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THE JOHN A. BLUME EARTHQUAKE ENGINEERING CENTER

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Letter from Director Anne Kiremidjian

It is hard to believe that ten years have gone by since I became a director of the Blume Center. In the past month I have been reflecting back on those years. They were both exciting and challenging. When I took over the Center from **Helmut Krawinkler** plans for the renovation and seismic upgrading were already underway, but it fell upon me to oversee the reconstruction of the building and the renovation of the laboratories. The shaking table received a new actuator, bearings, and controller with funds from the National Science Foundation and Stanford University. During that time, **Dr. Stephanie King** had joined me as the Associate Director of the Blume Center and helped with numerous tasks and activities. **Carol Strovers** was the Center administrator who took great pains in refurbishing the place paying attention to the last detail, keeping the labs and the entire building always in perfect order. We celebrated the reopening with many of our friends joining us for the occasion; but perhaps what was most rewarding was to see **John Blume's** face light up when he came to visit the Center just as it was completed and shortly before the reopening ceremonies.

First on Stephanie's and my agenda a year after the reopening was the offering of a professional course on Applications of Geographic Information Systems to Earthquake Hazard and Risk Assessment. The course was well received and helped with raising much needed funds. Stephanie also took over the editorship of the Blume Center Newsletter from **Allison Smith** and took charge of many of the activities around the Center. We continued to have a very successful affiliates and donor program and held our regular Affiliates meetings. It was delightful to see old friends while showing them the work of our students and faculty. What was truly exciting was to see the doctoral students working feverishly, preparing their posters and presentations. Our students have always made us proud and I thank all of them through the years for their help and dedication, but most of all for their friendship.

Earthquakes around have kept all of us extremely busy – the Northridge event of January 17, 1994 followed by the catastrophic event in Kobe, Japan on exactly the same day a year later. Many of us participated in reconnaissance activities and studied these events extensively. More recently, the earthquakes in India, Taiwan and Turkey provided opportunities for our younger colleagues to learn from those events first hand. Over the years we have shared our knowledge with colleagues from around the world. We had visiting scholars, official delegations and held workshops with researchers from Japan, China, Korea, Singapore, Taiwan, the Philippines, Slovenia, Italy, Germany, Austria, Spain, France, Switzerland, Hungary, the Check Republic, Mexico, Chile, Colombia and Canada. It has been a truly enriching experience.

In 1999 Carol left and **Racquel Hagen** took over the administrative duties of the Blume Center. Very adept with the computer, Racquel set out to redesign the web page for the Blume Center. In the meantime, Stephanie was expecting her third child and needed more flexible schedule. I was sad to see her leave, but we have continued working together over the years and she still organizes events for the Blume Center Alumni. The Center has continued to run smoothly like a "fine Swiss clock", as my father would often say, primarily due to Racquel's dedication and extraordinary efforts. I have indeed been blessed with wonderful people around me. I thank you wholeheartedly.

Two years ago we initiated the John A. Blume Distinguished Lecture Series with our first lecturer **Tom Paulay**, followed by **Ron Hamburger**. The series has been very successful drawing large audiences and bringing the recognition to Dr. Blume that he so well deserved. We were all saddened by his passing away and I felt a great personal loss for he had been an inspiration to me professionally and a dear friend personally.

Through all those years key to our success have been the incredible faculty and students involved with the Center. Helmut, **Jim Gere** and **Haresh Shah** – past directors of the Center, were always within reach and always willing to help and go the extra mile. I am greatly indebted to them. In many ways they made it easy for me. The Center was set in motion; I just had to make sure not to go astray. **Kincho Law**, **Ronnie Borja** and Allison always responded with great enthusiasm and helped with everything I always asked of them. The Center has truly gained with the addition of **Greg Deierlein**, **Eduardo Miranda** and **Chuck Menun**. Over the past two years Greg has been helping me with the Blume Center activities in the capacity of Associate Director. He has also been instrumental in reactivating the experimental program of our laboratory.

I thank each and every one of you for your continued support and friendship.

I leave with mixed emotions. I am sad because a chapter of my life has come to a close. I am happy and excited, however, for I know that the Blume Center will continue to excel under the leadership of Greg Deierlein.

Thank you for the opportunity to have served you.

RESEARCH SPOTLIGHT

Airgap Analysis of Floating Structures Subject to Random Seas

By Bert Sweetman

Introduction

Airgap is defined as the instantaneous vertical distance between the top of the sea surface and the lowest deck of an offshore structure. The consequences of exceeding the design airgap in a storm can be quite serious, and can include: structural damage due to unexpected wave impact, loss of life or equipment damage due to water on deck, or vessel capsize due to loss of vessel stability.

Airgap modeling is of concern for both fixed and floating structures, but is particularly challenging in the case of floating structures because of their large volumes and the resulting effects of wave diffraction and radiation. Standard airgap response prediction uses linear theory, which generally does not effectively reproduce measurements from model tests. First-order diffraction is considerably less demanding than second-order, so use of only first-order diffraction merits some consideration. Second-order diffraction effects are expected to better reflect observed data. But, these radiation/diffraction panel calculations are very sensitive to the numerical modeling.

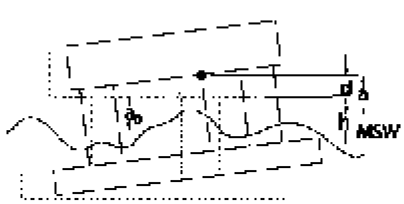

Figure 1. Side-view of semi-submersible in offset position: definition of airgap terms.

Figure 1 shows the various terms relevant to airgap calculation. The airgap, ????, can be considered a linear combination of three terms: ? ?, the still-water airgap distance, ????, the wave surface elevation at a particular location along the structure measured with respect to a fixed observer, and ???? the corresponding vertical motion of the platform. Among the various terms in an equation describing the airgap, ???? ??? ? ???????????????, the vertical offset due to rigid body motion of the vessel, ????, is perhaps the most straightforward to model. Linear diffraction theory may often suffice to accurately model this offset. In contrast, the free surface elevation, ????, generally shows nonlinear behavior—and hence represents a non-Gaussian process. Modeling attention is therefore focused on ????.

In the research summarized here, the numerical impact of modeling diffraction effects including several new post-processing methodologies is assessed. Various predictions of the statistical behavior of the free surface are compared with model test results. Diffraction results come from an industry-standard state-of-the-art computer program (WAMIT) which applies second-order panel diffraction theory. All analysis and model test results are relevant to the Veslefrikk semisubmersible, the plan view of which is shown in Figure 2. An extensive set of model test data is available for the Veslefrikk semisubmersible. Wave impact under the deck was unexpectedly observed in the field, which motivated the vessel owner to undertake a substantial physical model test program. Wave impact was also observed in these tests; the failure of analytical design tools to predict these events motivates the research presented here. The nine numbered locations on the figure correspond to the nine locations for which model test results are available. Other relevant particulars for the vessel as analyzed include: draft: 23 m, displacement: 40,692 tonnes, airgap to still water level: 17.5 m and water depth on location: 175 m.

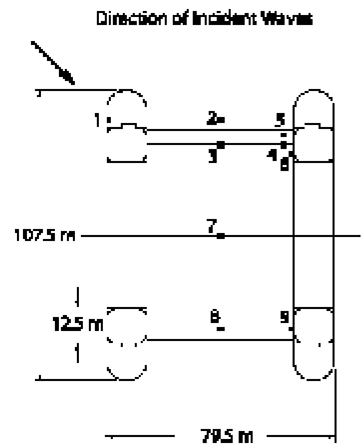

Figure 2. Plan-view of Veslefrikk platform and location of airgap probes.

In this research, statistical and dynamic non-linearities in ocean waves and wave-structure interaction are considered. Focus is on prediction of extreme airgap events for semisubmersibles. Two sources are assumed to account for all nonlinearity: incident waves, and wave-structure interaction. Various methods of predicting extremes based on post-processing hydrodynamic analysis and model test results are proposed.

Methods and Results

First, methods using regression and fractile trend-lines to predict extreme airgap events from model test results are developed and confirmed. Example results are shown in Figure 3. The objective here is to use model test results to predict extreme design events which may not have been simulated in the test basin.

Second, methods to predict extreme airgap events based on linear diffraction results are developed and confirmed. An example of the numerical model used in the panel diffraction (WAMIT) calculations is shown in Figure 4. All of these new models include Stokes second-order incident waves. Extremes are estimated using a Poisson approximation and a 4-moment Hermite statistical transformation. Example results from each of the three new methods investigated are shown in Figure 5. The objective here is to improve the post-processing of results from standard, robust hydrodynamic tools to enable better prediction of extreme events.

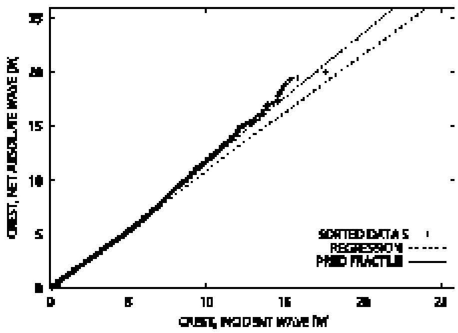

Figure 3. Observed airgap demand crest elevations compared with linear regression and fractile predition trend lines.

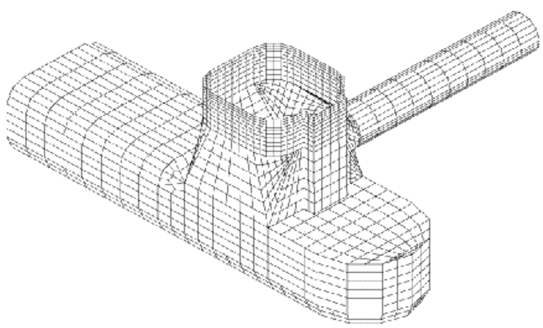
Figure 4. One-quarter of the (bi-symmetric) panel model used in the hydrodynamic diffraction calculation.

Third, full second-order hydrodynamic panel diffraction is applied. Two new methods of modifying quadratic transfer functions (QTF's) are developed: In one, QTF's predicted by panel diffraction are replaced with those predicted by Stokes theory for short periods only. In the other, known on-diagonal QTF's predicted by multi-column analysis are extrapolated to estimate off-diagonal terms. An example quadratic transfer function matrix is presented in Figure 6; each intersection in the mesh represents a single entry in the QTF matrix. A more simplified representation which shows only the diagonal of the matrix, along with the QTF's predicted by Stokes theory, is presented in Figure 7. The objective here is to make use of valuable contributions from second-order diffraction theory while removing the effects of unreasonable QTF predictions.

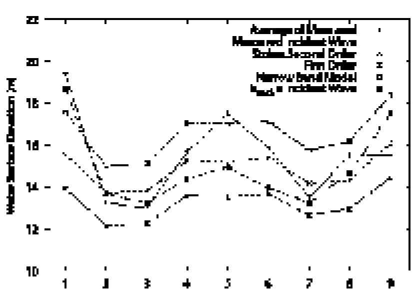

Figure 5. First- and hybrid second-order predictions based on first-order diffraction results.

Fourth, black-box system identification is used to extract first- and second-order transfer functions from measured data. The reasonableness of the Stokes substitution (above) is confirmed, as is the capability of second-order modeling of airgap demand. The diagonal of the transfer function matrix as identified from measured data is compared with that predicted by second-order panel diffraction and Stokes theory are compared in Figure 8. The objective here is to confirm that the QTF prediction results being neglected in the third topic (above) are not accurate representations of the true QTF's.

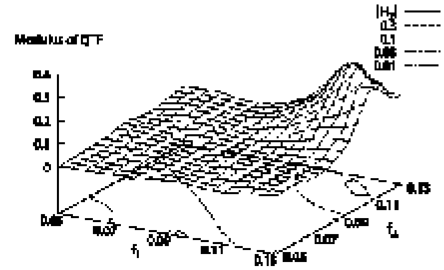

Figure 6. Quadratic transfer functions from diffraction: magnitude of complex terms in QTF matrix.

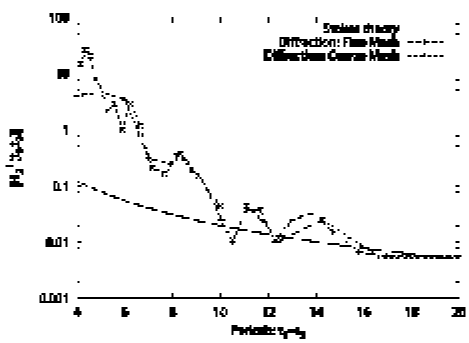

Figure 7. Quadratic transfer functions from diffraction: diagonals of QTG matrices.

Conclusions

The most significant conclusions are: second-order effects are important to prediction of airgap demand; panel diffraction over-predicts these effects for high frequencies; incident waves are a meaningful source of second-order effects, and application of first-order diffraction with second-order incident waves is reasonable when estimating airgap extreme statistics.

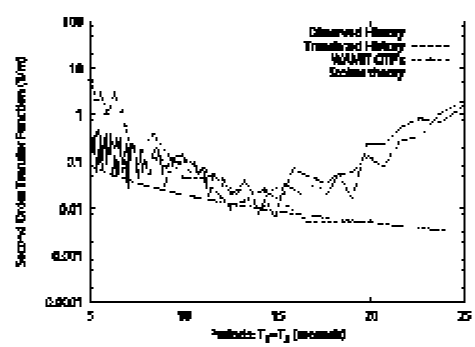

Figure 8. Quadratic transfer functions from system identification: diagonals of QTF matrices.

Blume Center News

Profs. Greg Deierlein, Helmut Krawinkler, Eduardo Miranda and **Allin Cornell** made presentations at the PEER 2002 Annual Meeting, held in Oakland on Jan. 17-18, 2002. Titles and details or the presentations are at *http://peer.berkeley.edu/2002annualmeeting/index.html*.

Prof. Allin Cornell has been named as chair of the Senior Advisory Council of COSMOS (the Consortium of Organizations for Strong Ground Motion Observation Systems).

Prof. Greg Deierlein gave an invited presentation at the EERI 2002 Annual Meeting in Long Beach (Feb. 7-9, 2002), entitled *"Performance-Based Earthquake Engineering: A Framework for the Future"*.

Prof. Greg Deierlein gave an invited talk entitled, *"Parallels Between Performance-Based Engineering for Fire and Earthquake Hazards"* at a NIST workshop on Research Needs for Fire Resistance Determination and Performance Prediction, Gaithersburg, MD, Feb. 19-20, 2002

Prof. Allin Cornell has been named to the Strong Motion Instrumentation Advisory Committee (SMIAC), a committee of the Seismic Safety Commission which advises the Strong Motion Instrumentation Program of the California Geological Survey (formerly CDMG).

In March 2002, **Prof. Greg Deierlein** and **Paul Cordova**, Ph.D. candidate, visited the NCREE Lab in Taiwan to coordinate planning with Prof. K.C. Tsai and his colleagues on a full-scale composite steel-concrete frame test, which will be conducted at NCREE later this year. Paul Cordova will be spending summer 2002 at NCREE to participate in the final planning, coordination and testing of the frame.

Winter 2002 Graduates

Students graduating with a Master of Science degree in Winter Quarter 2002 were **Craig Foster**, **Dae Yong Kim**, **Adrian Persaud, Eileen Prencke**, **Jorge Fuentes** (DCI), **Valerie Tzu-Yi Ou** (DCI) and **Ravi Raghu** (DCI). Craig Foster and Jorge Fuentes will be staying on as PhD Candidates at Stanford. Congratulations also to **Tina Kashef-Haghighi** for received her PhD.

Research Funding

Profs. Allin Cornell and **Greg Beroza** of Geophysics have been awarded a second NSF project in the US-Japan Urban Hazard Reduction for "Severe Ground Motions". Prof. Beroza and Post-Doc Patti Guatteri will focus on simulation of strong ground motion using a stochastic dynamic model of the fault rupture, Prof. Cornell's portion will focus on the effect on structures.

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