in bridge
- Induced currents ~100mA
- Bridge structure represents a ground connection
- Bridge structure unlikely to be source of electrical shock
Induced Potential: Surrounding structures

- Floating potential in Manlift ~600V
- Manlift structure electrically isolated by rubber tires
- Measured potentials validate model predictions
Electrical Shock due to Manlift

- Potential difference of ~600V between manlift and bridge
- Bridge connected to ground
- Worker provides conductive pathway between manlift and bridge
Electrical Shock Mitigation

• Reduce/eliminate potential difference between manlift and bridge
  1. Ground manlift basket to bridge
  2. Ground manlift at the lift base
• Connect conductive jumper cable between bridge structure and manlift basket