Sustainability and Resilience of Infrastructures: Role of Technology

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Natural Disasters and Climate Change

• Hurricanes, earthquakes, floods, will continue to create havocs in our lives, globally in increasing frequencies.  
• Existing infrastructures are in danger more than ever.  
• Urban areas are particularly vulnerable – more and more people will live in urban areas in the future.  
• Sea-level rise
Major hurricanes of 2017 in America, floods in South Asia, Recent earthquakes in Mexico, Nepal, Haiti
Urbanization

In 1950
30% of population lived in cities

In 2050
70% of population will live in cities
Three keywords defining civil/construction engineering in the 21st Century

• Infrastructure
• Sustainability
• Technology
... and they are related

- **Infrastructure**
  - Resilience
  - Efficiency
  - Sustainability

- **Sustainability**
  - Society
  - Environments
  - Economy
  - Technology

- **Technology**
  - Smart products
  - Intelligent processes

**Infrastructure**

- Infrastructure: Infra - below, underneath, beneath; It also means that it is not normally seen or necessarily visible.

- Two types - Civil infrastructure (“horizontal”) and Social infrastructure (“vertical”). All are constructed facilities.
  - Civil infrastructure include two major categories: (1) Transportation infrastructure (bridges, highways, roads, rail, water and airports), and (2) Utility infrastructure (power, water, dams, sewer and waste, fuel lines and communications).

- Educational facilities and hospitals are examples of social infrastructure. Shopping malls and high-rise buildings are not necessarily infrastructure.

- Social infrastructures can be part of the infrastructure system for disaster management (e.g. hurricane shelters).
Sustainability

• But they need to be sustainable. What does sustainability mean?

“sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (Brundtland 1987).

[According to the United Nation’s Brundtland Commission.]

Resilience

• Resilience aims to achieve the robustness and rapid recovery of systems –

• “Resilience is the ability of human communities to withstand external shocks or perturbations to their infrastructure and to recover from such perturbations” (Timmerman 1981).

• Building a resilient structure does not necessarily mean creating a sustainable structure (although often both terms are used together).
Challenges and Opportunities

• Problems/concerns – natural disasters/climate change – man-made?
• Solutions/responses – sustainability/resilience
• Means/Ways/Processes – technology (ICT/digital/engineering)

New Paradigm

• Cities are integrating the Internet of things, new sensor development and deployment, and new ways to get essential data into the hands of decision makers.
• For example, Barcelona is using the Internet of Things to integrate buses and bus stops, parking lot sensors that communicate with cars, and sensors in street lights. All these things are connected to a dynamic management system that improves city efficiency and makes life in the city better.
• Other cities are investigating installing sensors in bridges and other infrastructure to monitor their health.

Today’s civil engineer....

“Civil engineers are being called on to develop integrated (system of systems) strategies to ensure that not only movement of people and goods is efficient but also strategies for resilient power supply, management of water resources and for treating waste as a resource”

- Andrew Comer, BSc CEng FIICE FIHT, Director, Cities Group, BuroHappold Engineering

Opportunities for CEM

- Globalization
- Urbanization
- Demand for sophisticated large scale infrastructure and building projects
- Awareness about sustainability
- Need for interdisciplinary knowledge/skills
- Advances in computing, information and communication technologies
Technology

• Product
  • Materials
  • Renewable energy
  • Equipment (3-D printing)
  • Hardware
  • Robotics
• Process
  • Software
  • Artificial Intelligence
  • Sensor
  • Data Analytics
  • Virtual Reality
  • Internet of Things (IoT)

Dubai Hyperloop
Dubai Hyperloop

IoT

“Constellation of inanimate objects [that] is being designed with built-in wireless connectivity, so that they can be monitored, controlled and linked over the Internet”
- Walt Mossberg

Smart connections

When virtual-world capabilities meet real-world businesses

- Sensors and network technology
- Processes and interactions

### Information and analysis

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<tr>
<td>Tracking behavior</td>
<td>Enhanced situational awareness</td>
<td>Sensor-driven decision analytics</td>
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<td>Monitoring the behavior of persons, things, or data through space and time. Examples: Presence-based advertising and payments based on locations of consumers. Inventory and supply chain monitoring and management.</td>
<td>Achieving real-time awareness of physical environment. Example: Smoke detection using detection of sound to locate shooters.</td>
<td>Assisting human decision making through deep analysis and data visualization. Example: DNA test results validated with 3D visualization and simulation. Continuous monitoring of chronic diseases to help doctors determine best treatments.</td>
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### Automation and control

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<td>Process optimization</td>
<td>Optimized resource consumption</td>
<td>Complex autonomous systems</td>
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<td>Automated control of non-fixed (self-contained) systems. Example: Maximization of line throughput via wireless sensors. Continuous, precise adjustments in manufacturing lines.</td>
<td>Control of consumption to optimize resource use across network. Example: Smart meters and energy grids that match loads and generation capacity in order to lower costs. Data-center Management to optimize energy storage, and processor utilization.</td>
<td>Automated control in open environments with great uncertainty. Example: Collision avoidance systems to sense objects and automatically apply brake. Clean-up of hazardous materials through the use of swarms of robots.</td>
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### 4 big ways IoT is impacting design and construction

- **Building Information Modeling** – Data from IoT sensors can be pulled into the BIM to model energy usage patterns, temperature trends, people movement, etc.
- **Green Building** – driving towards sustainable architecture and construction. IoT can help engineer buildings so that they can shut down unnecessary systems automatically when unoccupied, and to optimally function building amenities and appliances.
- **Intelligent prefab** – IoT can help coordinate construction of large commercial prefab buildings by using RFID sensors to track individual prefab parts throughout the supply chain, and then feeding this information into the BIM.
- **Construction Management** – Planning logistics and operation of heavy equipment on site by outfitting them with sensors allowing preventive maintenance and avoiding unnecessary delays.

Technology adoption

Challenges

• Cybersecurity
• Terrorism
• Environmentalism
• Digital divide
Thank you!