PORTFOLIO

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PORTFOLIO

* Background Graphic produced using "R." Data obtained from USGS and NOAA showing global earthquake and hurrciane tracks recorded since 1950.

EDUCATION:

Stanford University — **Stanford, CA, 2011-2015**
PhD. in Catastrophic Risk Modeling of Cities

University of California at Berkeley — **Berkeley, CA, 2008-2009**
Masters of Science in Structural Engineering

Massachusetts Institute of Technology — **Cambridge, MA, 2003-2007**
Bachelor of Science Degree in Civil/Environmental Engineering

AWARDS AND FELLOWSHIPS:

Fellowship - Shah Family Fellowship for research on Catastrophic Risk, 2012
Fellowship - John A. Blume Fellowship in Earthquake Engineering, 2011
Fellowship - P.K. Mehta Fellowship, UC Berkeley, 2008
Fellowship - New Zealand Red Cross Research Fellowship on leadership in disaster recovery, 2014-2015.
Award - Development Impact Award. Project coordinator for the World Bank 2010 Haiti Post-Disaster Damage Assessment Program. Project won the Development Impact Honors awarded by the United States Secretary of Treasury. Award accepted by Work Bank President Jim Kim from US Congressman Eliott Engel, 2013 (http://tinyurl.com/lqbc5zj).
Award - World Bank Vice Presidency Unit (VPU) Award for work on post-disaster response in Haiti, 2011.
Invited Keynote Speaker - "Uses of Information Technology Products for Disaster Response & Recovery", Annual Meeting, Information Products Laboratory for Emergency Response, Rochester Institute of Technology (2010)
Invited Plenary Speaker - "Supporting and Informing the Process of Risk Arbitration in Post-Disaster Recovery" Plenary Talk, Third International Conference on Urban Disaster Recovery, Sept 28-Oct 1st, 2014. Boulder Colorado.

SUCCESSFUL FUNDING/GRANTS:

NSF Grant Proposal (NSF Grant No 106756) to conduct research on dynamic urban disaster risk modeling ($400,000)
Google Earth Engine Research Grant ($70,000 unrestricted gift)
California Seismic Safety Commission Grant. Primary contributor to a Global Earthquake Model (GEM) proposal for modeling urban recovery to earthquake disasters ($300,000)

WORK EXPERIENCE:

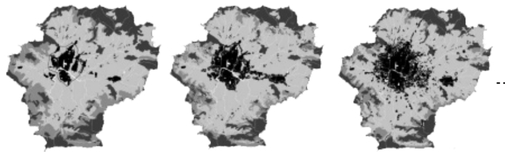
Global Facility for Disaster Reduction and Recovery — **2012-Present**
Steering Committee – Disaster Recovery Framework

The World Bank Group — **Port-au-Prince, Haiti, 2010-2012**
Disaster Risk Management Consultant

Buro Happold — **New York, NY, 2007 – 2008**
Structural Designer

Understanding and Managing Extremes Graduate School — **Pavia, Italy, 2012-2013**
Teaching Faculty -- urban risk modeling and post-disaster recovery (Graduate Level)

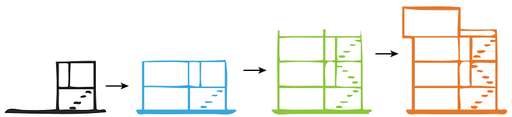
Project: Forecasting potential future risk of cities to envision paths towards future resilience
Location: Stanford University, 2011-2015
Funder: National Science Foundation Grant CMMI -106756
Collaborators: World Bank, Global Facility for Disaster Reduction and Recovery (GFDRR)

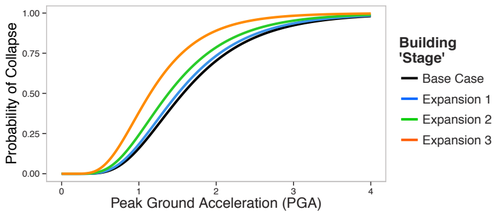


Urban Growth of Kathmandu, Nepal (1991- 2011)

Photo: Julia King

The add-hoc process of incremental construction is the default and most prevalent form of urban construction in developing countries.





Modeling the increase in vulnerability resulting from incremental building expansions.

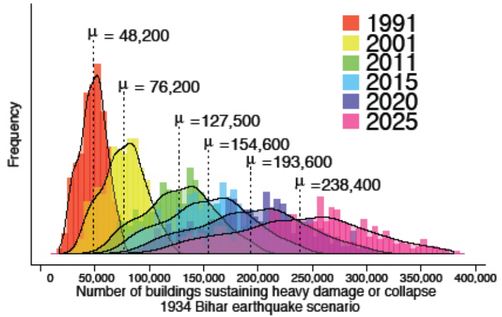
The Project:

The dramatic urban transformation of the past century has shifted the landscape of risk, with cities becoming the major source of global risk. In the next few decades, the equivalent of all the urban infrastructure and housing built in the past 6000 years will be rebuilt (Goethert, 2013). **This poses simulatneously a tremendous challenge and a tremendous opportunity to ensure that our future cities are resilient.**

Our current risk assessment models however fall short in characterizing the spatial and temporal dynamics of the urban environments in terms of rapidly changing local exposure and vulnerability, often leading to large underestimation of risk. The two main objectives of the research are to improve current risk assessment methodologies by (1) incorporating **dynamic changes in hazard exposure**, reflecting increases in population, and its specific patterns of distribution over a multi-hazard landscape, and (2) incorporating **time-varying vulnerability**, reflecting incremental construction practices and evolving building regulations.

Risk sensitive urban planning and policy offers a unique opportunity to control current trends in urban risk, but only if **decision-makers are informed of their likely risk trajectories and the methods to control them**.

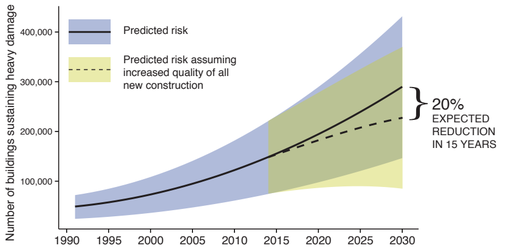
Modeling the seismic risk of Kathmandu over time



In most of the world's rapidly growing cities, addressing existing risk is incredibly complex, expensive and politically infeasible. By modeling various "trajectories of risk" with and without policy interventions, the tools enable policymakers and muncipal governements to understand how **decisions made today can impact risk in the future**. By allowing a **side-by-side comparison of probabilistic loss versus cost of mitigation**, the models will reinforce the notion that risk mitigation can be an investment rather than an expense. It further promotes the notion that risk is very litteraly constructed (embeded in decisions of where, what and how we build our infrastructure), rather than cast upon us. **Hence we are empowered (and responsible) to choose our risk trajectory.**

Part of this research is also to develop **novel ways to model and communicate uncertainty and risk information.**

How do decisions made today effect the risk of tomorrow?



Outputs:

- Lallemant, D., Wong, S., Kiremidjian, A. (2014). A Framework for Modeling Future Urban Disaster Risk. In Understanding Risk in an Evolving World: Emerging Best Practices in Natural Disaster Risk Assessment. Editors: A. Simpson, S. Frazer. Global Facility for Disaster Reduction and Recovery.
- Lallemant, D. (2015). "Managing Post-Disaster Riskscapes – Lessons Learned from Port-au-Prince, Haiti", Invited Speaker, National Building Museum, Designing for Disaster exhibit, Feb 2nd 2015, Washington DC.
- Lallemant, D., Wong S., Morales K., Kiremidjian, A., (2014). "A Framework and Case Study for Urban Seismic Risk Forecasting," Conference paper and presentation, 10th National Conference on Earthquake Engineering, July 21-25 2014, Anchorage, Alaska.
- Lallemant, D. (2014) "Modeling Future Risk to Envision Paths towards Future Resilience," Presentation, Understanding Risk Conference, London, June 2014.

Project: Rapid Post-Disaster Damage Assessment using Remote Sensing and Geostatistical Analysis
Location: Stanford University, 2010-2015
Collaboratiors: World Bank, United Nations Operational Satellite Applications Programme

High resolution aerial image used for post earthquake assessment in the weeks following the 2010 earthquake in Haiti

A good estimate of the scale and distribution of damage after a disaster is critical for effective response and recovery. It provides information to make best use of emergency responders, distribute medical, food or other aid, manage debris removal, and advo-cate for and leverage international aid based on a clear understanding of losses.

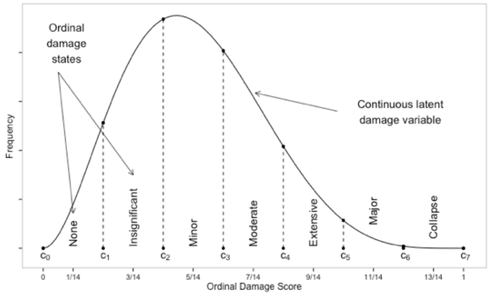
Current methods used for rapid post-disaster assessment are often based on remote-sensing methods using high-resolution radar or aerial imagery. These methods identify extreme damage from top view (building collapse), but **cannot capture lower levels of damage**, which often make up the majority of losses in a disaster. Furthermore, significant ommisions result from the fact that much damage is not detectable from top-view, such as soft-story collapses in an earthquake.

This research builds on existing methods for remote-sensing based damage assessment and proposes **a new approach for damage estimation over large areas, using geostatistical analysis methods on combined remote-sensing and limited field-based damage assessment data.** The model takes advantage of the spatial auto-correlation and cross-correlation bewteen remote-sensing and field-based damage assessments to produce updated estimates of the mean damage over the entire affected area. A Beta distribution model is developed to characterize a continuous latent variable of damage, or discretize damage into ordinal damage states. This can be used to estimate the distribution of all damage states based only on the mean damage state.

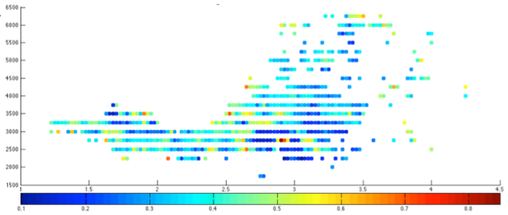
Post-disaster damage is often not detectable from top-view, such as the soft-story collapse shown here

Modeling the seismic risk of Kathmandu over time

Based on data from the 2010 earthquake in Haiti, results show **significant improvements in estimating the full distribution of damage states, and its spatial distribution accross an earthquake affected area**. These positive results have **led to a collaboration with the World Bank to explore the use of this model for future rapid post-disaster damage assessment missions.**

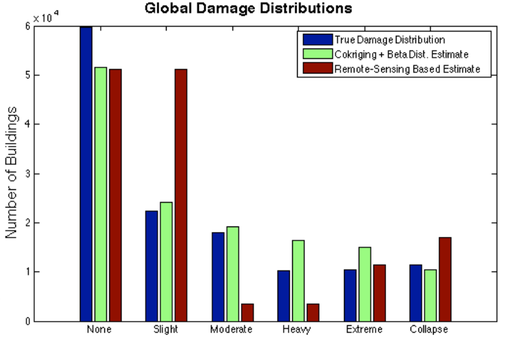


Geostatistical tools are developed to provide better estimates of damage distribution accross large areas



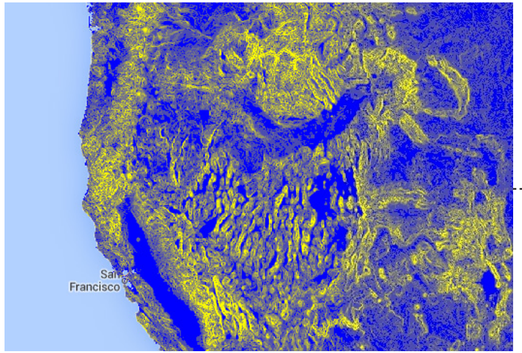
Outputs:

- Lallemant, D., Kiremidjian, A. (2014). A Beta Distribution Model for Characterizing Earthquake Damage State Distribution. Earthquake Spectra, p.140514111412006.
- Lallemant, D., Kiremidjian, A. (2013). "Rapid Post-Earthquake Damage Estimation using Remote-Sensing and Field-Based Damage Data Integration," Conference paper and presentation, 11th International Conference on Structural Safety & Reliability, June 16-20, 2013.
- C. Corbane, K. Saito, L. Dell'Oro, E.Bjorgo, S. Gill, B. Piard, C. Huyck, T. Kemper, G. Lemoine, R. Spence, R. Shankar, O. Senegas, F. Ghesquiere, D. Lallemant, G. Evans, R. Gartley, J. Toro, S. Ghosh, W. D. Svekla, B. Adams, and R. Eguchi (2011). A Comprehensive Analysis of Building Damage in the 12 January 2010 Mw7 Haiti Earthquake Using High-Resolution Satellite and Aerial Imagery, Photogrammetric Engineering & Remote Sensing, Vol. 77, No. 10, October 2011, pp. 0997-1009.
- Lallemant, D. (2010). "Uses of Information Technology Products for Disaster Response & Recovery", Keynote Presentation, Annual Workshop - Information Products Laboratory for Emergency Response, Nov 12, 2010, Rochester Institute of Technology, Rochester, NY.



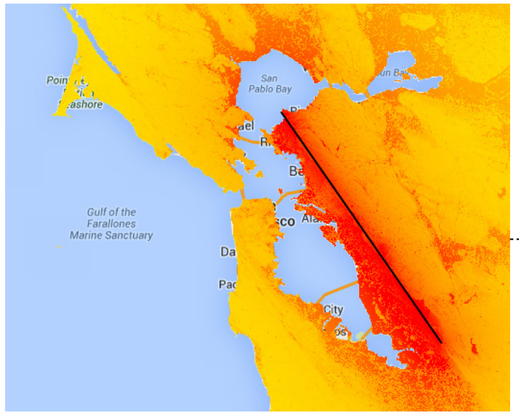
Results (in green) show significant improvements compared with previous state of the art damage estimation methods (in red)

Project: Novel Technologies for Rapid Urban and Regional Scale Earthquake Risk Modeling
Location: Stanford University, 2014-2015
Funder: Google Research Grant (2014)
Collaborators: Google



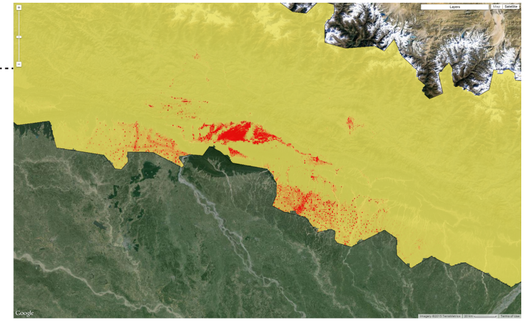
global scale estomation of seismic site amplification (shear wave velocity Vs30).

This research in partnership with Google makes use of Google Earth Engine to model earthquake hazard. Taking advantage of the **multi-layer geospatial data repository and parallelized computing engine** of Google's new Earth Engine, I developed (1) a global estimate of shear wave velocity at 30m depth, used to to compute site-related earthquake ground motion amplification, and (2) very rapid estimation of ground shaking for a given earthquake scenario event, such as the rupture of the hayward fault shown here.



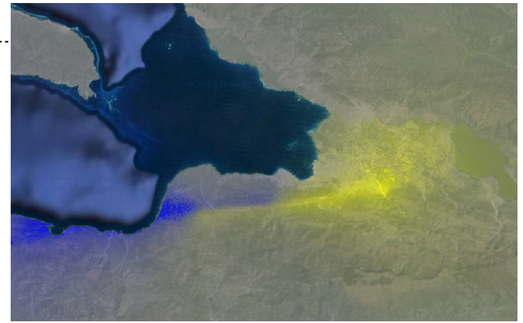
earthquake ground motion prediction from a rupture of the hayward fault in the San Francisco Bay Area.

Computing national estimated fatality distribution for nepal resulting from a reproduction of the 1934 Great Bihar earthquake



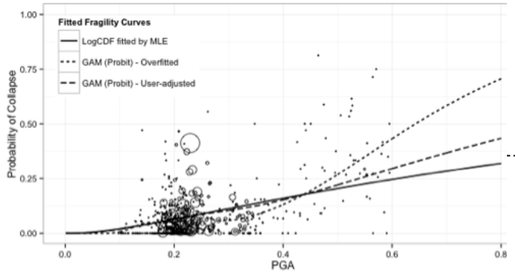
Currently we are working to develop **first order estimates of national and global eartquake risk and how it has changed over the past decades**. We are developing tools for **rapid simulation of spatially coherent ground-shaking fields**, necesary to properly understand risk to spatially distributed infrastructure. In addition, we will attempt to use the Google Earth Engine platform for automated basin detection, and geostatistical tool to estimate basin depth in order to provide better estimates of earthquake ground shaking.

difference in ground shaking between the actual 2010 earthquake in Haiti and the expected earthquake (still expected), highlighting the significant remaining risk of Port-au-Prince.



Outputs:

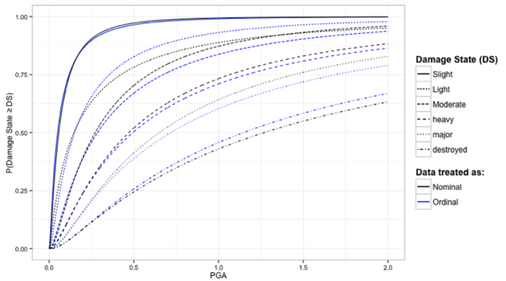
- Lallemant, D., (2014). "Waiting for the Big One: the Continued Earthquake Risk of Port-au-Prince, Haiti" Conference paper and presentation, 3rd International Conference on Urban Disaster Recovery, Sept 28-Oct 1st. Boulder Colorado.
- Lallemant, D. (2014) "Tools for Modeling Changing Riskcapes," Presentation, Understanding Risk Conference, London, June 2014.
- Project showcased at the 2014 Google I/O event.
- Lallemant, D., Markhvida, M., Baker, J., (2015). "Preliminary Impact Assessment of the April 2015 Earthquake in Nepal."



Project: statistical procedures and treatment of uncertainty in earthquake fragility modeling
Location: Stanford University, 2012-2014
Funder: National Science Foundation Grant CMMI -106756, Global Earthquake Model Foundation Grant
Collaborators: Global Earthquake Model Foundation

The choice of statistical model has significant impact on the resulting fragility curve

Earthquake damage to ground-motion relationships are a key component for earthquake loss estimation and the performance-based analysis of the risk of structures. Also called fragility curves, they describe the probability of experiencing or exceeding a particular level of damage as a function of ground shaking intensity. While fragility curves abound in earthquake engineering and risk assessment literature, the focus has generally been on the methods for obtaining the damage data (i.e. the analysis of structures), and little emphasis is placed on the process for fitting fragility curves to this data, nor on how to characterize and account for the uncertainty in such models. This project does just that.

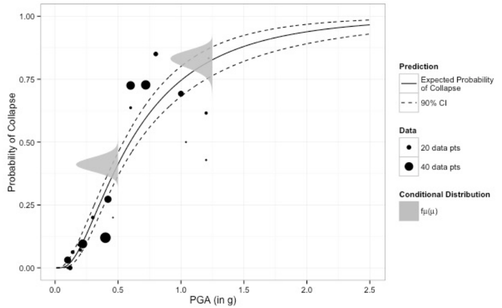


cumulative-link generalized linear models take advantage of the ordinality of damage data to provide better fragility curves for multiple damage states

This research also demonstrates that **accounting for the uncertainty in the fragility model, as well as intrinsic variability in outcome based on the model, can significantly modify our understanding of earthquake risk**, especially for infrastructure portfolios.

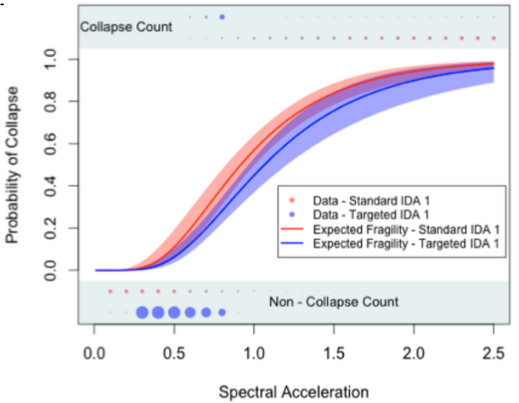
Numerous statistical methods were investigated and discussed for developing fragility curves, including generalized linear models, cummulative link models, generalized additive models and kernel smoothing. Methods are also proposed for treating uncertainty in the ground-shaking intensity measure.

accounting for uncertainty in fragility curves and variability in outcome can significantly change our understading of the risk of buildings



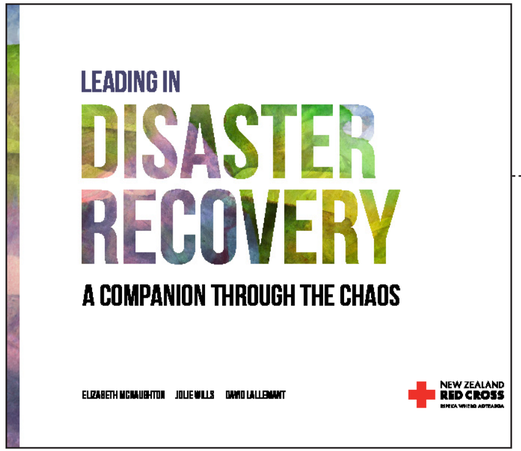
Modeling the uncertainty in fragility curves can also be used to target structural analysis for intensity measures that matter most. In this way we can **minimize the overal uncertainty in the estimated risk, and also significantly reduce the computations needed to reach a target confidence level.**

by characterizing the uncertainty in fragility curves, we can target structural analysis so as to reduce uncertainty where it matters most



Outputs:

- Lallemant D., Kiremidjian A. and Burton H. (2015), Statistical procedures for developing earthquake damage fragility curves. Earthquake Engineering and Structural Dynamics. doi: 10.1002/eqe.2522.
- Noh H. Y., Lallemant D., and Kiremidjian A. S. (2014) Development of empirical and analytical fragility functions using kernel smoothing methods, Earthquake Engineering and Structural Dynamics. doi: 10.1002/eqe.2505.
- Burton, H. Deierlein, G., Lallemant, D., Lin, T. (2015). "A Framework for Assessing Building Performance Limit states that Inform Community Seismic Resilience," ASCE Special Issue: Resilience-based design of structures.
- Lallemant, D., Kiremidjian, A., (2013). "Fitting Fragility Functions to Empirical Data," Global Earthquake Model (GEM) Report.
- Noh. H., Kiremidjian, A. Lallemant, D., (2012). "Issues Related to the Development of Empirical Fragility Functions," GEM Report.
- Lallemant, D. (2012). "Probability Concepts & Statistics in Using or Inferring from Field Survey Data," Presentation, Global Vulnerability Estimation Methods Workshop. September 23rd, 2012, Lisbon Portugal.



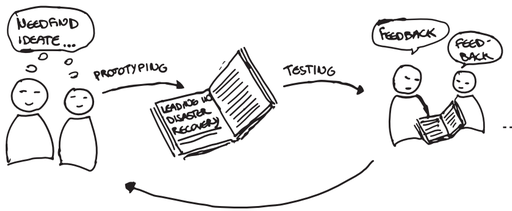
PROJECT: LEADERSHIP IN DISASTER RECOVERY
LOCATION: WELLINGTON, NEW ZEALAND, 2015
FUNDERS: RED CROSS, GLOBAL DISASTER PREPAREDNESS CENTER

LEADING IN DISATSER RECOVERY: A COMPANION THROUGH THE CHAOS - TITLE OF BOOK CO-AUTHORED BY MYSELF, ELIZABETH MCNAUGHTON AND JULIE WILLS.

From Nov 2014 to Feb 2015, I worked in New Zealand on a fellowship to co-author a handbook for those who find themselves working in a disaster recovery setting. **This book reflects my own experience working and living in post-disaster Haiti for two years following the 2010 earthquake, as well as over 100 interviews conducted over the past 3 years of people from around the world who have worked in disaster recovery**. The book was published by the Red Cross Global Disaster Preparedness Center in March 2015, and **launched at the United Nations World Conference on Disaster Risk Reduction in Sendai, Japan.**

The publication itself was developed following a **Design Thinking approach** as practiced at the Stanford Design School: needfinding, ideation, prototyping, reader feedback, all in rapid itteration. It resulted in a book which is concise (people working in disasters take little time to read), highly visual (keeps it interesting!), highly personal (easier to connect with) and filled with practical tools.

Book available here: http://preparecenter.org/resources/leading-in-disaster-recovery



THE HANDBOOK WAS PROCUED USING A "DESIGN THINKING" APPROACH TO ENSURE THAT IT REFLECTED USER NEEDS.

From the introductory page:

"Recovering from a disaster is a deeply human event – it requires us to reach deep inside of ourselves and bring to others the best of who we can be. It's painful, tiring, rewarding and meaningful. The responsibility can be heavy and at times you may feel alone. This is your companion through chaos that will connect you with over 100 other people who have walked in similar shoes.

This Companion is about leadership in disaster recovery. Many, like those who contributed, will not identify as leaders – yet they undoubtedly are. Leadership takes many shapes. It takes a web of connected and supported leaders to catch the opportunities that recovery offers communities.

Manuals for recovery programming abound. This is not one. This Companion shares hard-won wisdom and practical strategies. These are the messages others wished they'd had, and tools for putting these ideas in place because in a pressured environment with many priorities, hearing the message is often not enough. We have distilled the wisdom of more than 100 leaders in recovery who have gone before. The insights shared so generously were honest, personal and brave and have resulted in a companion to serve and support others."

SAMPLE PAGE - ON ETHICAL LEADERSHIP

THE BOOK HAS RECEIVED ENDORSEMENTS BY:

- Helen Clark, Administrator of the United National Development Program (third-highest UN position), and 37th Prime Minister of New Zealand.
- Elizabeth Ferris, co-director of the Brookings-LSE Project on Internal Displacement.
- Hon. Gerry Brownlee, Minister for Earthquake Recovery, New Zealand

On disaster recovery:
"This is not a marathon, this is not a sprint, this is not a relay. It's every horrible endurance event that you can imagine all rolled into one."
Dr. Sarb Johal, clinical psychologist, New Zealand.


BEING ETHICAL
it takes courage to do the right thing

Accept that, in recovery, your ethics and values will be tested. Time, funders, media, even colleagues – sometimes everything seems to be conspiring against you.

Be brave enough to act ethically. It might not get you promoted. It probably won't help you move quickly. It might make even more work or require 'creative rule-bending'.

Determine your non-negotiables, the issues where you will put your courage and energy to ensure ethical outcomes. Build a network – whether formal or informal – of people whose ethics and values you trust and who can help you when you're faced with situations where doing the right thing is difficult or unpopular.

I'm just being me. My core is aloha love and respect. You don't need to change your style for other people.
Magnus Tebbutt, community development set, Sukura and Christchurch

It is important to do the right thing, as opposed to blindly following the rules. As, generally speaking, the rules have been designed or created for different purposes.
David Meates, Canterbury District Health Board, Christchurch

You get out there and you walk the talk and do the doing and model the values you're after. And when you do that, people will follow because they see something in it.
Duncan Gibb, Stronger Christchurch Infrastructure Rebuild Team

While intentions may be noble, time and political pressure, moral uncertainty and stress often conspire to push us down the path of least resistance.
Doing the 'right thing' is rarely popular or expedient. That's why it takes courage.
David Lallemant, engineer, World Bank, Haiti

I respect the people who had the courage to stand up and do what they thought was right.
Sharon Torstonson, supporting community service groups, Christchurch

We are guided by a set of values handed down by our ancestors – Mō tātou, ā, mō kā uri ā muri ake nei – for us and our children after us.
Dr Mark Solomon, Kaiwhakahaere (Chief) Te Rūnanga o Ngāi Tahu

Hold onto the integrity of who you are, because that's what will get you through and out the other side and be able to look back and be comfortable with who you are and what you did during that time.
Michelle Mitchell, Canterbury Earthquake Recovery Authority, Christchurch

10 A COMPANION THROUGH THE CHAOS

Project: Building Resilience in Post-Disaster Recovery
Location: Stanford University, 2011-2015
Collaborators: World Bank, Global Facility for Disaster Reduction and Recovery (GFDRR)

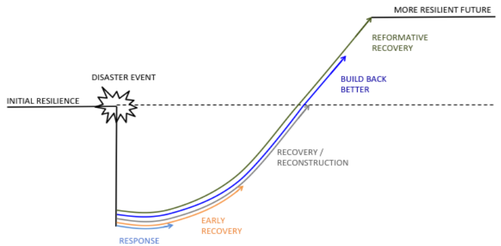


Diagram: Lallemant, D. "Building Resilience in Reconstruction"

Reframing post-disaster recovery in terms of building resilience

Disasters make obvious the need to reduce risk in reconstruction, so that avoidable calamities are not repeated. Often however, the demand and need for risk reduction in reconstruction is faced with significant obstacles due to the complexity and constant urgency of post-disaster environments.

Since 2013 I have participated in a multi-sector, multi-institution assessment of the recovery from the 2010 earthquake in Haiti. My specific role has been to **investigate the process of risk reduction in post-disaster reconstruction**. The goal is to derive key lessons which can still be applied in Haiti, as well as lessons for disasters still to come elsewhere.

This work challenges current theory and practice of "restorative recovery," in favor of a culture of "reformative recovery." Traditionally the aim of reconstruction has been to restore to the previous state. Any improvements from the previous state is usually focused solely on the physical infrastructure. Reformative recovery by comparison is a **process through which new dynamics for resilience are created, often through government and social reform.** Reformative recovery focuses on **systemic barriers to resilience**, which will most likely require reform of institutions, legal frameworks, land-use policy, markets, supply-chains and other regulatory tools.

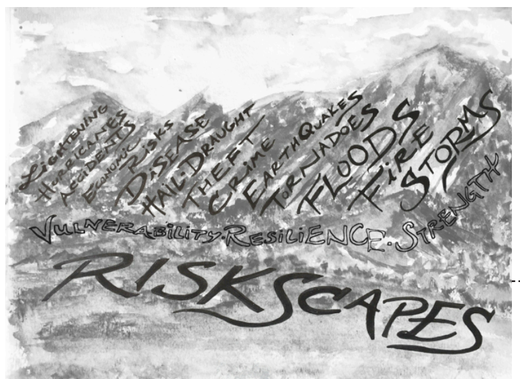
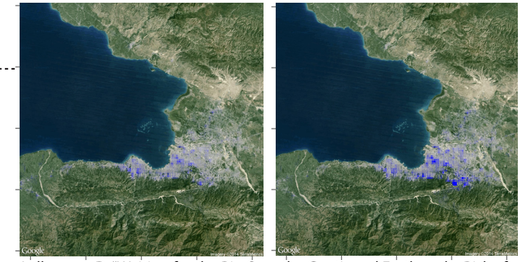


Illustration by Abby Van Muijen and David Lallemant

Communities don't face singular hazards. They live in a "riskscape" consisting of multiple hazards of varying intensities and recurances, and against which they possess various levels of resilience.

Actual damage from the 2010 Haitian earthquake vs damage (more significant) from a plausible event on the fault still expexted to rupture.The remaining hazard makes risk recuduction in reconstruction particularily important



Lallemant, D. "Waiting for the Big One: the Continued Earthquake Risk of Port-au-Prince, Haiti."

This research also proposes the following (non-exhaustive) list of **key characteristics for successful disaster risk reduction in reconstrucion**: (1) setting standards for disaster risk reduction in reconstruction early and communicating them clearly, covering both site risk and building risk, and based on an open and realistic discussion of "acceptable risk"; (2) conducting large scale, repeated and continual communication on best practices for more resilient reconstruction; (3) establishing DRM policy that addresses the various levels of vulnerability of households, and changing vulnerability over time; (4) capitalizing on the short-term awareness of risk created by the disaster to permanently shift the culture of risk; (5) giving support to promote informed risk arbitration decisions by households; (6) recognizing that promoting safe housing does not necessarily mean building safe homes, but removing the barriers to safe construction; (7) promoting "reformative" processes in reconstruction whenever possible, rather than just "restorative" ones.

Can we avoid the reconstruction of vulnerability?

Photo: Anna Konotchick

Outputs:

- Lallemant, D., (2014), Chapter title: "Risk Reduction in Post-Disaster Reconstruction," in "Analyzing the Haiti Post-earthquake Shelter and Housing Response: What was Done and What Was Learned?," The World Bank Publications.
- Lallemant, D., (2014). "Waiting for the Big One: the Continued Earthquake Risk of Port-au-Prince, Haiti" Conference paper and presentation, 3rd International Conference on Urban Disaster Recovery.
- Lallemant, D., (2014). "Supporting and Informing the Process of Risk Arbitration in Post-Disaster Recovery," Plenary Talk and paper, Third International Conference on Urban Disaster Recovery, Sept 28-Oct 1st, 2014. Boulder Colorado.
- Lallemant, D. (2015). "Managing Post-Disaster Riskscapes – Lessons Learned from Port-au-Prince, Haiti", Invited Speaker, National Building Museum, Designing for Disaster exhibit, Feb 2nd 2015, Washington DC.

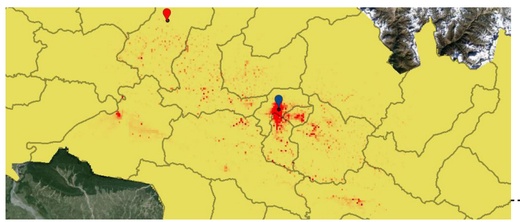
Photo: David Lallemant

Project: Nepal 2015 Earthquake Recovery Planning
Location: Kathmandu, Nepal, May-June 2015
Funder: World Bank, Global Facility for Disaster Reduction and Recovery (GFDRR)

The 2015 Earthquake in Nepal Led to 9,000 Fatalities and the Destruction of over 500,000 Buildings.

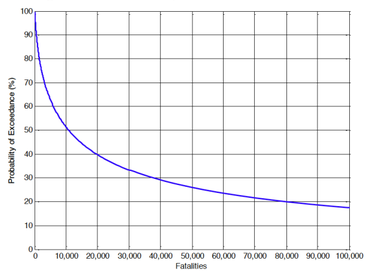
On April 25th 2015, an 7.8 magnitude earthquake struck Nepal, leading to 9,000 fatalities and over 20,000 wounded. Immediately following the earthquake, I was asked by the World Bank to assist them in their support to the Nepali Governement. Specifically, my activities were to:

- **Provide a preliminary impact estimate based on my damage and fatality prediction models.**
- **Write guidance notes to the Nepali Governement on post-earthquake recovery best practices.**
- **Lead the housing sector post-disaster needs assessment as part of the joint Nepali, United Nations, World Bank, Asian Development Bank and EU assessment leading up to the donor conference.**
- **Spearhead the development of the housing damage and beneficiary survey, based on best practices from Haiti, Pakistan and elsewhere.**



Analysis with Google Earth Engine platform (see section on "Novel Technologies for Urban and Regional Scale Earthquake Risk Assessment")

Damage and Fatality Prediction Model Results:
(1) Geographic Distribution of Damages
(2) Fatality exceedance curve



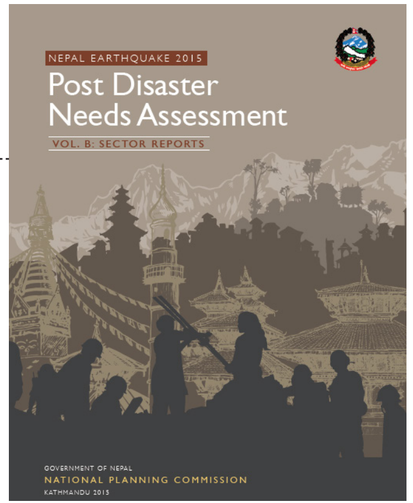
Along with Prof. Jack Baker and M.Sc. student Maryia Markhvida, I developed a preliminary impact assessment report in the days following the earthquake. Combining a ground-motion model, building fragility curves and gridded population data, our model provided the total **estimated number of fatalities and the geographic distribution of damages.** These are key information to guide early decisions for relief and recovery. We estimated an expected fatality count of 11,000 (actual was 9,000) and provided a **fatality exceedance curve** to communicate the uncertainty around such predictions.

Unreinfroced Masonry Construction Suffered Severe Damages, Including Most Historic Buildings and Rural Housing.

I spent nearly 2 months in Kathmandu to assist the Government of Nepal to develop their earthquake recovery strategy. As part of the joint Nepali Governement, United Nations, World Bank, European Union and Asian Development Bank Post-Disaster Needs Assessment process, I was the international (non-government) **lead for the housing sector assessment and preliminary recovery strategy**. In addition to quantifying the estimated financial needs for reconstruction, the process further elaborated principles for reconstruction and preliminary implementation strategy. **The recovery startegy developed was one based on the principles of equity, inclusion and community participation through an owner-driven reconstruction approach to build back better.** The estimated damages in the housing sector were the greatest among all sectors, representing 65% of total losses ($3.5 billion USD). This assessment was the basis for the governement appeal to the international community, presented at the donor conference on June 25th 2015.

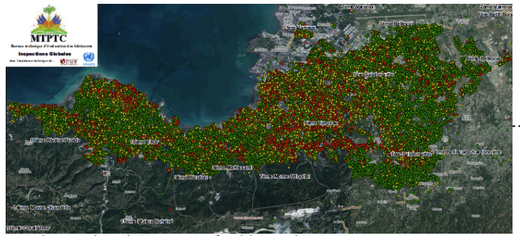
Photo: David Lallemant

The "Post-Disaster Needs Assessment" report is the basis for financial appeals to the international community. It further sets preliminary recovery principles and strategy.



Outputs:

- Lallemant, D., Keiko, K., Nepal, G., Mainali, G. (2015). Nepal 2015 Earthquake Post Disaster Needs Assessment (PDNA)– Housing and Human Settlement Sector Report. Government of Nepal National Planning Commission.
- Lallemant, D., Markhvida, M., Baker, J., (2015). "Preliminary Impact Assessment of the April 2015 Earthquake in Nepal."
- Lallemant, D., Ranghieri, F. (2015) "Guidance Note to Government of Nepal - Rural Housing Reconstruction Strategy."
- Lallemant, D. (2015) "Transitional Sheltering Suport Strategy Note."
- Lallemant, D. (2015) "The 2015 Earthquake in Nepal - Tectonics and Seismcity - What We Know and Don't Know." Presentation. World Bank Country Office, May 2015, Kathmandu, Nepal.



Map by Word Bank / Ministry of Public Works

Project: Haiti Building Damage Assessment
Location: Port-au-Prince, Haiti, 2010-2012
Governement Partner: Haitian Ministry of Public Works
Funder: The World Bank

Maped evaluation results for over 400,000 buildings

The Project:

On January 12th 2010, a 7.0 earthquake devastated the capital city of Port-au-Prince, Haiti. Approximately **300,000 people lost their lives, 1.5 million were made homeless, and nearly a third of the city's infrastructure was destroyed.** Following this event, the World Bank launched a Building Damage Assessment, led by the Haitian Ministry of Public Works. It's goals were to:

- Inform the population of dangerous buildings
- Promote the reoccupation of safe buildings (homes, schools, businesses)
- Develop the starting point for recovery
- Create a georeferenced inventory for recovery planning

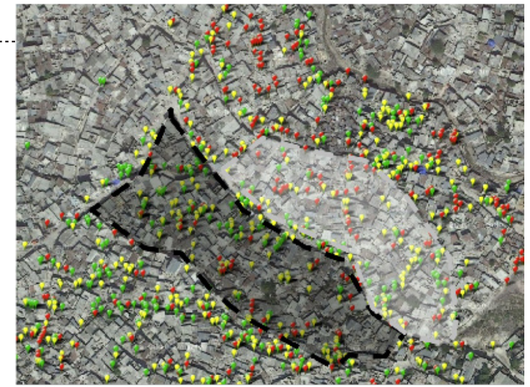

Photo: David Lallemant

Downtown Port-au-Prince in June 2010

The project was innovative in its scale (half a million buildings) and its method. Nearly **300 engineers** were equipped with hand-held GPS enabled devices in order to fill out the evaluation form, obtain the **GPS coordinate** of the building, and justify the evaluation with pictures. Among other things, this led to the first map of the built environment of Port-au-Prince, an invaluable tool for recovery planning.

The project has led to the evaluation of **400,000 buildings.**

Building damage evaluation results critical data for neihborhood rehabilitation planning


World Bank / Ministry of Public Works

My Scope:

My role was to design and coordinated the project. This involved working very closely with the **Haitian Ministry of Public Works** to ensure that the initiative fed into the national framework for recovery.

Starting in Febuary 2010, I developed a concept proposal, the budget **($4 million),** oversaw the contracting of the various components of the project, supervised the training of the engineers, and provided technical assistance to the government implementer. We selected the use of the ATC-20 Building Damage Evaluation standard, which we adapted to the Haitian context. The use of hand-held GPS-enabled devices **streamlined the evaluation process**, as well as enable us to populate maps with the assessment results. These have become **critical in neighborhood level rehabilitation planning**.

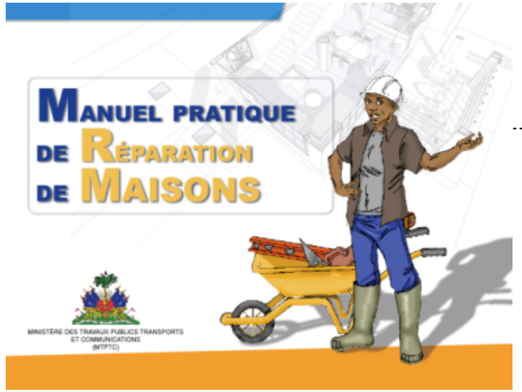
The landscape of Port-au-Prince: very dense urban environment, 25% destroyed buildings (red highlight) and 1.5 million living in tent camps (blue highlight)


Photo: Jean-Martin Brault

Outputs and Awards:

- Lallemant, D., (2014), Chapter title: "Risk Reduction in Post-Disaster Reconstruction," pages 80-98 in report "Analyzing the Haiti Post-earthquake Shelter and Housing Response: What was Done and What Was Learned?," The World Bank Publications.
- Lallemant, D., (2010), "The State of Haiti following the 2010 Earthquake," Berkeley Planning Journal, 23(1).
- Development Impact Award awarded by the United States Secretary of Treasury. Award accepted by Work Bank President Jim Kim from US Congressman Eliott Engel, 2013 (http://tinyurl.com/lqbc5zj).
- World Bank Vice Presidency Unit (VPU) Award for work on post-disaster response in Haiti, 2011.
- CNN World News Coverage on http://tinyurl.com/2acvd8b

Project: Post-Earthquake Reconstruction Guidelines
Location: Port-Au-Prince, Haiti, 2010-2012
Govenement Partner: Min. Public Works, Min. Interior
Funder: The World Bank



"Manual for the Repair of Residential Buildings"

The Project:

Following the devastating earthquake in Haiti, the World Bank launched a program to **develop reconstruction guidelines**. These were to be highly visual, showcasing simple constructions techniques that are **resilient to earthquakes** and other natural hazards. **These guides are aimed primarily at informal, non-engineered construction**. Their use is limited to one and two story residential buildings. The Ministry of Public Works is the technical partner, while the Ministry of Interior is mandated to lead the municipal government in following and enforcing the guidelines.

Step-by-step illustrations of best practices

My Scope:

After a new construction guidebook was well underway, I observed that it did not address repairs. Given that over a quarter of buildings are damaged but repairable, implementing agencies and individual households needed guidance on how to safely repair homes. I therefore put together a **technical working group** to develop repair guidelines. This group brought together engineers, architects and local contractors. The production of the guidebook took 3 months, and involved **reviewing exciting documentation on post-earthquake repair, testing and adapting chosen methods to the local setting, and illustrating techniques in very clear formats**. Currently this document is the only approved repair guideline for reconstruction in Haiti.

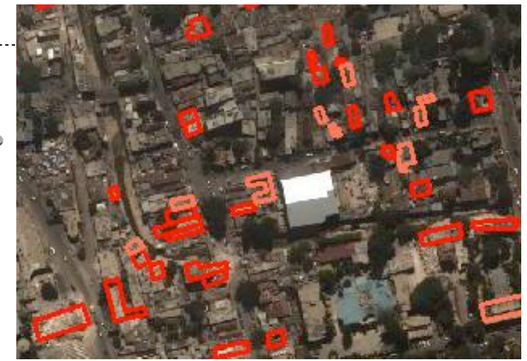
Project: remote sensing-based damage analysis
Location: Port-au-Prince, Haiti, 2010
Implementing Partner: ImageCat
Funder: The World Bank

High Resolution Imagery Used for Analysis

The Project:

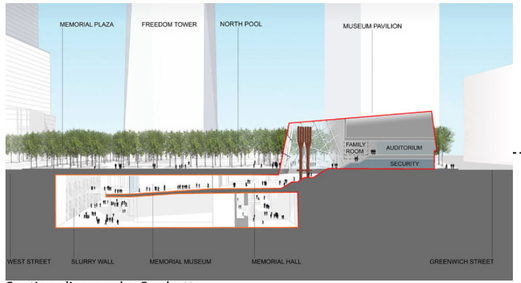
The Project was a **first-of-a-kind crowd-sourced remote sensing-based damage analysis**. Planes were flown over the disaster zone collecting high-resolution aerial imagery and Lidar. The structural and earthquake engineering community was then called upon to systematically analyze damage using the high-resolution images, and do so voluntarily. **Leveraging the expertise of hundreds of engineers from around the world**, we were able to provide the first complete figures of the scale and distribution of damage just **days after the earthquake.**

Crowdsourcing engineers to identify damage



My Scope:

Analyzing damage from areal images is limited, since much of the damage is undetectable from top-view. I went to Haiti to **validate the assessments and improve the models** by evaluating samples of buildings throughout the affected area. I extrapolated my observed results on the imagery assessment in order to add details of lower-level damage (not observable from the imagery) and **compensate for omissions**. The resulting figures were used in the **Post-Disaster Needs Assessment**, commissioned by the Haitian Government to define the international assistance to be requested.



Section diagram by Snøhetta

Section Diagram of Musieum Pavilion and underground structures

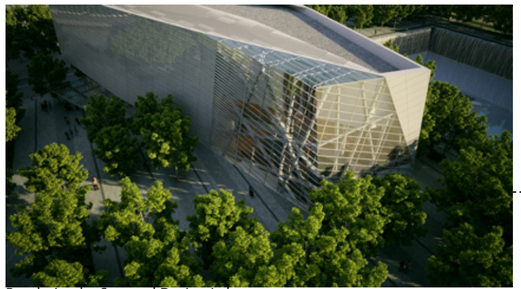
Project: National September 11 Memorial Museum
Location: Memorial Plaza, World Trade Center Site, NYC
Architect: Snøhetta
Engineers: Buro Happold

The Project:
The **Museum Pavilion**, designed by the Norwegian architecture firm Snohetta, is the primary structure above the ground at the Memorial site. It is located between the two Memorial Pools, and will welcome the many visitors to the site.

My Scope:

My work was on the façade structure of the large glazed atrium, located over the museums' Memorial Hall. This atrium forms the **main identity of the Pavilion,** as it allows visitors to see into the museum, where two large steel columns salvaged from the original World Trade Center are on display.

The architect wanted a translucent yet complex façade, to filter the light into the atrium while allowing views of the salvaged WTC columns, or "tridents". Several ideas were considered. I proposed an **exposed primary structure, wrapping around the atrium in a seemingly random pattern**. This fit with the architect's intent and was the starting point for the façade system.


Rendering by Squared Design Lab

Museum Pavilion & Reflecting pool at the World Trade Center Site

View of the "tridents" through the main atrium facade

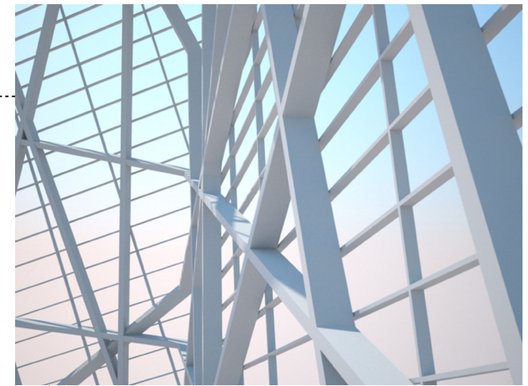
The structure is in fact not random but responds to the constraints and complexity of site: asymmetrical loading atop an intricate network of underground structures. Given these constraints, I wrote scripts to **generate thousands of different configurations.**

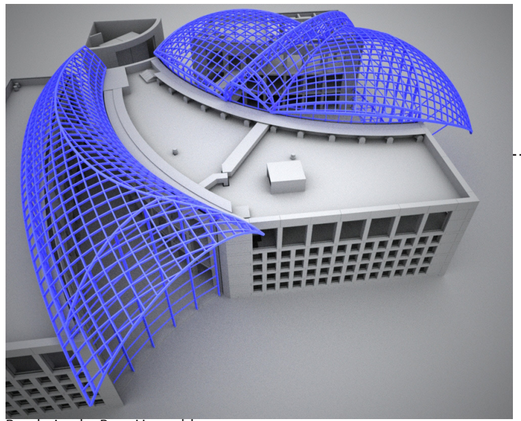
In order to filter through all these configurations I developed an automated system of progressively more complex analysis. The final step of this process involved complete non-linear structural analysis. I wrote scripts to automate the design patterns, the construction of the structural model, application of loads and output of meaningful results.

Through this process, we were able to maintain the **illusion of randomness**, and provide the architect not with a single solution but a **family of equally performing options.**


Rendering by Squared Design Lab

seemingly random primary structural system , wrapping around the corner of the atrium


Rendering by Buro Happold



Rendering by Buro Happold

Project: United States Institute of Peace Headquarters
Location: Washington DC, USA
Architect: Moshe Safdie
Engineers: Buro Happold

Grid-shell roofs spanning and connecting the three main sections

The Project:
Located on the northwest corner of the **National Mall** in Wahington, D.C., the new building will serve as a national center for advancing the study and practice of peacebuilding. The site is just steps from the Lincoln, WWII, Korean and Vietnam Veterans memorials, and will house a research library, classrooms and conference center.

Moshe Safdie's design consists of three main sections, linked together by expansive atriums covered by an undulating roof. This roof **forms wing-like elements**, the color and shape of which are reminiscent of a dove.

My Scope:
Due to my interest in complex geometries and automated analysis, I became one of two engineers assigned to work on the **steel grid-shell roofs and facades** that shelter the main atriums. These are particularly complex and had to be studied independently of the rest of the building.

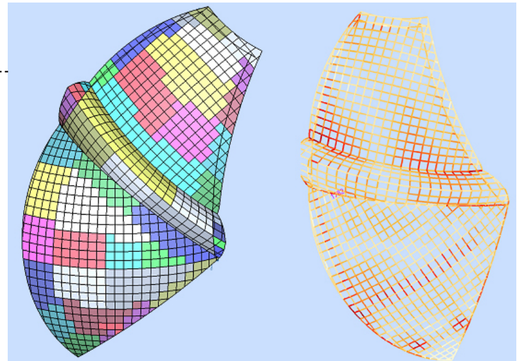
Due to its long and shallow span, the roof was analyzed for **global buckling** (snap-through). Since the three building sections move independently during high winds, special care was needed at the connections, to allow for **differential movement of the buildings** without inducing loads in the roof. At the corners, the main rib members have up to 8 elements framing into them at arbitrary geometries. After modeling these using various 3D packages, **mock-ups** were built by Seele in Munich.

View inside the main atrium

Pressure distribution and stress diagram

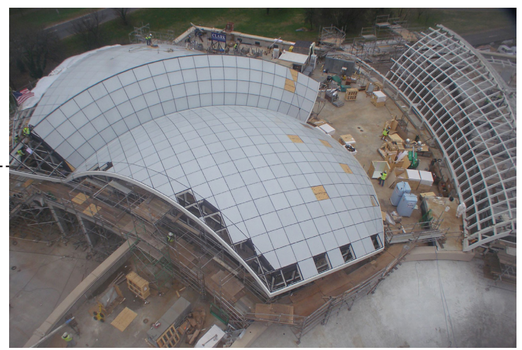
For the structural analysis of the roof, I wrote numerous computational tools to streamline the process. After conducting a wind-tunnel test of the structure, we were given dozens of unique wind pressures for nearly 100 different sections of the roofs. With the addition of complex snow load patterns, this led to **thousands of unique load patterns**. Taking advantage of the open API of the analysis platform, I wrote scripts to automate the analysis. This enabled us to **efficiently reproduce the conditions provided by the wind-tunnel test and snow load study**, find the controlling load combinations and extracting results.

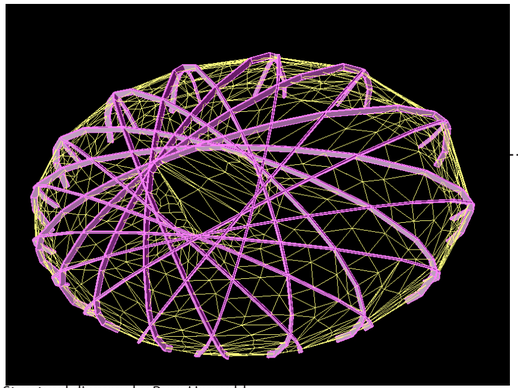
Construction documents were completed just before I left Buro Happold, and the building opened in 2012.



Structural Diagram by Buro Happold

construction site visit, Nov 15th 2009





Structural diagram by Buro Happold

Project: Orange County Great Park Visitor's Center
Location: Orange county, california
Architect: Ten Architectos
Engineers: Buro Happold

Structural analysis model of the main "pod"

The Project:
Buro Happold was the sustainability and structural engineer for Ten Architectos' Orange County Great Park project. The project was awarded the AIA's 2009 institute honor award for regional and urban design. Apart from completely new topographic features including a man-made canyon and river, the park contains several arts and cultural facilities and an outdoor amphitheatre.

My Scope:
For this project, a Buro Happold architects and myself were assigned the **structural and exterior skin design for various "pod" structures** including the main visitor center. This responsibility came out of a competition and workshop during which I developed a dynamic link between Bentley's Generative Components software (a powerful parametric modeling tool), and Robot structural analysis tool. In this case, it allowed us to **design and analyze dozens of unique pod structures with only a single parametric model**.

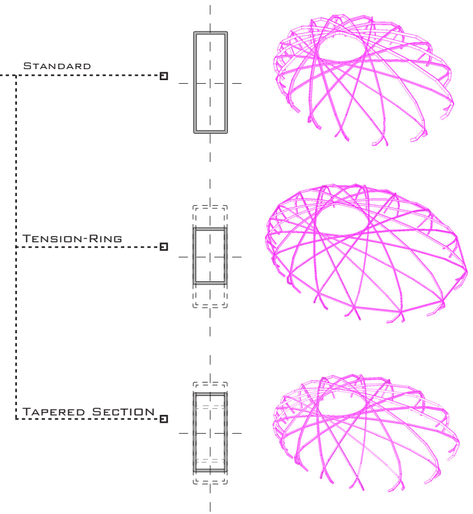
Rendering by Ten Architectos

Visitor Center Rendering

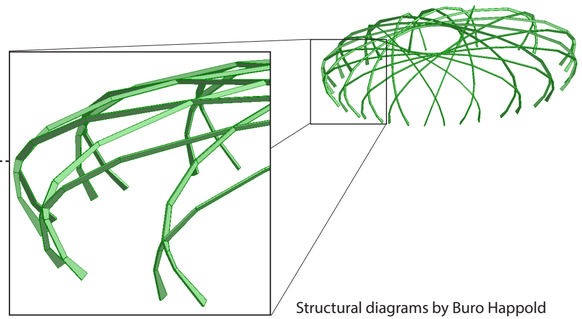
alternatives studied & resulting reduction in section depth

The main structure originally consisted of rectangular steel sections bent into unique curves, rising up and outward from the ground, then back in to from the domelike shape. We proposed several modifications to economize on material and simplify the fabrication process. A **tension ring** was suggested, in order to control the outward thrust produced at mid-height of the dome. This would reduce the steel weight by 25%. Using not a single section depth, but **varying depth** led to an additional 10% reduction in steel weight and made for a more interesting architectural design. Finally I wrote scripts in order to **break down the unique curves into segments with constant curvature**. This greatly simplifies the fabrication process without having any recognizable effect on the architectural vision of the building. Though the architect finally chose steel, we also investigated glulam beams and steel-glulam composite sections which would have created a more prominent structure.

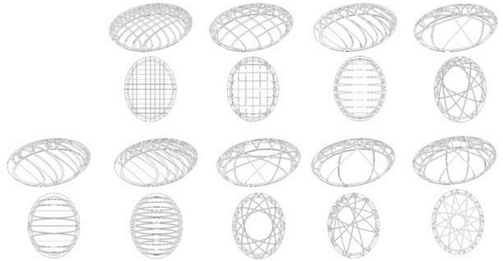
For the exterior skin, we proposed ETFE panels, such as the ones used in the Alliance Arena in Munich, or the Olympic Stadium in Beijing.



Detail of tapered section



Structural diagrams by Buro Happold



Diagrams by Buro Happold

Project: Parametric Structural Design & Kinetic Structures
Location: New York, USA; Munich, Germany

"If a building could mediate our needs and the environment outside, its demand on physical resources could be slashed. If it could transform to facilitate multi-uses, its function would be optimized. **If a building could adapt to our desires, it would shape our experience.**"
Michael A. Fox, Kinetic Design Group, M.I.T.

Analysing the multiple configurations for the OC Pods using a single model

The concept of **adaptive structures**--ones that are dynamic and responsive--is quite a compelling one. Structures that could attune their configuration in accordance to changing conditions, could brace themselves for high winds, provide shading and weather protection when and where needed; these would revolutionize the structural and environmental performance of the built environment.

However the conceptual and practical leap, **from static buildings to adaptive ones,** is difficult. With more tools designers could more effectively study these structures and see more of them become reality.

Office for Robotic Architectural Media & The Bureau for Responsive Architecture

Actuated "tensegrity" struture

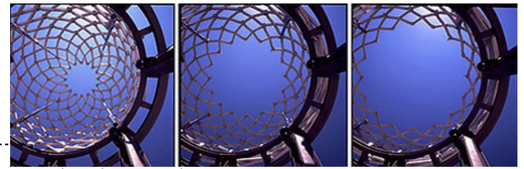
Expanding geodesic dome, designed by Hoberman and Associates

Picture by Hoberman and Associates

In 2008 Buro Happold launched a joint venture with kinetic structures expert **Chuck Hoberman.** They were then working on a giant **kinetic chandelier that would unfold and expand while twisting.** In order to analyze the structure, the engineers constructed **three separate models** to study the chandelier in its fully closed, fully opened and half-opened configurations.

I proposed to create a **hybrid model linking the kinetic parametric model (using generative components) with the structural analysis model** in order to analyze the kinetic structure for its **entire range of motion**. This had the dual advantage of enabling us to calculate the **state of the structure at every time-step and do so using a single model**.

Iris dome at the MoMA, Hoberman & Associates



Picture by Hoberman and Associates

The kinetic chandelier project was ultimately canceled, but the dynamic link between parametric design tool and analysis engine was used for several later projects. It has many applications, the most important of which are to study:

- Numerous parametrically controlled alternatives to a single structure
- Multiple structures having the same guiding principles.
- Kinetic structures

I presented this dynamic analysis tool at the **Smart Geometry Conference 2008 in Munich**.

Stage for U2's 360 tour, Buro Happold/Hoberman & Associates

Picture by U2EastLink

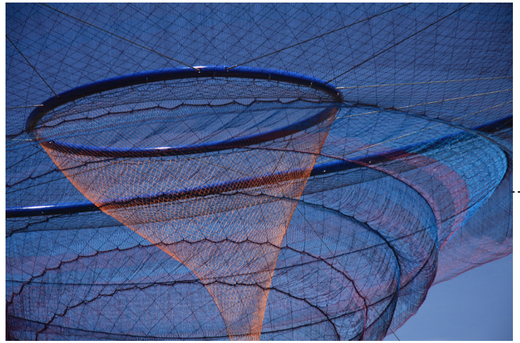


Photo by Karie Porter, courtesy of Janet Echelman

Close-up of the Phoenix net sculpture during the day

Photo by Karie Porter, courtesy of Janet Echelman

Phoenic net sculpture at night

Project: Janet Echelman's Net Sculptures
Location: Phoenix City Center, Arizona, USA; Richmond Winter Olympic Site, British Columbia, Canada
Designer: Janet Echelman
Engineers: Buro Happold

The Project:

Janet Echelman's art consists of **monumental net sculptures** that transform the urban airspace as they respond to the wind and light. I had the opportunity to work on two of her sculptures, titled Her Secret is Patience (Phoenix) and Water Sky Garden (Richmond). We created software to **rationalize the given geometry, conduct form-finding and output instruction drawings for the fabrication of the nets.** The doubly curved form is resolved by graduating cell sizes and using baiting, a lace-making detail used to move from one cell size to the next at every net increment.

Net Sculpture for the Vancouver winter Olympics

I also conducted the **wind analysis of the sculptures**. In order to find the forces acting on the cables supporting the net, I created **a fluid dynamic model**, representing the net as a series of rods (lace) and nodes (knots). As wind flows around these geometric shapes, it induces a force on them, which were then aggregated over the entire net with some correction due to shielding effects. While no previous study had been conducted on the wind forces on nets, I studied the **drag force on fish nets** as they are being pulled in water. I was therefore able to correlate empirical results from fish nets to the analysis of the net sculptures under wind load.

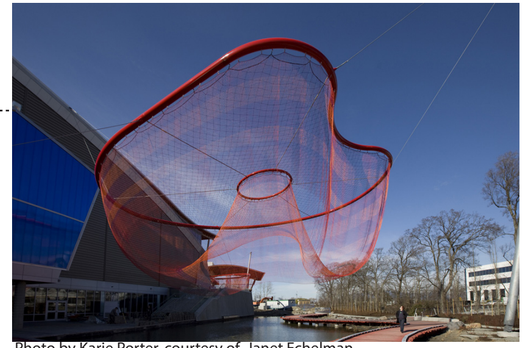
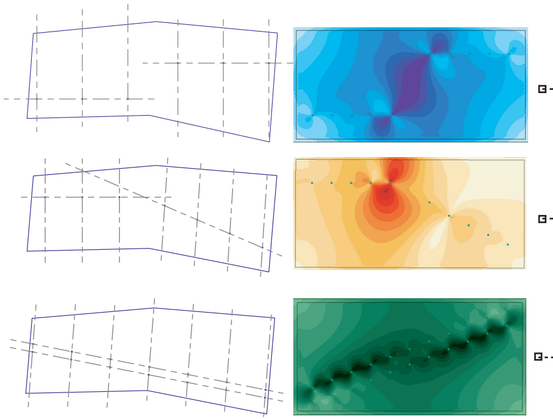


Photo by Karie Porter, courtesy of Janet Echelman

Fishing Nets in Normandie

Photo by David Lallemant



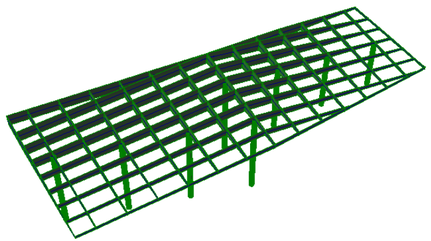
Diagrams by Buro Happold

Project: National September 11 Museum Canopy
Location: Memorial Plaza, World Trade Center Site, NYC
Architect: Snøhetta
Engineers: Buro Happold

Stress diagram for different column configurations

The Project:
Covering the front entrance and the ticket lines of the National September 11 Museum Pavilion is a large canopy. Its purpose is to **provide shading and weather protection** to the visitors as they stand in line for tickets, as well as to **organize the flow of pedestrian traffic underneath.**

My Scope:
I conducted the design and analysis for the canopy structure. Different column layouts were studied, according to their influence on traffic flow and cue patterns. Having defined a structural grid, I studied the impact of these different column layouts on the stress patterns of the canopy structure. The depth of the members do not correspond to their internal forces, but to a shape defined by the architect that reflects the geometry of the entire Museum. Using a link with Rhino, the **depth of the structural members are matched to that of the architect's chosen geometry.** The width of the members was then changed as necessary to meet structural requirements.

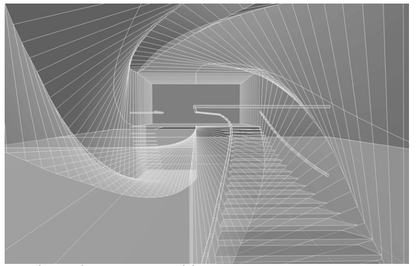


Structural model by Buro Happold

Analysis model of the WTC memorial canopy

Project: J-House
Location: New Orleans, Louisiana
Architect: AEDS, Ammar Elloueini
Engineers: Buro Happold

The twisting results in constantly changing elevations



Rendering by Buro Happold

The Project:
J-House uses a historical standard housing lot (30x150 ft), and is located in a **designated flood zone of New Orleans**. Bound by elevation requirements, the resulting design is lifted 10ft off the ground.

The design consists of **two 10x20x80 feet tubes, rotating 90 degrees** along their length. **The project won a 2009 AIA New Orleans Design Award**.

Physical model of structure showing the skylight

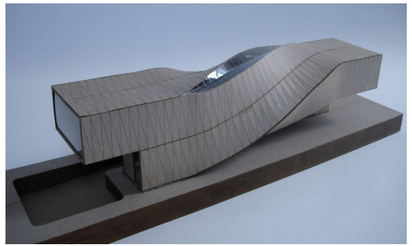


Image by AEDS

My Scope:
I conducted the **preliminary design and analysis** for this project. The irregular shape of the building, with a **constantly changing section** and long cantilevers made it particularly complex for such a small size project. This was exacerbated by the building requirements, located in a **hurricane wind zone and with expected floods of up to 9ft**.

Having created tools linking the 3D architectural model with the structural model, I was able to quickly analyze the structure and try out alternatives. These tools also allowed for **easy communication with the architect**, and greatly **simplified the process of making changes**, for either structural or architectural reasons.

Photography of J-House from the street level

The structure consisted of steel frames every 15ft and thin braces were added where necessary. **Dynamic analysis** led to slight modifications of the geometry because of large vibrations of the long cantilever sections. By taking advantage of the arch created by the two tubes, we were able to decrease structural demand of the foundations.

Image (above) and diagram (left) by AEDS

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