Civil & Environmental Engineering & Engineering Mechanics: Water Resource Systems

Capabilities:

- Optimizing Performance of Water Supply Systems
  - Minimize Pumping Costs
  - Minimize Power Generation and Associated Environmental Affects
- Modeling Behavior of Open Channels
  - Numerical Simulation
  - Steady and Unsteady Flow Conditions
- Modeling Behavior of Closed Conduit Systems
  - Numerical Simulation
  - Steady and Unsteady Flow Conditions
  - Design and Operation
- Modeling Behavior of Hydrologic Systems
- Developing Simulation Models

Water Resource Systems
Optimizing Water Supply System Performance

Problem (Overview):

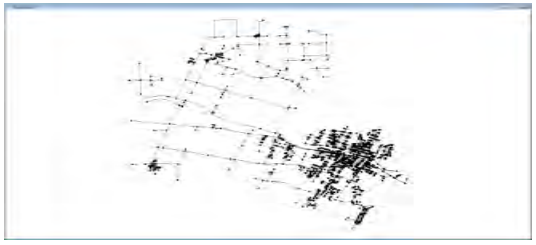
- Pumping stations large users of power
- Must maintain adequate level of service
- Large scale nonlinear problem

Approach:

- Minimize cost of pumping
- Minimize pollutant emissions
- Maintain adequate system-wide pressures
- Employ optimization strategy

Solution (Overview):

- Used genetic algorithm (GA) approach
- Coupled GA with state simulation model



Potential Impact/Results:

- Lower cost of pumping water
- Reduced pollution from power plants
- Improved operations

Civil & Environmental Engineering & Engineering Mechanics: Physical Modeling

Capabilities:

- Model Performance of Culverts
- Develop Regression Coefficients Describing Hydraulic Behavior
- Technology Transfer
  - Develop computer program for use by practicing engineers
  - Include research findings in internationally used simulation models

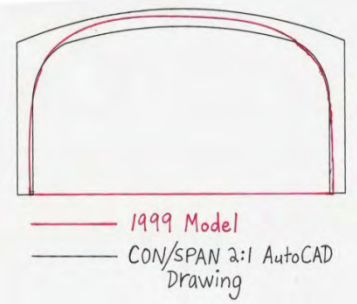
Water Resource Systems
Physical Modeling

Problem (Overview):

- Flow at culvert entrance very complex
- 3-Dimensional flow with rotation

Approach:

- Construct small-scale models
- Maintain similarity
  - Geometry
  - Hydraulic



Solution (Overview):

- Conducted over 6,000 tests
- Performed regression analyses

Potential Impact/Results:

- Safer stream crossings
- Cost savings
- More reliable design

ODOT's L&D Manual Turn Lane Storage Validation/Update

Problem

Queuing occurs at intersections mostly due to overflow or inadequacy of turn bays. The ODOT L&D Manual Volume 1 has storage requirements for both signalized and unsignalized intersections. Currently, there are no records whether these storage lengths computed by the methodology put forth in this manual are valid and accurately represent the actual conditions at intersections in Ohio.

Solution

L&D Manual accurately predicted the observed queues by about 81.6% and closely followed by HCS with 79.2% and SYNCHRO was last with a 46.0% accuracy. Due to higher accuracy, relatively straightforward procedure, and less data requirement, the L&D Manual method seem to be a more preferred model.

Approach

- traffic movements were video-taped at three different signalized intersections in the Columbus area, which resulted into sixteen hours of recording.
- L&D Manual's computed queue storage lengths were compared with actual queue lengths observed in the field.

Potential Impact/Results

The potential impact is that, engineers will continue using the method they know confidently by getting an assurance that their methodology has been tested and proved to be reliable and valid. In addition, ODOT won't have to engage into updating their methodology or buying complex but less accurate commercially available software packages.

Development of a GIS-Based Tool for Traffic Crash Analysis and Modeling Accident Occurrences

Problem

GIS is a powerful tool with unlimited potential use in many fields. It has been used in a variety of applications for planning, presenting, and analyzing data and results. There is a potential to develop a powerful tool capable of analyzing traffic crash data by utilizing the GIS referencing and graphical display capabilities, the readily available traffic crash inventories, traffic volumes and other roadway inventory data.

Solution

The product will include a software program built in ArcGIS software package (compatible with ArcInfo, ArcView, ArcReader) with complete in-built help system and a final report with a companion stand-alone user guide manual. The safety tool will be used by enforcement officers, safety engineers at all levels, researchers, and any interested.

Approach

- ArcObject software components will be used in building a user interface and extending ArcGIS, a component object model (COM)-based package.
- Using VB within ArcGIS Desktop, we will accomplish the majority of customization needs by writing VB scripts and macros that will be capable of performing various safety analyses.

Potential Impact/Results

The proposed tool will simplify and expedite the data analysis and decision making for enforcement officials, engineers, consultants, and researchers when identifying hazardous traffic locations or developing crash models for crash occurrences and predictions. The GIS component will simplify potentially tedious and time consuming activities such as adding new data, updating existing data, or network modifications.

Civil & Environmental Engineering
Geotechnical Engineering

Capabilities:

- Mechanics of Geo-materials
- Advanced Analysis of Foundations and Earth Structures
- Behavior of Pipe Materials and Pipeline Systems
- Dynamic/Seismic Analysis of Soils and Foundations
- Soil-Structure Interaction Modeling
- Numerical Modeling and Analysis
- Geotechnical Design Improvements for Safety, Economics, and Sustainability

Geotechnical Engineering

Problem (Overview):

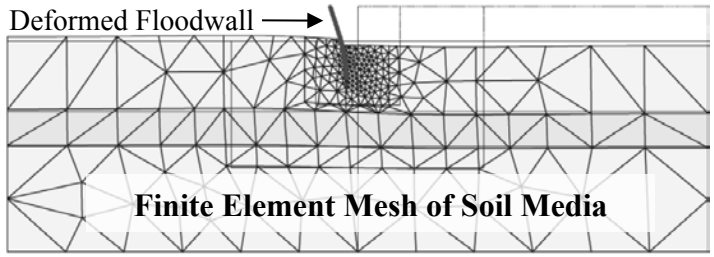
Inadequate floodwall/levee and other retaining wall systems

Approach:

- Through understanding of soil and wall mechanics and behaviors
- Soil and wall materials
- Local geological conditions
- Construction techniques
- Modeling the soil-floodwall interaction

Solution (Overview):

Modified design methods from the well analyzed wall behavior



Potential Impact/Results:

Safe, economical, and sustainable floodwalls/levees and earth retention systems

Civil & Environmental Engineering & Engineering Mechanics:
Mechanics of Composites

Capabilities (SoE):

- Fabrication of composite panels (wet lay-up and resin vacuum infusion)
- Quasi-static testing (screw-driven load frames)
- Modeling: Finite Element Analysis

Capabilities (UDRI):

- Fabrication of specialty panels: autoclave, nano-films
- Fatigue testing (servo-hydraulic load frames)
- Characterization: digital image correlation, scanning microscopes, C-scan, thermal analysis, etc.

Capabilities (Dayton area):

- Impact, lightening strike, rain erosion testing
- 3D X-ray computed tomography
- 3D modeling: b-spline analysis method

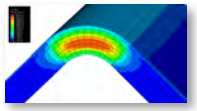
Mechanics of Composite Materials

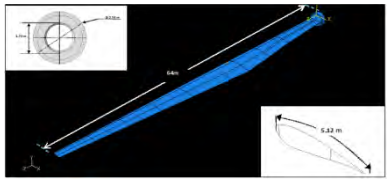
Problem (Overview):

- Complex 3D failure modes
- Effects of defects not well understood
- High cost and unknown reliability

Approach:

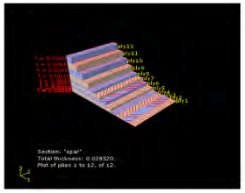
- Biomimetic analogies: esp. joining
- Hybridized structure
- Testing and 3D characterization
- 3D modeling

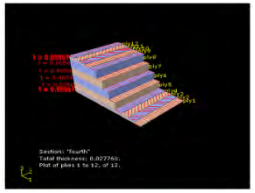




Solution (Overview):

- Highly optimized structures
- 3D fiber architectures
- Well understood effects of defects





Potential Impact/Results:

- Improved reliability
- Reduced cost
- Energy efficiency
- Expanded markets

Physical-Chemical Water Treatment

Capabilities:

- Identifying and quantifying aquatic natural organic matter and other water constituents
- Tailoring and evaluating adsorption media for contaminant removal
- Evaluating the fate and transformation of nanomaterials in aquatic environments

Research Area

Problem (Overview):

Refractory aquatic natural organic matter (NOM) is difficult to isolate, structurally characterize, quantify, and remove through drinking water treatment. This refractory NOM can participate in many interactions in water with chemical and biological species.

Approach:

- Derivatization techniques with Time of Flight Gas Chromatography-Mass Spectrometry (GC-MS)
- Solid State Nuclear Magnetic Resonance

Solution (Overview):

We have isolated refractory NOM from river water samples and quantified and identified lignin and fatty acids using a derivatization technique that makes the NOM less polar and more amenable to detection using GC-MS.

Potential Impact/Results:

Refractory NOM in drinking water can interact with disinfectants and form potentially harmful byproducts, or sorb anthropogenic chemicals and transport them in the aquatic environment. Identifying the NOM will improve its removal during drinking water treatment.

Research Area

Problem (Overview):

Adsorption can be a common and costly approach for water contaminant removal. Thus, adsorption efficiency of a particular media must be high to justify employing adsorption technology and treatment. Need to explore treatments in tandem with sorption.

Approach:

- Surface chemical modification by sorbing/loading surfactants, quaternary ammonium compounds, and inorganics to media
- BET surface area measurements
- Surface charge titrations

Solution (Overview):

We used the approach to improve the activated carbon adsorption of target compounds such as perfluorinated organics and other emerging contaminants. Explored the use of oxidant chemicals with sorption to improve removal of emerging contaminants.

Potential Impact/Results:

Improves the adsorption efficiency of a targeted contaminant in drinking water.

Research Area

Problem (Overview):

The environmental and health impacts of single-walled carbon nanotubes exposed to various aquatic environmental conditions is unknown (e.g. fate and transport and toxicity)

Approach:

- Batch adsorption tests with aquatic natural organic matter and SWCNTs
- Human cell monolayers (colon and lungs) exposed to environmentally-exposed SWCNTs
- SEM and TEM analysis of SWCNTs and human cells

Solution (Overview):

We used the approach to determine the interactions of aquatic natural organic matter with SWCNTs. We determined that environmentally-exposed SWCNTs are less toxic to human colon and lung cells than as-produced SWCNTs and cleaned, cut SWCNTs.

Potential Impact/Results:

Improve the environmental health and safety of SWCNTs and lead to more safe and environmentally sound use and handling of nanomaterials.

Engineering Mechanics
Hybrid Joining Technology

Capabilities:

- Mechanics of Hybrid Mechanical Joints
- Evaluation of thermal and mechanical characteristics of Hybrid Joints
- Simulation of Joint Performance and Efficiency
- Simulation of Damage Accumulation and Propagation in Hybrid Joints

Hybrid Joining Technology

Problem (Overview):

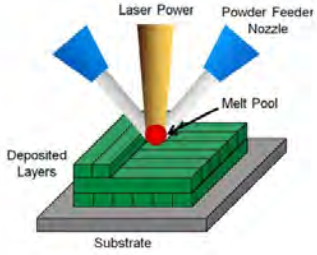
Avoid large adhesive joints in compact areas (e.g., Bleed Valves & Bypass Doors for Advanced Variable Cycle Jet Engines); Weight reduction as compared to a fully metal part; Increase max-use-temp in application with temp gradient

Approach:

- Apply additive manufacturing techniques
- Understand process parameters for chemical and mechanical interlock
- Develop characterization approaches
- Develop analytical techniques for thermomechanical simulation

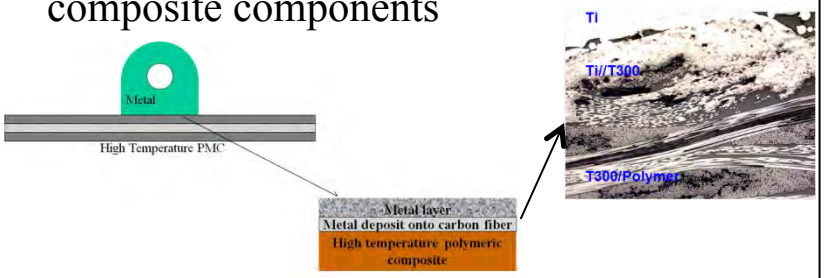
Solution (Overview):

Apply direct metal laser sintering and resin infusion to build hybrid joint at nano-scale.



Potential Impact/Results:

Strong, lightweight joining for metal-to-composite components



Engineering Mechanics
Structurally Integrated Thermal Protection Systems (SITPS)

Capabilities:

- Mechanics of graded SITPS under thermal and mechanical loads
- Evaluation of performance characteristics of SITPS
- Simulation of SITPS performance under thermal gradients and vehicle loads

Structurally Integrated Thermal Protection Systems (SITPS)

Problem (Overview):

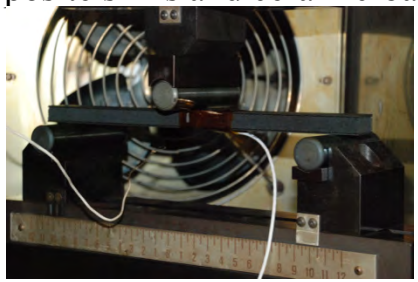
Thermal protection systems on current hypersonic and re-entry vehicles protect underlying structure but carry none of the vehicle loads – they are "parasitic." NEED: an SITPS that protects AND carries vehicle load.

Approach:

- Use hybrid or functionally graded materials to construct demonstration SITPS panel
- Understand residual processing stresses
- Develop characterization approaches
- Develop analytical techniques for thermomechanical simulation

Solution (Overview):

Graded sandwich panel with ceramic and organic matrix composite skins and ceramic-based core



Potential Impact/Results:

Light weight exterior materials for hypersonic vehicles

Structural Engineering

Capabilities:

- Innovative and Advanced Structural Design Systems
- Structural Materials and Experimental Testing
- Behavior of Reinforced Concrete and Masonry Structures
- Fiber-Reinforced Concrete

Research Area

Problem (Overview):

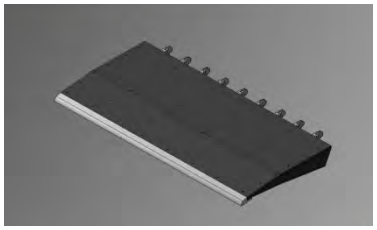
The hovercraft ramps are highly-loaded structures that must be rugged and durable to operate in extreme weather/environmental conditions.

Approach:

- Provide Structural Integrity
- Design of Innovative Joints
- Low-Cost Manufacturing
- Full-scale Prototype Testing
- NDE Testing

Solution (Overview):

Develop a lightweight and durable design using hybrid sandwich construction technology



Potential Impact/Results:

Significant impact on the mission capability and mobility of our armed forces.

The ramps could be translated commercially for ferries, cargo ships, trucks and railcars.