Development of a Statistical-Dynamical Model for Hurricane Storm Surge Forecast

A Proposal to

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Oceanic and Atmospheric Research, National Oceanic and Atmospheric Administration, Department of Commerce

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Abstract

Accurate simulation of storm surge is made possible in recent years due to the advancements made in high fidelity surge simulation models (e.g. SLOSH and ADCIRC). High fidelity models with fine resolution are often very computational demanding and time consuming to prepare. Despite the recent improvement in computing power, real-time storm surge forecasting using these high fidelity models is still limited due to execution time constraints. Under a rapid dynamically changing environment, for instant, for tropical cyclones that exhibit rapid intensification during the final landfalling hours, these high fidelity models might not be able to deliver surge prediction results in time for decision makers to response. This project proposes using a database-enable forecast model for rapid estimation of storm surge risk.

The proposed storm surge forecast methodology relies on three main modules: (1) a hurricane database which includes both the simulated and historical events; (2) a storm surge database with pre-analyzed storm surge scenarios using both synthetic and historical storm events; and (3) a hurricane selection algorithm which uses the real-time storm track information to select storms of similar characteristics from the hurricane database. In storm selection procedure, each simulated storm is described by the time histories of six parameters: (1) the storm track (latitude and longitude of the eye); (2) the central pressure; (3) the translational speed; (4) the heading direction; (5) the radius of maximum wind (*RMW*); and (6) the pressure field parameter. A table-lookup approach is utilized to identify synthetic storms that match the real storm parameters to within certain predefined tolerances. Once a group of candidate storms have been identify, a ranking procedure is then employed to determine the best-fit storms to use for peak wind speed and surge predictions.

The proposed forecast method is extremely efficient during the actual operational forecast. Since the forecast methodology relies on pre-analyzed surge and hurricane data, these surge and hurricane data can be developed and maintained during the off hurricane seasons. The only computational time involved during the actual forecast is the computational overhead of database searching. The tasks at hand here are: (1) to develop the synthetic hurricane database, (2) to create a surge database by pre-analyzing all the synthetic hurricane events using high fidelity surge simulation models, and (3) to develop a robust storm matching procedure. The proposed methodology is technically straightforward. No specialized IT hardware is needed. In addition, the proposed approach does not interfere with the existing Hurricane Weather Research and Forecasting model (HWRF) model. This is a low-risk and potentially high payoff approach as the proposed surge forecast model utilizes the HWRF results but it does not directly interfere with the HWRF operations.

1 Proposed Duration

The proposed duration of this project is two years.

2 Project Description

The objective of this project is to develop a database-enable forecast model to predict the peak surge heights and wind speeds of landfalling storms using real-time storm data (track, central pressure, heading direction and forward speed) issued by the National Hurricane Center (NHC) as inputs. Recent advances in the development of high fidelity surge simulation models (SLOSH [1]; ADCIRC [2][3]) allow reliable and accurate prediction of surge heights for a specific approaching storm. Due to the nonlinear and complex interaction of wind, pressure field, hydrodynamic processes and waves, execution of these high fidelity surge simulation models are often time consuming. In addition, the uncertainty in the forecast storm track has a huge impact on the accuracy of the forecast surge heights. We propose using archived surge simulation results pre-analyzed using a database of synthetic and historical storms to perform fast real-time peak surge and wind speed forecasts. Surge forecasting using pre-analyzed results have been explored by others with success [4][5].

This proposed project aims to address the NOAA National Hurricane Center (NHC) and Joint Typhoon Warning Center (JTWC) program priorities **NHC-6/JTWC-10 "Advanced coastal inundation modeling and application visualization that enhances operational storm surge forecast accuracy or delivery"**.

Proposed Methodology

The proposed storm surge forecast methodology consists of three main modules: (1) a hurricane database which includes both the simulated and historical events; (2) a storm surge database created by pre-analyzing the surge heights caused by each storm in the hurricane database; and (3) a storm identification module which uses the real-time storm track information issued by the NHC as inputs to select storms of similar characteristics from the hurricane database.

For the purpose of surge prediction, a hurricane database consists of 50,000 years of simulated hurricane has been created using a statistically-based stochastic hurricane simulation procedure [6][7]. The 50,000-year simulations resulted in 446,322 simulated hurricanes originated from the Atlantic Ocean, Gulf Coast and Caribbean Sea. Each simulated storm is described by the time histories of six parameters: (1) the storm track (latitude and longitude of the hurricane eye); (2) the central pressure; (3) the translational speed; (4) the heading angle or track azimuth; (5) the radius of maximum wind (*RMW*); and (6) the pressure field parameter, also known as the *Holland B parameter* (*B*).

To illustrate the proposed methodology, several proof-of-concept mock forecast analyses were performed using selected historical hurricane events for a location in Charleston, South

Carolina (CO-OPS water station 866553, lat. 32.78^{o}, lon. -79.93^{o}). Figure 1 depicts the selection of characteristic hurricanes performed at approximately 24 hours before the landfall of the 1989 Hurricane Hugo. Given the real-time storm information (storm eye position, central pressure, heading angle and travel speed), a three-step procedure was utilized to identify characteristic hurricanes:

Step 1) Find all simulated storms with their tracks travel within the search radius of the real approaching storm position (i.e. Hugo in this example). The selected synthetic storms are then further filtered by matching the real storm central pressure, heading angle, travel speed to within certain predefined tolerance values.

Step 2) Apply the same search criteria of Step 1 to the previous position of the real storm (i.e. 6 hours before the current step); however, this time only to those candidate storms identified in Step 1.

Step 3) Determine if any of the candidate storms in Step 2 make landfall near the site of interest (i.e. the CO-OPS water station in Charleston).

Figure 1 shows example storm tracks selected from a database of 50,000 years of simulated storm events using the known parameters of Hugo (i.e. eye location, central pressure and etc.) at 48 hours and 12 hours before the landfall. Note that while in this example, the hurricane parameters are taken from the observed 1989 Hurricane Hugo, in an operational forecast, these parameters will be obtained directly from the JHT operational forecast environment.

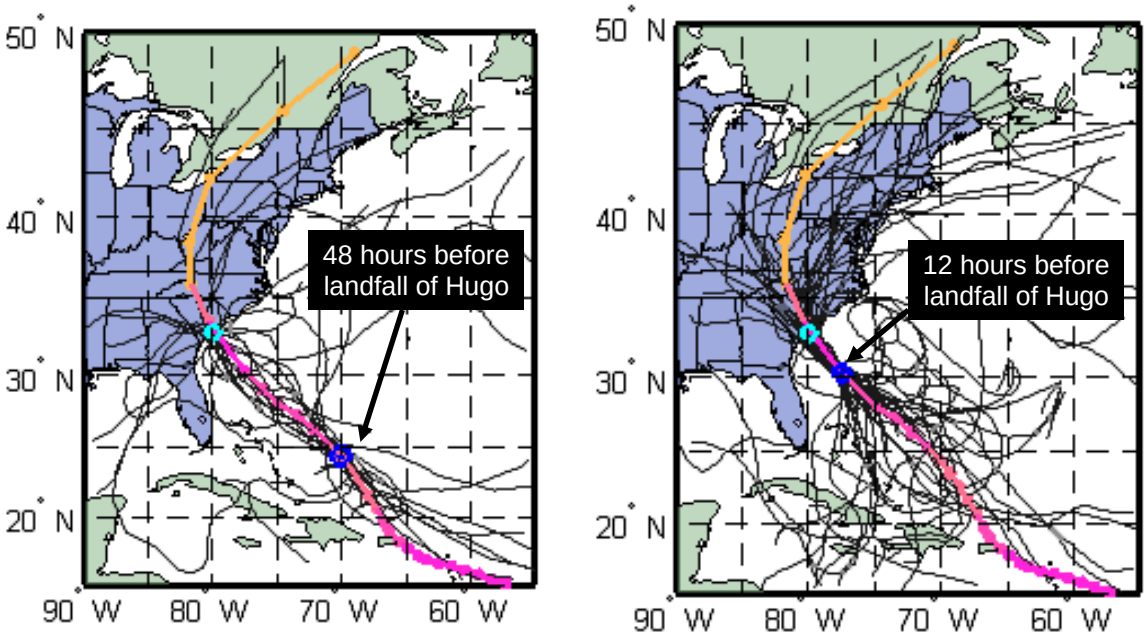

Figure 1. Selected synthetic tracks of similar characteristics to Hurricane Hugo (1989) at (a) 48 hours and (b) 12 hours before landfall.

Based on the selected storms at each time step, the surge height predictions at the site of interest were determined from the pre-analyzed storm surge results (surge database). Figure 2 shows the results of peak storm surge and wind speed predictions at the Charleston CO-OP water station. The observed peak storm surge and maximum 1-min sustained wind speed at this location during Hurricane Hugo are shown as horizontal dashed lines. Note that while the surge height predictions were obtained from the pre-analyzed surge database, the wind speeds were calculated using a wind field model [8]. As can be seen, the wind predictions provide reasonable estimate of peak surface wind speeds, particularly at about 12 hours prior to the storm landfall. The surge predictions converge to about +/- 2 feet of the observed water elevation at the final hours of landfall. Since a pre-analyzed surge results were utilized in this analysis, the execution time of wind and surge predictions at each time step (hours before landfall) took less than 10 minutes on a personal computer. We believe that the accuracy of the predictions can be increased by refining the storm selection procedure and by increasing the number of pre-analyzed storm surge events in the database.

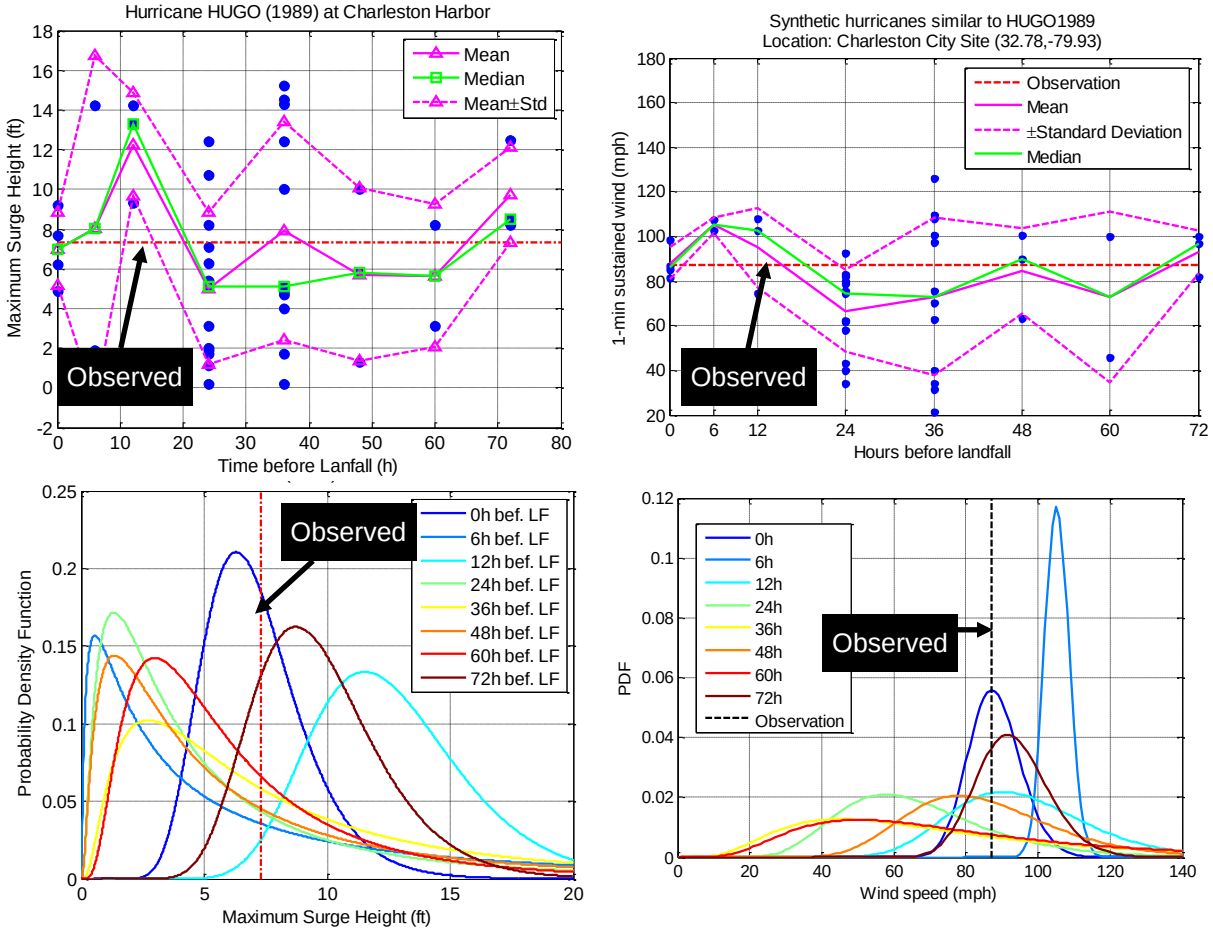

Figure 2. Maximum storm surge and peak wind speed predictions versus hours before landfall.

3 Proposed Work Plan

Task 1. Develop and Optimize Storm Selection Procedure

In Task 1, we will refine our current storm selection methodology and algorithm by performing hindcast using historical storm data (HURDAT). The current storm selection procedure is based on a direct table-lookup procedure with user defined tolerances (e.g. differences between heading directions and central pressures of real and synthetic storms). As part of the selection procedure, the differences (errors) between central pressures, storm eye locations, forward speeds, and heading angles of synthetic and real storms are first computed. The errors of each parameter are then rank ordered. Finally, a composite ranking is computed for each synthetic storm by taking the weighted sum of the individual rankings. Figure 3 shows example storm similarity ranking for various synthetic storms to the track and condition of Hugo at 6 hours before landfall. Few selected highly ranked synthetic storms are used for peak surge and wind speed predictions. The task at hand is how to obtain an optimal ranking system that will minimize both the storm surge and wind speed prediction errors. In this Task, the optimal selection criteria or tolerances (i.e. differences between heading directions, central pressures and etc.) for matching synthetic storms to real storms will be determined by minimizing the predication errors (both wind and surge) of known past storm events. These historical storm events can be obtained from HURDAT.

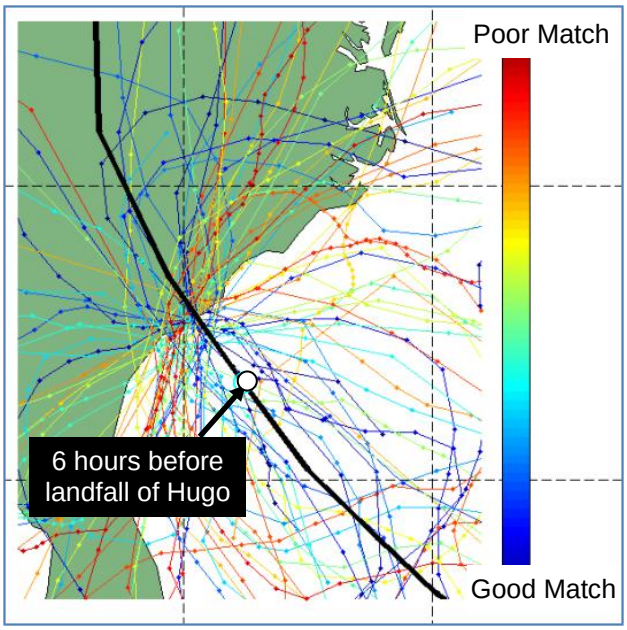

Figure 3: Matching and ranking synthetic storms to real storm. Black curve is the track of Hurricane Hugo. Synthetic storms are ranked based on the "current" position of Hugo identified as a dot on the Hugo track.

The current execution time of the storm selection procedure for 50,000 years of simulated events at a given time step of a real storm is approximately 5 minutes on a personal computer. While the execution time is reasonable, as the number of storms in the hurricane database increases, the total execution time or database search time will increase as well. In addition to the storm selection methodology discussed, we will also explore the use of other techniques such as the artificial neural network approach to help improve both the speed and quality of the selected storms.

Task 2. Develop Storm Surge Database

Currently, our hurricane database contains 50,000 years of simulated hurricane seasons with 446,322 synthetic storms. Among the approximately 446 thousand storms, approximately 10,000 of these storms were analyzed using the SLOSH program to obtain surge heights in the Charleston, SC area. It took us about 2 weeks to complete the SLOSH simulations using a cluster

of computers (the Palmetto Cluster at Clemson University). The two-week time included the preparation time for input files and post-analysis data processing time. We plan to expand our storm surge database to cover the Gulf of Mexico, and the entire Eastern and Northeastern coast of U.S. by analyzing the remaining 436,000 synthetic storms during the non-hurricane seasons. It should be noted that Tasks 1 and 2 can be conducted in parallel (see Table 1 in a later section).

In order to increase the available surge data, as part of Task 2, we will increase the number of simulated hurricane seasons from 50,000 to 100,000 years. The long-term hurricane simulations will be completed using a statistically-based hurricane simulation program developed by the PIs [10]. This hurricane simulation process is based on the simulation framework proposed by Vickery et al. [9] which is used to derive the U.S. building code design wind speed maps. The total storm surge simulation time is estimated to be about 40 weeks. Note that these additional storm surge simulations will be performed during both hurricane and non-hurricane seasons.

Task 3. Implement Surge Forecast Model with JHT Staff

Once the development of the storm selection procedure and surge database have been completed, the PIs will implement the integration of the proposed surge forecast procedure into the current Hurricane Weather Research and Forecasting (HWRF) framework. To implement the proposed methodology into the JHT quasi-operational environment, the research team plan to visit the JHT operational centers two times during the proposed of this project. The first visit will be made around April of 2014, prior to the hurricane season. The purpose of this visit is to setup technical points of contact in preparation for project testing and evaluation. The PIs will use this visit to get familiarize with the JHT facilities and computational environment. After the year 1 visit, the research team will adapt our code and develop algorithm that can be integrated into the HWRF framework. The development of the implementation code will be performed at the PIs' home institution. Testing and evaluation will be performed using the HWRF mirror operational configuration available on the DTC (Development Testbed Center) website. Once the development of implementation code has been completed, the PIs will make a second visit to JHT to deliver the product of this research and to train the JHT staff on how to run the forecast model. In collaboration with the JHT staff and forecasters, the proposed forecast modeled will be tested and evaluated in a quasi-operational environment. The JHT staff will be the primary forecasters that run the code in a quasi-operational environment while the PIs will facilitate the code testing and evaluation via remote access. In deemed necessary by the JHT staff, the PIs will make additional visit to the JHT to facilitate the final testing and evaluation process.

The computational product of this project will be developed using a Matlab computing environment. It should be noted that the computational product does not required any specialized IT hardware. Once the synthetic hurricane database and surge database have been developed, the JHT staff can easily maintain, operate, and update the database used by the forecast model. The proposed forecast method is extremely efficient during the actual operational forecast. Since the forecast methodology relies on pre-analyzed surge and hurricane data, these surge and hurricane

data can be developed and maintained during the off hurricane seasons. The only computational time involved during the actual forecast is the computational overhead of database searching.

4 Research Organization and Timeline

Dr. Pang (PI) and Dr. Testik (Co-PI) will work very closely to achieve the goals of this proposed activity. Dr. Pang has extensive expertise in the hurricane wind field modeling and statistical error analysis. Dr. Testik has an extensive expertise in the area of coastal hydrodynamics including wave mechanics and storm surges. Drs. Pang and Testik have already established a very productive collaboration on hurricane storm surge modeling and have been successfully co-advising a PhD student together over the past 2.5 years. In this proposed project, each of the PIs will lead a PhD student in achieving the goals of the assigned tasks, while both of them co-advising both of the PhD students. While working closely as a team, the PIs and the PhD students are charged with the proposed tasks as follows. Dr. Testik and his graduate student will lead the efforts in achieving the goals of Task 2. Dr. Pang and his graduate student will lead the efforts in achieving the goals of Task 1. Both of the PIs will be in charge of delivering the goals of Task 3.

The project work schedule is summarized in Table 1. This two-year project will be conducted from August 15th, 2013 till August 15th, 2015. Tasks 1 and 2 will be conducted in parallel during the first year of the project. The PIs will visit the JHT center in April 2014 (before the Atlantic hurricane season) to discuss about the forecasting methodology to be developed as part of Tasks 1 and 2 and the available JHT facilities with the JHT personnel. The validation/verification of the developed methodology (Task 3) will be conducted from June to November of 2014 during the hurricane season. Based upon the experience gained during the validation efforts, Tasks 1 and 2 will be completed from November 2014 till April 2015. In April 2015 before the hurricane season, the PIs will visit the JHT facilities to demonstrate the developed forecasting methodology and the associated computational product to the JHT personnel. The PIs will conduct final tests of the hurricane forecasting system from May till August 2015 during the early part of the hurricane season.

Table 1: Project Schedule.

Project Tasks	**Year 1**				**Year 2**			
	Q1	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**
Task I								
Task II								
Task III								
JHT Visit			X				X	

Q1 – August – October
Q2 – November – January
Q3 – February – April
Q4 – May – July
X – Several work days

5 Travel Plan

We plan to visit to the JHT facilities at least two times (see Table 1). The first visit to JHT operational center(s) will occur before the Atlantic hurricane season in 2014 around April. The PIs will discuss the forecasting methodology to be developed as part of Tasks 1 and 2 and the available JHT facilities with the JHT personnel. In April 2015 before the second hurricane season of this project, the PIs will visit the JHT facilities to deliver technical documentation and to demonstrate how to execute the developed forecasting computational product to the JHT personnel. The PIs will conduct final tests of the hurricane forecasting system from May till August 2015 during the early part of the hurricane season. In addition to the visits to JHT facilities, the PIs also plan to attend the annual Interdepartmental Hurricane conference (IHC) which occurs in early Match for years 2014 and 2015.

6 Estimates of JHT Staff Requirements

This project does not require on-site support from the JHT (i.e. visit by the JHT staff to the PIs' home institution). The development of the surge database can be accomplished at the PIs' home institution using parallel computing facility (Palmetto Cluster) at Clemson University. However, this project will require at least one JHT facilitator to serve as the point of contact for implementing the computational product development in this project. In addition, the project will require remote access to the JHT facility for two reasons: 1) to transfer the surge and simulated hurricanes to the JHT computation devices, 2) to access the real-time track forecast data at the JHT facility for testing and evaluating our code. Remote access to one or two computers tied to the JHT quasi-operational forecast environment is needed for testing our code.

The computational product of this project will be developed using a Matlab computing environment. It should be noted that the computational product does not required any specialized IT hardware. Once the synthetic hurricane database and surge database have been developed, the JHT staff can easily maintain, operate, and update the database used by the forecast model. The proposed forecast method is extremely efficient during the actual operational forecast. Since the forecast methodology relies on pre-analyzed surge and hurricane data, these surge and hurricane data can be developed and maintained during the off hurricane seasons. The only computational time involved during the actual forecast is the computational overhead of database searching.

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Member, Structural Engineers Association, SEA (2008-)
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Associate Member, American Society of Civil Engineers, ASCE (2007-)
Associate Member, Structural Engineering Institute, SEI (2007-)

PUBLICATIONS

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Davis-McDaniel, C., Chowdhury, M., and Pang, W., "Identification of Causal Factors of Bridge Failure Through Fault-tree Analysis and Intelligent Sensor Solutions," 18th Intelligent Transportation Society (ITS) World Congress, Orlando, FL, October 16-20, (2011).

Chandra, K., Pang, W., and Chowdhury, M., "Bridge and Pavement Deterioration due to Repeated Overweight Trucks – A Framework for Technology and Policy Solutions," 18th Intelligent Transportation Society (ITS) World Congress, Orlando, FL, October 16-20, (2011).

Pang, W., Rosowsky, D.V., van de Lindt, J.W., and Pei, S., "Performance-based Shear Wall Design of Six-Story Capstone Building via Simplified Direct Displacement Design Procedure," *Structures Congress ASCE,* Kissimmee, FL (2010).

Pang, W., and Shirazi, S.M.H., "Next Generation Numerical Model for Non-linear In-plane Analysis of Wood-frame Shear Walls," 11th World Conference on Timber Engineering, Trentino, Italy, June 20-24, (2010)

Pang, W., and Rosowsky, D.V., "A Beam-Spring Analog Model for Seismic Analysis of Semi-Rigid Wood Diaphragms," 11th World Conference on Timber Engineering, Trentino, Italy, June 20-24, (2010)

Pang, W., Rosowsky, D.V., van de Lindt, J.W., and Pei, S. "Simplified Direct Displacement Design of Six-story NEESWood Capstone Building and Pre-test Seismic Performance Assessment," 11th World Conference on Timber Engineering, Trentino, Italy, June 20-24, (2010)

Wang, Y., Rosowsky, D.V. and Pang, W. "Toward a Performance-based Procedure for Direct Displacement Design of Engineered Woodframe Structures," 11th World Conference on Timber Engineering, Trentino, Italy, June 20-24, (2010)

Pang, W., Rosowsky, D.V., van de Lindt, J.W., and Pei, S. "Simplified Performance-based Seismic Design of NEESWood Capstone Building and Pre-Test Performance Evaluation," *9th US National and 10th Canadian Conference on Earthquake Engineering*, (2010).

Research Reports

Pang, W., and Rosowsky, D.V., "Direct Displacement Procedure for Performance-based Seismic Design of Multistory Woodframe Structures," Texas A&M University, *NEESWood Report NW-02, MCEER-10-0001*, (2010).

Pang, W., Rosowsky, D.V., van de Lindt, J.W., and Pei, S., "Simplified Direct Displacement Design of Six-story NEESWood Capstone Building and Pre-Test Seismic Performance Assessment," Clemson University, *NEESWood Report NW-05*, *MCEER-10-0002*, (2010).

PRESENTATIONS

Pang, W. "Seismic Retrofit of Wood-framed Structures," *Structural Engineers Association of South Carolina 6th Annual Meeting*, Columbia, SC (June-24 2011).

Pang, W., Grayson, J.M., and Schiff, S., "Development of Debris Impact Fragility Curves for Light-frame Wood Construction Subjected to Hurricanes," *2012 Joint Conference of the Engineering Mechanics Institute and the11th ASCE Joint Specialty Conference on Probabilistic Mechanics and Structural Reliability*, Notre Dame, IN (Jun 2012)

SPONSORED RESEARCH

"Development of Solid and Hollow-core Cross-laminated Timber Systems for Low- and Mid-rise Construction," United States Department of Agriculture through North Carolina State University, Co-Investigator, $372,101 ($88,067), (2012-2015), received award notice.

"Engineering and Managing Sustainable and Resilience Infrastructure," GAANN (Graduate Assistance in Areas of National Needs), U.S. Department of Education, Co-Investigator, $799,596 ($159,919), (2012-2015), received award notice.

"Numerical Study of the Structural Performance of Large Diaphragms," FPInnovations, Canada, $38,000 ($38,000), (2012-2013).

"Building Resilient Residential Communities through Hurricane Mitigation Assessments: NSF Fellowship for James Michael Grayson," National Science Foundation, $121,500, ($121,500), (2011-2014).

"NEESR-CR: NEESsoft: Seismic Risk Reduction for Soft Story Woodframe Buildings," National Science Foundation through Colorado State University, Co-Investigator, $1,236,000, ($178,684), (2010-2013).

"Study of the Rate of Deterioration of Bridges and Pavements As Affected by Trucks," South Carolina Department of Transportation, Co-Investigator, $249,775, ($74,933), (2011-2013).

"Science Master's Program: Sustainable and Resilient Infrastructure," National Science Foundation, Co-Investigator, $700,000, ($87,500), (2010-2013).

"Predicting Building Envelope Failure of Residential Structures due to Atlantic Basin Hurricane Wind Hazard," South Carolina Sea Grant, Principal-Investigator; $120,850, ($60,425), (2010-2012).

"Accelerated Bridge Construction: An Investigation of a Precast Alternative for Flat Slab Span," South Carolina Department of Transportation, Co-Investigator; $204,146, ($67,368), (2009-2013).

OTHER SPONSORED ACTIVITY

Travel Grant, Japan NEESWood Test, National Science Foundation, $2,400, (2009)

Invitational Workshop on Improving Nonlinear Seismic Modeling of Light-frame Wood Buildings, Tuscaloosa, AL, Co-sponsored by Forest Products Laboratory and University of Alabama (2011).

Travel Grant, 8th International Conference on Urban Earthquake Engineering (8CUEE), Tokyo Japan, Tokyo Institute of Technology (2011).

GRADUATE STUDENT ADVISING

Previous Graduate Advising

Seyed Masood Hassanzadeh Shirazi, (PhD Civil), "Propagation of Uncertainty in Light-frame Wood Buildings," (Jul-2012).

Bin Pei, (MS Civil), "An Error Quantification Methodology for Hurricane Storm Surge Simulations," (Dec-2012).

Joshua Caron (MS Civil), "3D Reconstruction for Post-Disaster Analysis of Civil Infrastructure," (Dec-2012)

Fangqian (Abby) Liu, (MS Civil), "Development and Calibration of Central Pressure Filling Rate Models for Hurricane Simulation," (May-2012).

James Michael Grayson, (MS Civil), "Development and Application of a Three-Dimensional Probabilistic Wind-borne Debris Trajectory Model," (Dec-2011).

Caitlyn E. Davis-McDaniel (MS Civil), "Fault-tree Model for Bridge Collapse Risk Analysis," Co-advisor (Dec-2011)

Robert Michael Funcik, (MS Civil), "Determining Transverse Design Forces for a NEXT-D Bridge using 3D Finite Element Modeling," Co-advisor (Dec-2011).

Armando Flores Duron, (MS Civil), "Behavior of the NEXT-D Beam Shear Key: A Finite Element Approach," Co-advisor (Aug-2011).

Sara Elise Roberts, (MS Civil), "Influence of Shear Key Performance on the Fatigue Life of Adjacent Beam Bridges," Co-advisor (Aug-2010).

Current Graduate Advising

MengYu Yang (MS Civil), "Structural Reliability of Flexural Members Constructed using Visually Graded Southern Pine Dimension Lumber," (Est. Dec-2012)

Fangqian (Abby) Liu, (PhD Civil), "Influence of Climate Change on Long-term Hurricane Risk," (Est. May-2013).

Bin Pei, (PhD Civil), "Hurricane Storm Surge Modeling," (Est. Dec-2013).

Michael Grayson, (PhD Civil), "Performance-based Wind Engineering," (Est. May-2014).

Ershad Ziaei (PhD Civil), "Seismic Risk Reduction for Soft Story Woodframe Buildings", (Est. Dec-2014)

Linbo Chen (MS Civil), "Finite Element Analysis of the Deterioration of Highway Bridges due to Overloading Trucks", (Est. May-2013)

Sami Pant (MS Civil), "Design of Large Wood Diaphragms," (Est. May-2013)

TEACHING

Courses Taught

CE 3201, Structural Engineering II, Steel and Reinforce Concrete Design, Michigan Technological University
CE 201, Statics, Clemson University
CE 402, Reinforced Concrete Design, Clemson University
CE 808, Earthquake Engineering, Clemson University
CE 893, Risk Assessment of Civil Infrastructure, Clemson University

UNIVERSITY AND PUBLIC SERVICE

Committees

Professional: Member, ASCE Technical Committee on Wood (2010-)
Department: Member, Scholarship & Awards Committee (2008-)
Department: Member, Structures Faculty Search Committee (Spring 2009; Spring 2012)
Department: Member, Advisory Committee (2012-)
Department: Member, Science Masters Program in Sustainable and Resilient Steering Committee (2010 -)

Other Service

Session Moderator for the NEES & MCEER Annual Meeting (2011)

Research Collaborator, Design of 6-story Woodframe Capstone Building, NEESWood Project (2008-2010)

Resilient Home Program, Stakeholder Group, (2010-2011)

Referee Service for Journals: Natural Hazards Review, ASCE Journal of Structural Engineering, Structural Engineering International, Engineering Structures, Journal of Bridge Engineering, Advances in Structural Engineering, ASCE Journal of Performance of Constructed Facilities, Journal of Earthquake Engineering, Earthquake Engineering and Structural Dynamics

Abbreviated CV

Firat Y. Testik, *Ph.D.*

Associate Professor
Glenn Department of Civil Engineering
Clemson University

Mailing Adress: 110 Lowry Hall, Glenn Department of Civil Engineering,
Clemson University, Clemson, SC 29634
Email: ftestik@clemson.edu

EDUCATION

Ph.D., Arizona State University, 2003, Aerospace Engineering

M.S., University of Minnesota, 2000, Aerospace Engineering

B.S., Orta Dogu Teknik Universitesi, 1999, Aerospace Engineering

PROFESSIONAL EXPERIENCE

Clemson University, 2012 - Present, Associate Professor of Glenn Department of Civil Engineering

Clemson University, 2006 - 2012, Assistant Professor of Glenn Department of Civil Engineering

Duke University, 2005-2006, Postdoctoral Research Associate of Civil and Environmental Engineering

NASA-WFF, 2005, Visiting scientist conducting raintower experiments.

Tubitak-Sage Missile Company, 2004, Senior Researcher of Internal Combustion Division

Arizona State University, 2004, Postdoctoral Research Associate of Mechanical and Aerospace Engineering

Arizona State University, 2000-2003, Research Associate of Mechanical and Aerospace Engineering

University of Minnesota, 1999-2000, Research and Teaching Assistant of Aerospace Engineering and Mechanics

Roketsan Missile Company, 1998, Summer Intern of Guidance and Control Division

Istanbul Airlines, 1997, Summer Intern of Engineering Division

MEMBERSHIPS

Member, American Society of Civil Engineers, *ASCE*, (2006-)

Member, American Physical Society, *APS*, (2005-)

Member, American Geophysical Union, *AGU*, (2005-)

Member, The American Shore & Beach Preservation Association, *ASBPA*, (2010-)

Member, The Scientific Research Society, *Sigma Xi*, (2005-)

Member, The Oceanography Society, *TOS*, (2005-2006)

PROFESSIONAL ACTIVITIES

1) Member of the *Precipitation Committee*, American Geophysical Union (May 2009 – May 2010)

2) Conference/Meeting Session Convener:

   (i) "General session on precipitation", American Geophysical Union Spring Meeting, Acapulco, Mexico (May 2007).

   (ii) "Hydrometeorological Processes: Observation, Modeling and Analysis", American Geophysical Union Spring Meeting, Acapulco, Mexico (May 2007).

   (iii) "Rainfall measurement, estimation, and validation: advances and hydrologic applications", American Geophysical Union Fall Meeting, San Francisco (Dec. 2007).

   (iv) "General session on precipitation", American Geophysical Union Spring Meeting, Fort Lauderdale, USA (May 2008).

   (v) "General Session on Precipitation", American Geophysical Union Joint Assembly – Meeting of the Americas, Toronto, Canada (May 2009).

   (vi) "General Session on Precipitation", American Geophysical Union Joint Assembly – Meeting of the Americas, Foz do Iguassu, Brazil (August 2010).

3) Session Chair:

   (ii) "Hydrometeorological Processes: Observation, Modeling and Analysis", American Geophysical Union Spring Meeting, Acapulco, Mexico (May 2007).

   (iii) "General session on precipitation", American Geophysical Union Spring Meeting, Acapulco, Mexico (May 2007).

4) Program Committee member, REAS' 03 - Research in Engineering and Applied Sciences Symposium, Tempe, Arizona (2003)

PUBLICATIONS

Books

1) ***Testik F.Y.,*** and Gebremichael, M., 2010. "Rainfall: State of the Science", American Geophysical Union, December 2010.

Book Chapters

2) Voropayev, S.I., ***Testik, F.Y.***, Fernando H.J.S., Balasubramanian, S., "Sediment transport, ripple dynamics, and object burial under shoaling waves" book chapter in *Particle Laden Flow: From Geophysical to Kolmogorov Scales*, Eds. B.J. Geurts, H.J.H. Clercx, W.S.J. Uijttewaal, Springer Science (2007).

3) Jones, B.K., Saylor, J.R., ***Testik, F.Y.***, 2010, "Raindrop Morphodynamics" book chapter in *Rainfall: State of the Science*, Eds. ***F.Y. Testik*** and M. Gebremichael, American Geophysical Union.

4) Gebremichael, M., ***Testik, F.Y.***, 2010, "Microphysics, Measurement, and Analyses of Rainfall" book chapter in *Rainfall: State of the Science*, Eds. ***F.Y. Testik*** and M. Gebremichael, American Geophysical Union.

Refereed Journal Publications in the Last Three Years ("*" indicates Advisee)

5) Chowdhury*, M.R., ***Testik, F.Y.***, "Viscous Propagation of Two-Dimensional non-Newtonian Gravity Currents", *Fluid Dynamics Research,* 44, 045502 (2012).

6) Prat O.P., Barros, A.P., ***Testik F.Y.***, "On the influence of raindrop collision outcomes on equilibrium drop size distributions", *Journal of the Atmospheric Sciences*, 69 (5) p.p. 1534-1546 (2012).

7) Johnson*, E.B., ***Testik, F.Y.***, Ravichandran, N., Schooler*, J., "Levee scour from overtopping storm waves and scour countermeasures", *Ocean Engineering,* 57, p.p. 72-82 (2013).

8) Pei*, B., Pang, W., ***Testik, F.Y.***, Ravichandran, N., "Uncertainty Quantification for Hurricane Storm Surge Predictions along the U.S. Eastern Coast and Gulf of Mexico", *Natural Hazards Review,* (2012, *In Press*).

9) Heiliger*, C., Kaye, N., ***Testik, F.Y.***, "A computational study of the role of particle size standard deviation on the collision frequency in differential settling", *International Journal of Sediment Research,* (2012, *In Press*).

10) Jacobson*, M.R., and ***Testik, F.Y.***, "On the Concentration Structure of High-Concentration Constant-Volume Fluid Mud Gravity Currents" *Physics of Fluids*, (2012).

11) Mills, B.H., Saylor, J.R., ***Testik, F.Y.***, "An experimental study of Mesler entrainment dependence on drop Weber number and axis ratio" *AIChE Journal*, 58 (1), p.p. 46-58 (2012).

12) Chowdhury*, M.R., ***Testik, F.Y.***, "Laboratory testing of mathematical models for high-concentration fluid-mud turbidity currents" *Ocean Engineering,* 38 (1), 256-270 (2011).

13) Young*, D.M., ***Testik, F.Y.***, "Wave reflection by submerged vertical and semicircular breakwaters" *Ocean Engineering,* 38 (10), 1269-1276, (2011).

14) ***Testik, F.Y.***, Barros, A.P., Bliven, L.F., "Towards a physical characterization of raindrop collision outcomes" *Journal of the Atmospheric Sciences*, 68 (5), 1097-1113, (2011).

15) Barros, A.P., Prat, O.P., ***Testik, F.Y.***, "Size distribution of raindrops"", *Nature – Physics*, 6, 232,(2010).

16) Malek-Mohammadi*, S., and ***Testik, F.Y.***, "A New Methodology for Laboratory Generation of Solitary Waves", *ASCE - Journal of Waterway, Port, Coastal, and Ocean Engineering*, 136 (5), 286-294, (2010).

Conference Proceedings in the Last Three Years

17) Johnson*, E.B., Schooler*, J., ***Testik, F.Y.***, Ravichandran, N., "Effectiveness of levee scour protection measures for storm waves", *ASBPA National Coastal Conference,* San Diego, CA, (Oct. 9-12 2012).

18) Pei*, B., Pang, W., ***Testik, F.Y.***, Ravichandran, N., "Joint Distributions of Hurricane Wind and Storm Surge for the U.S. Eastern Coast and Gulf of Mexico", *ATC-SEI Advances in Hurricane Engineering Conference*, Miami, FL, (Oct 24-26, 2012).

19) Mun*, J.W., ***Testik, F.Y.***, "Simulations of the Wave Field around a Submerged Breakwater in a Numerical Wave Tank", *2012 National Conference on Beach Preservation Technology*, Stuart, Florida (February 8-10, 2012).

20) Chowdhury*, M.R., ***Testik, F.Y.***, "Subaqueous cohesive sediment gravity flows from open water pipeline dredge disposal: laboratory experiments and mathematical modeling", ASCE-COPRI Coastal Engineering Practice, San Diego, CA, (August 21-24 2011).

21) Kim, N.H., ***Testik, F.Y.***, Mun*, J.W., "A study on beach morphology change caused by overwash on the Iho Beach", Korean Society of Civil Engineers Conference, (October 2010).

22) Pang, W., ***Testik, F.Y.***, Lee, K.H., "Development of a Synthetic Coastal Hurricane Surge Database for South Carolina", *Hurricane Hugo 20th Anniversary Symposium on Building Safer Communities*, Charleston, SC (October 2009)

PRESENTATIONS & ABSTRACTS

Professional Meetings in the Last Three Years

1) Johnson*, E., ***Testik, F.Y.***, Ravichandran, N., "Levee scour protection for storm waves", Abstract, *Proceedings of AGU Fall Meeting*, San Francisco, CA (December 5-9, 2011).
2) Yilmaz*, N.A., ***Testik, F.Y.***, "Numerical simulation of fluid mud gravity currents", Abstract, *Proceedings of AGU Fall Meeting*, San Francisco, CA (December 5-9, 2011).
3) Jacobson*, M., ***Testik, F.Y.***, "Turbulent entrainment into non-Newtonian fluid mud turbidity currents" Abstract, *Proceedings of 64th Annual Meeting of the APS Division of Fluid Dynamics*, Baltimore, MD, USA (November 20–22, 2011).
4) Chowdhury*, M.R., ***Testik, F.Y.***, "Transitions of the Propagation Phases for non-Newtonian Gravity Currents" Abstract, *Proceedings of 64th Annual Meeting of the APS Division of Fluid Dynamics*, Baltimore, MD, USA (November 20–22, 2011).
5) Chowdhury*, M.R., ***Testik, F.Y.***, "Laboratory testing of mathematical models for high-concentration fluid-mud turbidity currents" Abstract, *Proceedings of 63rd Annual Meeting of the APS Division of Fluid Dynamics*, Long Beach, CA, USA (November 21–23, 2010).
6) Saylor, J.R., Mills, B.H., ***Testik, F.Y.***, "The dependence of Mesler entrainment on Weber number and drop axis ratio", Abstract, *Proceedings of 62nd Annual Meeting of the APS Division of Fluid Dynamics*, Minneapolis, Minnesota, USA (November 22–24, 2009).

HONORS AND AWARDS

1) **ENCORA-YPEP** Travel Award (2008).
2) **Vermont – EPSCoR** Travel Award (2008).
3) **ASCE-ExCEEd Teaching Fellow** (2007)
4) **Student Affairs' Tribute**, Arizona State University (2003).
5) **NATO Science Fellow** (1999-2003).
6) **Sabanci Foundation Scholarship** (1995-1999).

SPONSORED RESEARCH

1) "Critical raindrop characteristics: Fall speed, shape, and size distributions" **National Science Foundation, PI**, ≈ $504,150 (Sept. 2012 – Sept. 2015).
2) "Shallow water disposal of dredge spoil" **US Army Corps of Engineers, PI**, ≈ $320,000 (Pending Approval, 2012 - 2016).
3) "Jet disposal of dredge spoil: transport, entrainment, and deposition of fluid mud" **US Army Corps of Engineers, PI**, $248,844 (June 2009 - June 2012).
4) "Sediment transport and morphodynamics around submerged artificial reefs" **PADI Foundation, PI**, $6,000.
5) "Levee scour protection for storm waves for robust levee designs" NSF-SMP, PI, ≈$35,000 (2011-2012) [as a part of the NSF Science Masters Program initiative].
6) "High-speed Imaging of Rainfall" Clemson University Creative Inquiry Grant, PI, $ 8,000 (2013-2014).
7) "Instrumentation of remote-controlled aircraft for monitoring water resources" Clemson University Creative Inquiry Grant, PI, $ 10,000 (2009-2010).
8) "Coastal structures under extreme waves" Clemson University Creative Inquiry Grant, PI, $ 10,000 (2008-2009).
9) "Sand Segregation in the Coastal Zone" Clemson University Research Grant, PI, $3,475 (2006-2007).
10) "Laboratory development", Civil Engineering Department, Clemson University, Research Infrastructure Development Grant, Co-PI, $8,400 (2008).

GRADUATE STUDENT ADVISING

Current Graduate Advising

1) Nazli A. Yilmaz (CE, PhD student), (Expected graduation: December 2013).
2) Bin Pei (CE, PhD student, Co-advising with Dr. Pang), (Expected graduation: May 2014).
3) Kalimur Rahman (CE, PhD student), (Expected graduation: December 2015).

Previous Graduate Advising

4) Mijanur Chowdhury (CE, PhD, September, 2011).

5) Malek-Mohammadi, Siamak (CE, PhD, December, 2009).
6) Michael Jacobson (CE, MSc, February, 2012).
7) Earnest Johnson (CE, MSc, 2012).
8) Young, David Morgan (CE, MSc, Dec., 2007).
9) Mathew Hornack (CE, MSc, March, 2011).
10) Chad Heiliger (CE, MSc, December, 2010)

TEACHING

Courses Taught

CE 462/662, Coastal Engineering I

CE 860, Advance Fluid Mechanics

CE 341, Fluid Mechanics

CE341L, Fluid Mechanics Laboratory

CE 208 & EM202, Dynamics

UNIVERSITY AND PUBLIC SERVICE

Editorial Service for Journals

(i) Ocean Engineering (Elsevier), Editorial Board member (September 2011 – present)

(ii) Environmental Fluid Mechanics (Springer), Guest Editor for the Special Issue on "Gravity Currents in the Environment". (Jul. 2012 - Present)

(iii) IJNES – International Journal of Natural and Engineering Sciences, Editorial Board member (January 2008 – present)

(iv) GJET – Global Journal of Engineering and Technology, Editorial Board member (March 2008 – present)

Referee Service for Journals and Conferences

ASCE - Journal of Hydraulic Engineering; IEEE – Journal of Oceanic Engineering; AGU – Water Resources Research; AGU - Advances in Water Resources; AGU - Journal of Geophysical Research – Oceans; Ocean Engineering –Elsevier; ASME – Journal of Applied Mechanics Review; Environmental Fluid Mechanics Journal – Springer; ASCE – Journal of Engineering Mechanics; Coastal Engineering – Elsevier; International Journal of Heat and Fluid Flow – Elsevier; Quarterly Journal of the Royal Meteorological Society – Wiley; ASCE – Waterway, Port, Ocean and Coastal Engineering; REAS' 03 - Research in Engineering and Applied Sciences Symposium, Tempe, Arizona (Conference); ISOPE

2007 – International Polar and Offshore Engineering Conference, Lisbon, Portugal (Conference)

Referee Service for Funding Agencies

(i) National Institute for Water Resources (NIWR) and US Geological Survey (USGS)

(ii) SERDP Program, Department of Defense (DoD).

(iii) National Science Foundation (NSF)

11/29/2012

Current & Pending Support

Principal Investigator: WeiChiang Pang
Date: December 5, 2012

Status: Current – Acct 2007536	Proposal #2009001062 | 2011000436
Title	*Accelerated Bridge Construction – An investigation of a precast alternative for flat slab span*
Sponsor	South Carolina Department of Transportation
Location of Project	Clemson University
Total Award Amount	$394,128
Total Award Period Covered	08/27/09 – 10/26/2013
Person-Months per year	1.0 month Summer
P.I./Co-Inv./%	Co-Inv./33
Status: Current – Acct 2077890	Proposal #2010000744
Title	*Science Master's Program: Sustainable and Resilient Infrastructure*
Sponsor	NSF
Location of Project	Clemson University
Total Award Amount	$700,000
Total Award Period Covered	07/01/2010-06/30/2013
Person-Months per year	0
P.I./Co-Inv./%	Co-P.I./9
Status: Current – Acct 2008423	Proposal #2010001118
Title	*Study of the Rate of Deterioration of Bridges and Pavements as Affected by Trucks*
Sponsor	SCDOT
Location of Project	Clemson University
Total Award Amount	$249,775
Total Award Period Covered	03/29/2011-05/14/2013
Person-Months per year	1.0 Summer
P.I./Co-Inv./%	Co-P.I./30
Status: Current – Acct 2008191	Proposal #2010001312
Title	*NEESR-CR: NEESoft: Seismic Risk Reduction for Soft-Story Woodframe Buildings*
Sponsor	NSF thru University of Alabama
Location of Project	Clemson University
Total Award Amount	$178,684
Total Award Period Covered	10/01/2010-09/30/2013
Person-Months per year	1.0 Summer
P.I./Co-Inv./%	P.I./100

Current & Pending Support

Principal Investigator: WeiChiang Pang
Date: December 5, 2012

Status: Current	Proposal #2012001026
Title	*Numerical Study of the Structural Performance of Large Diaphragms*
Sponsor	FPInnovations
Location of Project	Clemson University
Total Award Amount	$38,000
Total Award Period Covered	04/01/2012 – 03/31/2013
Person-Months per year	1.0 month academic
Investigator/%	PI/100
Status: Current-Acct: 2099215	Proposal #2012000725
Title	*GAANN*
Sponsor	US Dept of Education
Location of Project	Clemson University
Total Award Amount	$266,532
Total Award Period Covered	08/16/12-08/15/15
Person-Months per year	0
Investigator/%	Co-Inv./20
Status: Current-Acct: 2009255	Proposal #2013000016
Title	*Development of Solid and Hollow-Core Southern Pine Cross-Laminated Timber Systems for Low and Mid-rise Construction*
Sponsor	USDA thru North Carolina State University
Location of Project	Clemson University
Total Award Amount	$52,515
Total Award Period Covered	09/01/2012 – 08/31/2015
Person-Months per year	1.0 month academic
Investigator/%	P.I./50
Status: Pending	Proposal #2013000112
Title	*CAREER: Utilizing High-Performance Computing (HPC) for Improving the Earthquake Resilience of Residential Buildings*
Sponsor	NSF
Location of Project	Clemson University
Total Award Amount	$401,999
Total Award Period Covered	02/15/13-02/14/18
Person-Months per year	1.5 Summer
Investigator/%	P.I./100

Current & Pending Support

Principal Investigator: WeiChiang Pang
Date: December 5, 2012

Status: Pending	Proposal # 2013000324
Title	*Robust Bridge Management Under Multiple Objectives and Constraints*
Sponsor	NSF
Location of Project	Clemson University
Total Award Amount	$545,074
Total Award Period Covered	05/15/13-05/14/16
Person-Months per year	1.0 Summer
Investigator/%	P.I./34

Current & Pending Support

Principal Investigator: Firat Y. Testik
Date: July 20, 2011

Status: Current-Acct: 2009183	Proposal #2012000010
Title	*Critical Raindrop Characteristics: Fall Speed, Shape, and Size Distributions*
Sponsor	NSF
Location of Project	Clemson University
Total Award Amount	$190,616
Total Award Period Covered	09/15/12-08/31/15
Person-Months per year	1.5 Summer
P.I./Co-Inv./%	P.I./50
Status: Pending	Proposal #2012000968
Title	*Shallow water placement of dredged material*
Sponsor	US ARMY
Location of Project	Clemson University
Total Award Amount	$337,995
Total Award Period Covered	03/01/2012 – 03/01/2016
Person-Months per year	1.5 Summer
Investigator/%	P.I./100

BUDGET JUSTIFICATION

Duration of the project is two years and the total amount of funding requested from JHT program is $319,651. Requested budget consists of personnel salaries (partial faculty summer salaries for both of the PIs and assistantship salaries for two doctoral students), travel expenditures for Interdepartmental Hurricane Conference (IHC) participation, JHT visit, and scientific meeting/conference attendance, advanced computational facility costs.

Key personnel for the proposed research are Dr. Weichiang Pang and Dr. Firat Y. Testik of the Glenn Department of Civil Engineering at Clemson University, and two doctoral graduate students.

Funds requested for salaries of the key personnel are calculated based on the following considerations. Dr. Pang and Dr. Testik will each contribute 1 month of their time for each year of the project. The graduate students will work half-time (20 hours / week) for 12 months for each year of the project.

Fringe is calculated at 26.2% for faculty and 3% for students. Clemson has a pooled fringe rate which is negotiated by DHHS (for details see: http://www.clemson.edu/cfo/comptroller/rates/index.html).

Requested travel funding will cover the travel expenses associated with: (i) IHC participation for both of the PIs for each year of the project (an estimated cost of $2,000 per PI per conference, total of $8,000 for the entire period of the project), (ii) conference attendances by each of the PIs or their graduate students (two conference attendances per year with an estimated cost of $2,000 per conference, total of $8,000 for the entire period of the project), (iii) JHT visit by both of the PIs for each year of the project to discuss and introduce the product and train the JHT personnel (an estimated cost of $1,500 per person, total of $6,000 for the entire period of the project).

Estimated cost for advance computing facility for 5 computational node is $50,000 ($10,000 per node). This cost is only for the first year of the project.

Tuition Remission is charged at a rate of $9,295 per student with an annual increase of 5% as per Clemson University's policy.

Facility and Administration rate (F&A) is 50%. F&A is negotiated by DHHS. (For details see: http://www.clemson.edu/cfo/comptroller/rates/index.html)

OMB Number: 4040-0004
Expiration Date: 03/31/2012

Application for Federal Assistance SF-424

* 1. Type of Submission:	* 2. Type of Application:	* If Revision, select appropriate letter(s):
☐ Preapplication	☒ New	
☒ Application	☐ Continuation	* Other (Specify):
☐ Changed/Corrected Application	☐ Revision	

* 3. Date Received:	4. Applicant Identifier:
12/06/2012	

5a. Federal Entity Identifier:	5b. Federal Award Identifier:

State Use Only:

6. Date Received by State:	7. State Application Identifier:

8. APPLICANT INFORMATION:

* a. Legal Name:	Clemson University
* b. Employer/Taxpayer Identification Number (EIN/TIN):	576000254
* c. Organizational DUNS:	0426298160000

d. Address:

* Street1:	Office of Sponsored Programs
Street2:	300 Brackett Hall, Box 345702
* City:	Clemson
County/Parish:	Pickens
* State:	SC: South Carolina
Province:	
* Country:	USA: UNITED STATES
* Zip / Postal Code:	296345702

e. Organizational Unit:

Department Name:	Division Name:
Civil Engineering	College of Engrg. & Science

f. Name and contact information of person to be contacted on matters involving this application:

Prefix:	Ms.	* First Name:	Dianne
Middle Name:			
* Last Name:	Myers		
Suffix:			

Title:	Grants Administrator
Organizational Affiliation:	
* Telephone Number:	864-656-5534
Fax Number:	864-656-4518
* Email:	dmmyers@clemson.edu

Application for Federal Assistance SF-424

*** 9. Type of Applicant 1: Select Applicant Type:**

H: Public/State Controlled Institution of Higher Education

Type of Applicant 2: Select Applicant Type:

Type of Applicant 3: Select Applicant Type:

* Other (specify):

*** 10. Name of Federal Agency:**

Department of Commerce

11. Catalog of Federal Domestic Assistance Number:

11.459

CFDA Title:

Weather and Air Quality Research

*** 12. Funding Opportunity Number:**

NOAA-OAR-OWAQ-2013-2003469

* Title:

FY 2013 Joint Hurricane Testbed

13. Competition Identification Number:

2297052

Title:

14. Areas Affected by Project (Cities, Counties, States, etc.):

Add Attachment | Delete Attachment | View Attachment

*** 15. Descriptive Title of Applicant's Project:**

Development of a Statistical-Dynamical Model for Hurricane Storm Surge Forecase

Attach supporting documents as specified in agency instructions.

Add Attachments | Delete Attachments | View Attachments

Application for Federal Assistance SF-424

16. Congressional Districts Of:

* a. Applicant: SC-003 | b. Program/Project: SC-003

Attach an additional list of Program/Project Congressional Districts if needed.

Add Attachment | Delete Attachment | View Attachment

17. Proposed Project:

* a. Start Date: 07/01/2013 | * b. End Date: 06/30/2015

18. Estimated Funding ($):

* a. Federal	315,151.00
* b. Applicant	0.00
* c. State	0.00
* d. Local	0.00
* e. Other	0.00
* f. Program Income	0.00
* g. TOTAL	315,151.00

*** 19. Is Application Subject to Review By State Under Executive Order 12372 Process?**

☐ a. This application was made available to the State under the Executive Order 12372 Process for review on .

☐ b. Program is subject to E.O. 12372 but has not been selected by the State for review.

☒ c. Program is not covered by E.O. 12372.

*** 20. Is the Applicant Delinquent On Any Federal Debt? (If "Yes," provide explanation in attachment.)**

☐ Yes ☒ No

If "Yes", provide explanation and attach

Add Attachment | Delete Attachment | View Attachment

21. *By signing this application, I certify (1) to the statements contained in the list of certifications and (2) that the statements herein are true, complete and accurate to the best of my knowledge. I also provide the required assurances** and agree to comply with any resulting terms if I accept an award. I am aware that any false, fictitious, or fraudulent statements or claims may subject me to criminal, civil, or administrative penalties. (U.S. Code, Title 218, Section 1001)**

☒ ** I AGREE

** The list of certifications and assurances, or an internet site where you may obtain this list, is contained in the announcement or agency specific instructions.

Authorized Representative:

Prefix: Dr. | * First Name: Gerald

Middle Name:

* Last Name: Sonnenfeld

Suffix:

* Title: Vice President for Research

* Telephone Number: 864-656-2424 | Fax Number: 864-656-0881

* Email: CUOSP@clemson.edu

* Signature of Authorized Representative: Dianne Myers | * Date Signed: 12/06/2012

BUDGET INFORMATION - Non-Construction Programs

OMB Number: 4040-0006
Expiration Date: 06/30/2014

SECTION A - BUDGET SUMMARY

Grant Program Function or Activity (a)	Catalog of Federal Domestic Assistance Number (b)	Estimated Unobligated Funds		New or Revised Budget		
		Federal (c)	Non-Federal (d)	Federal (e)	Non-Federal (f)	Total (g)
1. FY 2013 Joint Hurricane Testbed	11.459	$	$	$ 315,151.00	$ 0.00	$ 315,151.00
2.						
3.						
4.						
5. Totals		$	$	$ 315,151.00	$	$ 315,151.00

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SECTION B - BUDGET CATEGORIES

6. Object Class Categories	GRANT PROGRAM, FUNCTION OR ACTIVITY (1)	(2)	(3)	(4)	Total (5)
	FY 2013 Joint Hurricane Testbed				
a. Personnel	$ 58,148.00	$	$	$	$ 58,148.00
b. Fringe Benefits	6,419.00				6,419.00
c. Travel	8,000.00				8,000.00
d. Equipment					
e. Supplies					
f. Contractual					
g. Construction					
h. Other	68,590.00				68,590.00
i. Total Direct Charges (sum of 6a-6h)	141,157.00				$ 141,157.00
j. Indirect Charges	36,283.00				$ 36,283.00
k. TOTALS (sum of 6i and 6j)	$ 177,440.00	$	$	$	$ 177,440.00
7. Program Income	$	$	$	$	$

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SECTION C - NON-FEDERAL RESOURCES

(a) Grant Program	(b) Applicant	(c) State	(d) Other Sources	(e)TOTALS
8. FY 2013 Joint Hurricane Testbed	$	$	$	$
9.				
10.				
11.				
12. TOTAL (sum of lines 8-11)	$	$	$	$

SECTION D - FORECASTED CASH NEEDS

	Total for 1st Year	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
13. Federal	$ 177,440.00	$ 81,860.00	$ 31,860.00	$ 31,860.00	$ 31,860.00
14. Non-Federal	$				
15. TOTAL (sum of lines 13 and 14)	$ 177,440.00	$ 81,860.00	$ 31,860.00	$ 31,860.00	$ 31,860.00

SECTION E - BUDGET ESTIMATES OF FEDERAL FUNDS NEEDED FOR BALANCE OF THE PROJECT

(a) Grant Program	FUTURE FUNDING PERIODS (YEARS) (b)First	(c) Second	(d) Third	(e) Fourth
16. FY 2013 Joint Hurricane Testbed	$ 177,440.00	$ 137,711.00	$	$
17.				
18.				
19.				
20. TOTAL (sum of lines 16 - 19)	$ 177,440.00	$ 137,711.00	$	$

SECTION F - OTHER BUDGET INFORMATION

21. Direct Charges:

22. Indirect Charges: 50% MTDC, PRED, 11, DHHS

23. Remarks:

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OMB Number: 4040-0007
Expiration Date: 06/30/2014

ASSURANCES - NON-CONSTRUCTION PROGRAMS

PLEASE DO NOT RETURN YOUR COMPLETED FORM TO THE OFFICE OF MANAGEMENT AND BUDGET. SEND IT TO THE ADDRESS PROVIDED BY THE SPONSORING AGENCY.

NOTE: Certain of these assurances may not be applicable to your project or program. If you have questions, please contact the awarding agency. Further, certain Federal awarding agencies may require applicants to certify to additional assurances. If such is the case, you will be notified.

As the duly authorized representative of the applicant, I certify that the applicant:

1. Has the legal authority to apply for Federal assistance and the institutional, managerial and financial capability (including funds sufficient to pay the non-Federal share of project cost) to ensure proper planning, management and completion of the project described in this application.

2. Will give the awarding agency, the Comptroller General of the United States and, if appropriate, the State, through any authorized representative, access to and the right to examine all records, books, papers, or documents related to the award; and will establish a proper accounting system in accordance with generally accepted accounting standards or agency directives.

3. Will establish safeguards to prohibit employees from using their positions for a purpose that constitutes or presents the appearance of personal or organizational conflict of interest, or personal gain.

4. Will initiate and complete the work within the applicable time frame after receipt of approval of the awarding agency.

5. Will comply with the Intergovernmental Personnel Act of 1970 (42 U.S.C. §§4728-4763) relating to prescribed standards for merit systems for programs funded under one of the 19 statutes or regulations specified in Appendix A of OPM's Standards for a Merit System of Personnel Administration (5 C.F.R. 900, Subpart F).

6. Will comply with all Federal statutes relating to nondiscrimination. These include but are not limited to: (a) Title VI of the Civil Rights Act of 1964 (P.L. 88-352) which prohibits discrimination on the basis of race, color or national origin; (b) Title IX of the Education Amendments of 1972, as amended (20 U.S.C.§§1681-1683, and 1685-1686), which prohibits discrimination on the basis of sex; (c) Section 504 of the Rehabilitation Act of 1973, as amended (29 U.S.C. §794), which prohibits discrimination on the basis of handicaps; (d) the Age Discrimination Act of 1975, as amended (42 U. S.C. §§6101-6107), which prohibits discrimination on the basis of age; (e) the Drug Abuse Office and Treatment Act of 1972 (P.L. 92-255), as amended, relating to nondiscrimination on the basis of drug abuse; (f) the Comprehensive Alcohol Abuse and Alcoholism Prevention, Treatment and Rehabilitation Act of 1970 (P.L. 91-616), as amended, relating to nondiscrimination on the basis of alcohol abuse or alcoholism; (g) §§523 and 527 of the Public Health Service Act of 1912 (42 U.S.C. §§290 dd-3 and 290 ee- 3), as amended, relating to confidentiality of alcohol and drug abuse patient records; (h) Title VIII of the Civil Rights Act of 1968 (42 U.S.C. §§3601 et seq.), as amended, relating to nondiscrimination in the sale, rental or financing of housing; (i) any other nondiscrimination provisions in the specific statute(s) under which application for Federal assistance is being made; and, (j) the requirements of any other nondiscrimination statute(s) which may apply to the application.

7. Will comply, or has already complied, with the requirements of Titles II and III of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 (P.L. 91-646) which provide for fair and equitable treatment of persons displaced or whose property is acquired as a result of Federal or federally-assisted programs. These requirements apply to all interests in real property acquired for project purposes regardless of Federal participation in purchases.

8. Will comply, as applicable, with provisions of the Hatch Act (5 U.S.C. §§1501-1508 and 7324-7328) which limit the political activities of employees whose principal employment activities are funded in whole or in part with Federal funds.

9. Will comply, as applicable, with the provisions of the Davis-Bacon Act (40 U.S.C. §§276a to 276a-7), the Copeland Act (40 U.S.C. §276c and 18 U.S.C. §874), and the Contract Work Hours and Safety Standards Act (40 U.S.C. §§327-333), regarding labor standards for federally-assisted construction subagreements.

10. Will comply, if applicable, with flood insurance purchase requirements of Section 102(a) of the Flood Disaster Protection Act of 1973 (P.L. 93-234) which requires recipients in a special flood hazard area to participate in the program and to purchase flood insurance if the total cost of insurable construction and acquisition is $10,000 or more.

11. Will comply with environmental standards which may be prescribed pursuant to the following: (a) institution of environmental quality control measures under the National Environmental Policy Act of 1969 (P.L. 91-190) and Executive Order (EO) 11514; (b) notification of violating facilities pursuant to EO 11738; (c) protection of wetlands pursuant to EO 11990; (d) evaluation of flood hazards in floodplains in accordance with EO 11988; (e) assurance of project consistency with the approved State management program developed under the Coastal Zone Management Act of 1972 (16 U.S.C. §§1451 et seq.); (f) conformity of Federal actions to State (Clean Air) Implementation Plans under Section 176(c) of the Clean Air Act of 1955, as amended (42 U.S.C. §§7401 et seq.); (g) protection of underground sources of drinking water under the Safe Drinking Water Act of 1974, as amended (P.L. 93-523); and, (h) protection of endangered species under the Endangered Species Act of 1973, as amended (P.L. 93-205).

12. Will comply with the Wild and Scenic Rivers Act of 1968 (16 U.S.C. §§1271 et seq.) related to protecting components or potential components of the national wild and scenic rivers system.

13. Will assist the awarding agency in assuring compliance with Section 106 of the National Historic Preservation Act of 1966, as amended (16 U.S.C. §470), EO 11593 (identification and protection of historic properties), and the Archaeological and Historic Preservation Act of 1974 (16 U.S.C. §§469a-1 et seq.).

14. Will comply with P.L. 93-348 regarding the protection of human subjects involved in research, development, and related activities supported by this award of assistance.

15. Will comply with the Laboratory Animal Welfare Act of 1966 (P.L. 89-544, as amended, 7 U.S.C. §§2131 et seq.) pertaining to the care, handling, and treatment of warm blooded animals held for research, teaching, or other activities supported by this award of assistance.

16. Will comply with the Lead-Based Paint Poisoning Prevention Act (42 U.S.C. §§4801 et seq.) which prohibits the use of lead-based paint in construction or rehabilitation of residence structures.

17. Will cause to be performed the required financial and compliance audits in accordance with the Single Audit Act Amendments of 1996 and OMB Circular No. A-133, "Audits of States, Local Governments, and Non-Profit Organizations."

18. Will comply with all applicable requirements of all other Federal laws, executive orders, regulations, and policies governing this program.

19. Will comply with the requirements of Section 106(g) of the Trafficking Victims Protection Act (TVPA) of 2000, as amended (22 U.S.C. 7104) which prohibits grant award recipients or a sub-recipient from (1) Engaging in severe forms of trafficking in persons during the period of time that the award is in effect (2) Procuring a commercial sex act during the period of time that the award is in effect or (3) Using forced labor in the performance of the award or subawards under the award.

* SIGNATURE OF AUTHORIZED CERTIFYING OFFICIAL	* TITLE
Dianne Myers	Vice President for Research
* APPLICANT ORGANIZATION	* DATE SUBMITTED
Clemson University	12/06/2012

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FORM **CD-511**
(REV 1-05)

U.S. DEPARTMENT OF COMMERCE

CERTIFICATION REGARDING LOBBYING

Applicants should also review the instructions for certification included in the regulations before completing this form. Signature on this form provides for compliance with certification requirements under 15 CFR Part 28, 'New Restrictions on Lobbying.' The certifications shall be treated as a material representation of fact upon which reliance will be placed when the Department of Commerce determines to award the covered transaction, grant, or cooperative agreement.

LOBBYING

As required by Section 1352, Title 31 of the U.S. Code, and implemented at 15 CFR Part 28, for persons entering into a grant, cooperative agreement or contract over $100,000 or a loan or loan guarantee over $150,000 as defined at 15 CFR Part 28, Sections 28.105 and 28.110, the applicant certifies that to the best of his or her knowledge and belief, that:

(1) No Federal appropriated funds have been paid or will be paid, by or on behalf of the undersigned, to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress in connection with the awarding of any Federal contract, the making of any Federal grant, the making of any Federal loan, the entering into of any cooperative agreement, and the extension, continuation, renewal, amendment, or modification of any Federal contract, grant, loan, or cooperative agreement.

(2) If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a member of Congress in connection with this Federal contract, grant, loan, or cooperative agreement, the undersigned shall complete and submit Standard Form-LLL, 'Disclosure Form to Report Lobbying.' in accordance with its instructions.

(3) The undersigned shall require that the language of this certification be included in the award documents for all subawards at all tiers (including subcontracts, subgrants, and contracts under grants, loans, and cooperative agreements) and that all subrecipients shall certify and disclose accordingly.

This certification is a material representation of fact upon which reliance was placed when this transaction was made or entered into. Submission of this certification is a prerequisite for making or entering into this transaction imposed by section 1352, title 31, U.S. Code. Any person who fails to file the required certification shall be subject to a civil penalty of not less than $10,000 and not more than $100,000 for each such failure occurring on or before October 23, 1996, and of not less than $11,000 and not more than $110,000 for each such failure occurring after October 23, 1996.

Statement for Loan Guarantees and Loan Insurance

The undersigned states, to the best of his or her knowledge and belief, that:

In any funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with this commitment providing for the United States to insure or guarantee a loan, the undersigned shall complete and submit Standard Form-LLL, 'Disclosure Form to Report Lobbying,' in accordance with its instructions.

Submission of this statement is a prerequisite for making or entering into this transaction imposed by section 1352, title 31, U.S. Code. Any person who fails to file the required statement shall be subject to a civil penalty of not less than $10,000 and not more than $100,000 for each such failure occurring on or before October 23, 1996, and of not less than $11,000 and not more than $110,000 for each such failure occurring after October 23, 1996.

As the duly authorized representative of the applicant, I hereby certify that the applicant will comply with the above applicable certification.

* NAME OF APPLICANT

Clemson University

* AWARD NUMBER

N/A

* PROJECT NAME

Prefix: Dr.

* First Name: Gerald

Middle Name:

* Last Name: Sonnenfeld

Suffix:

* Title: Vice President for Research

* SIGNATURE: Dianne Myers

* DATE: 12/06/2012