engineering news
School of Engineering
FALL 15
SANTA CLARA UNIVERSITY

DEAN'S MESSAGE

"It is time we educate the engineers of the future, those who possess the skills, desire and sense of duty to protect the earth and to ensure its fruitfulness for coming generations." Pope Francis issued this call to action last June in his encyclical letter concerning the drastic state of the environment and the need to address climate change. Stirring in its urgency, this imperative only deepens our resolve at Santa Clara University to adhere to the Jesuit philosophies guiding our efforts to educate leaders of intellectual and ethical excellence.

In the School of Engineering we offer a number of programs and extracurricular activities to do just that. Our interdisciplinary graduate programs in sustainable energy and our undergraduate Latimer Energy Laboratory research opportunities are designed to train the next generation of energy gurus. Our active Engineers Without Borders chapter has students partnering with communities across the globe to build a more just, humane, and sustainable world.

Another example of our effort to involve students in effecting change is our participation in the 2016 Tiny House competition to be held in Sacramento, California, next October. Our team of undergraduates is currently designing a 238-square-foot, solar-powered home that they will then build on a trailer in competition against other universities from California. This type of hands-on, project-based learning is central to our mission to educate the steward-engineers of the future, and you can read more about the team and some of our other efforts in this issue.

Happy reading!

Godfrey Mungal
Dean
School of Engineering

Photo: John Gensheimer

Computer engineering graduate students Yan Long and Sonam Rudraraju at Chandler Tripp Preschool

Grad Students Go Back to Preschool

The 5-year-old sitting at the keyboard leaned in close to the monitor, concentrating intently while her pink Converse-clad feet swung wildly below her tiny chair. "I did it!" she squealed, eliciting cheers and applause from Yan Long and Sonam Rudraraju, computer engineering graduate students who took her success to heart. The two were testing some very special software they had designed and produced along with classmates in adjunct lecturer Radhika Grover's COEN 275 course, Object-Oriented Analysis, Design, and Programming.

Tasked with creating an educational game that preschoolers with and without visual impairment could enjoy together in the classroom, the pair guided groups of 3- to 5-year-olds through their alphabet and storytelling games at Chandler Tripp Elementary—a public special education school in San Jose. Early on, Ginger Brown, a teacher at the school, visited Grover's class to introduce the SCU students to the needs of her preschoolers, getting them started on the right path.

In describing the design process, Long's teammate Nimisha Mathews said, "We had to think from a different perspective. We're used to designing with visual effects—you see something and click on it and the next thing comes. For this project, we had to rely more on auditory cues. We created three little games to teach the alphabet, develop analytical skills, and improve listening capability. Those who can see a little can click on a letter, others can listen and use a braille keyboard."

Rudraraju's teammate Roberto Youssef said their "game uses just the space bar, which makes it easy for everyone. We wanted it to be fun, not just learning, with games, songs, stories, visual and audio effects." Rudraraju added, "The questions are randomized so kids can't memorize the sequence and are divided by age level. We also keep statistics on the class and individual students, and average scores to determine if questions are too hard or too easy."

A big hit with the faculty at Chandler Tripp, many of the students' games have been installed on the preschool computers. "Other games like ours cost at least $250 to install on each PC. That's just not feasible for schools like Chandler Tripp. Hopefully these alternatives will help," said Youssef. If the avid attention and delighted cries emitting from the classroom are any indication, they already have.

When Going to the Dogs Is a Good Thing

How can you reap gigantic benefits from a teeny house?

For a group of SCU students competing in the Sacramento Municipal Utility District 2016 Tiny House Competition, the solution was easy: When the contest is over, pass along the 238-square-foot solar-powered home to a very worthy organization—Operation Freedom Paws (OFP), a 501(c)3 nonprofit organization empowering military veterans and others with disabilities to restore their independence by teaming them up with a service dog.

Photo: Heidi Williams

SCU Tiny House team members listen intently as Mary Cortani shares Operation Freedom Paws' mission.

"We've already done a lot of research and bought the trailer that our Tiny House will be built on, but construction hasn't started yet. Knowing who we are designing for and how the home will be used informs our design choices and gives us even more passion for the project," said J.J. Galvin '17, a mechanical engineering major working on the thermal analysis and HVAC systems for the house.

Recently, the students spent a morning at OFP's facility in San Martin, California, seeing the operation in action and getting to know founder Mary Cortani. A Certified Army Master of Canine Education, Cortani prepared dogs for work in sentry and explosive detection during the Vietnam era. In a way, she does much the same thing through OFP, training dog-and-veteran teams to deal with the daily minefields encountered by those suffering from post-traumatic stress disorder (PTSD), traumatic brain injury (TBI), and/or any number of other physical, neurological, or psychological challenges.

Using a 30-step process, Cortani and her team of experts identify suitable dogs to match with veterans. "Eighty percent of our dogs come from shelters, rescue programs, or were bred to be guide dogs but didn't make the cut," said Cortani. "We assess the client's needs and match them with a dog. Together, they train here two to four times a week for 48 weeks—about 350 hours—receiving lessons, guidance, and exercises to practice at home. For people with PTSD or TBI, life can seem hopeless; just going to the grocery store or talking with strangers can be overwhelming; sleep is nearly impossible because of nightmares or night terrors. But as they train together, the dog learns to help the client stay calm and focused and alerts the client to events or danger. The veteran learns to trust the dog and is then able to venture out into the world. The team is healing together and providing each other with a new lease on life," she said. Veterans' accounts posted on operationfreedompaws.org attest to the miracles taking place through this organization.

While the cost of a service dog ranges from $10,000 to $60,000, all of OFP's services are provided to veterans and others with disabilities at no cost.

During their visit to OFP, the SCU students helped teams learn to deal with strangers wanting to pet the dogs (nearly every breed imaginable: Chihuahua, Rottweiler, Great Dane, Poodle, Greyhound, Labrador Retriever, and plenty of mutts); they witnessed the healing powers of "puppy yoga" as veterans practiced calming exercises; and they knew this was where they wanted their Tiny House to find its "forever home." Following the competition, their Tiny House will serve as temporary accommodations for a variety of visitors—out-of-town veterans being paired with a dog, shelter workers receiving training to identify potential service dogs, or trainers coming in to help lead classes. Installed between the Victory Garden and meditation memorial garden, and adjacent to the children's play area, rEvolve House will provide a serene and soothing environment for its guests.

"Before we ever met the people at OFP, we'd named our house 'rEvolve,' in the tradition established with SCU's entries in the 2007, '09, and '13 Solar Decathlon competitions—Ripple House, Refract House, and Radiant House," said Nick Jensen '15, civil engineering. "It's almost like it was meant to be, that SCU and OFP would come together. Being a part of Operation Freedom Paws' evolution and of the veterans' growth and healing is a gift far greater than anything we are giving."

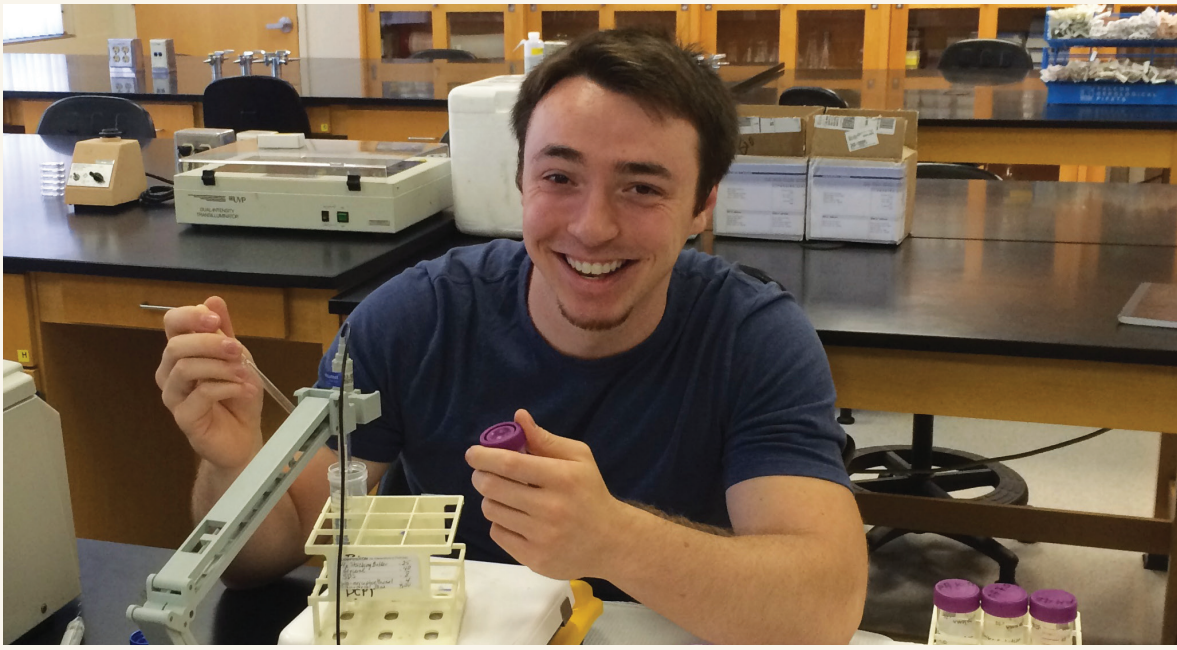
Learn more:
- operationfreedompaws.org
- smud.org
- revolvehouse.com

RESEARCH WITH A SIDE OF COMPETITION

A fascination for solving the puzzle of how to get other biological systems to harness biological concentration gradients, as electric eels do, to generate electricity has kept bioengineering senior Conary Meyer busy for years. "Using algae as a model photosynthetic system, I've been working on how to trigger unidirectional ionic flux through the cell to create electrical current from sunlight in a completely biological system. I came up with an idea for a bio-organic solar cell about four years ago and have been developing and testing different versions; I'm on my 23rd attempt now," he said. Recipient of an Honors Program Hayes Fellowship, Meyer receives funding and lab space to perform his research independently, which he does when he's not occupied with a smorgasbord of other activities. He has a campus job as a community facilitator, is a private tutor and TA for the physics department, was on the SCU boxing team before a torn ACL and meniscus sidelined him … oh, and he also enjoys painting, working out, and is learning to play the guitar. Sleep much?

And yet, with all this going on, he added one more thing to his plate, stepping up as leader of SCU's team participating in the International Genetically Engineered Machine (iGEM) competition, the premier contest for synthetic biology. In 2014, SCU's Joseph Ayar and Campbell Yore were the first law students to ever participate in the iGEM competition. They were back on board for the 2015 event, joining Meyer and fellow bioengineers Matt Kubit and Carlos Medina, along with Alex Codik (biochemistry), and Nicole Mattson and Vikrum Jain (biology). "One of the goals of the contest is to produce scientists who think outside the lab, who consider the societal and ethical implications of their work. Having the law students on the team gives a unique perspective, and of course as Santa Clara students, we are all accustomed to considering the ethical ramifications of our work," said Meyer.

Photo: Heidi Williams



Conary Meyer '16 at work in the biology lab

Their project focuses on improving bioreactor technology. "In current bioreactors, especially fermenters, there is a serious problem with acid buildup inside the culture. As the cells grow and multiply they produce this organic acid which, if left unchecked, will kill the cells and end the culture. We aim to create an acid defense system that can be implemented in any organism with a simple genetic modification so that they can be used in these continuous cultures without having to neutralize the acid. Our loftier goal is that by making cells less sensitive to acid, we might be able to trick the cells into reaching higher cell concentrations which would increase protein yields, making more product, boosting profit," said Meyer.

In summer, all the teams received a kit of biological materials from the Registry of Standard Biological Parts, from which they could build new parts or find novel ways for using the standardized pieces called BioBricks. After pondering numerous ideas, team SCU iGEM landed on the use of the gene found in *E. coli*, a bacterium known to withstand highly acidic environments. Their idea: create a sort of barbed wire effect at the edge of the microorganisms' cells to keep acid out. "*E. coli* changes its membrane permeability by making a cyclopropane group off of the phospholipid tails at the same carbon site all around the bottom and top layer of the cell membrane. Once we found that, we knew we had it!" Meyer said.

"From there, we just had to figure out how to test and build the system. Our system is designed to cause the addition of a step in the fatty acid biosynthetic pathway that causes the insertion of an extra carbon to their chains which will cause an overhaul of the membrane with these modified phospholipids. This change to the membrane would then make it more challenging for acid to diffuse across the membrane, resulting in the acid resistant phenotype that we were striving for."

At the iGEM competition, teams from 234 universities, representing 39 countries, presented their genetically engineered machines—including academic findings, community service and entrepreneurship aspects. Santa Clara's team, advised by Bioengineering Associate Professor Zhiwen (Jonathan) Zhang and the Business School's Bill Mains, Director of Sustainability and Leadership Development, was awarded the Silver Medal!

"The hope," Meyer said, "is that anyone working with bioreactor technology can plug this part in to change the membrane composition so that they no longer have to waste money neutralizing the acid. Basically, we're messing with DNA, working to standardize the system, and finding which sequences do what in order to expand the Registry's library."

Meyer smiled. "We're adding on. Paying it forward."

ENERGIZING STUDENTS … AND THE WORLD

For students working in the Latimer Energy Laboratory, summer days were anything but lazy when Lab director and electrical engineering professor Tim Healy called on Robert Van Buskirk to mentor the next generation of energy experts. Since earning his Ph.D. in physics at Harvard, Van Buskirk has had an illustrious career as an energy activist, doing what he calls "technical solidarity work" in Nicaragua and consulting on Native American water rights in the 1990s. These days, the former program manager at Lawrence Berkeley National Laboratory spends a lot of his time in Africa as he transitions into a new career organized around clean energy.

Photo: Heidi Williams

Front row (l to r): Professor Timothy Healy, Michael Rudolf, Chris Clark, Fred Feyzi; Back row: Ryan Baron, Ethan Hayden, Maximilian Reese, Eduardo Melendez, Andy Ly, Matt Burke, Ryan Greenough, Nico Metais

"Robert is a stellar role model for our students," said Healy. "He's obviously got the technological know-how, but his entrepreneurial spirit, his commitment to serving the poor, and his ability to communicate and work with others to realize his vision and goals are what set him apart. Our mission in the Lab is to educate students on sustainable energy so they can use that knowledge in innovative ways to solve real world problems; Robert is an example of just how that can be done."

Van Buskirk took time out between trips to enlist the students' help on three of his pet projects: a micro-grid power allocation device, a cookstove fan that pasteurizes water while generating electricity, and a system for pulling water out of the air to irrigate vegetation that might die in times of drought.

Power to the People

For the first project, mechanical engineering seniors Matt Burke and Ryan Greenough along with electrical engineering senior Nico Metais and junior Scott Ryan developed the foundations of a smart system to control micro-grid power distribution from a central power station. "As Africa becomes electrified with solar, new technologies are needed to manage how the electricity is distributed and to ensure people are getting what they need and what they pay for," said Van Buskirk. Starting with a prototype their mentor provided, the students got to work optimizing the scheme.

"The original design used a single output DC to DC converter at the central power station. This meant the same voltages would be sent to all the distribution power systems regardless of actual need for different households," said Greenough. "Our goal was to create a DC to DC converter that could receive a voltage from one source and output several different voltages," continued Burke. "We designed a system to read how much power is being used down the line by each group distribution unit, and adjust the output accordingly," said Metais. The team used "a digital potentiometer controlled by an Arduino microcontroller to receive voltages and vary resistance to reach the desired output voltage at the central station," added Ryan.

At the end of the summer, they had Silicon Valley startup eIQ Energy—specialists in optimizing PV power systems using power electronics—perform a design review on their converter. Ryan will implement this input as he continues the work for his yearlong senior design project. Meanwhile, Van Buskirk is developing a partnership with the Catholic Diocese in Malawi to bring an electrification project to the area where the converter will be put to the test.

Where There's Smoke…

We've all heard the adage "where there's smoke, there's fire," but a certain team of summer energy scholars has crushed that old chestnut by chasing away the smoke to find electricity and clean water beyond the haze. And, no, it's not all just smoke and mirrors!

Juniors Fred Feyzi (computer engineering), Ryan Baron (electrical engineering), and Chris Clark and senior Mike Rudolf (both mechanical engineering) set out to solve three

problems common in the developing world. The solution they came up with seems magical but is really just great engineering.

The problems: 1) lack of electricity during cloudy winter months in areas dependent on solar power; 2) unsafe levels of poisonous gases produced by indoor cookstoves; and 3) unsafe drinking water. "By making a few improvements to a common cookstove, we can provide effective ventilation to eliminate the buildup of poisonous gases within a home, purify drinking water for a family, and create a means of income through the generation of electricity that can be sold back to a micro-grid," said Feyzi.

Their prototype, dubbed the Cool Stove, works like this: Electrical power to run a ventilation fan is created using thermoelectric generation chips (TEGs). These chips require a hot and cold side to produce a temperature differential large enough to create output voltage. Horizontal aluminum rods attached to the hot side of the TEGs transfer heat from the fire to the chips. For the cold side, a coolant, such as water, is needed. Here's where the magic happens: Room-temperature unpurified water enters an aluminum tank attached to the other side of the TEGs to help the chips keep their cool. Over time, as electricity is being generated from the chips and the air is being cleared of smoke, the water gradually heats up to 72^0 C, at which point—fully pasteurized against *E. coli* and other diarrhea-inducing bacteria—it is removed to a clean water container, and the tank is refilled with a fresh supply of unfiltered, room-temperature water. Excess electricity generated from the Cool Stove can be sold back to the local micro-grid to serve the community.

"Our final tests of the summer showed that nearly four liters of water could be pasteurized in just over an hour and a half, but what is really significant about the results is that even as the cool side of the chips increased all the way up to pasteurization temperature, the chips were still able to produce enough power to maintain the energy supply rate way above 10 watts," said Baron.

"If it's too much trouble or too expensive to disinfect water, people won't do it," said Van Buskirk. "This solution provides motivation to disinfect since power is generated in the process. Nobody I know is doing this, and I am very, very excited by what the students have come up with. Their approach to heating up the chips and then cooling them down with transient application of the cooling water is quite novel and allows for a rapid heat flow through the chips without building a complicated mechanical heat transfer system. Very nice!"

Save the Trees!

Here's a sad number for you: 12.5 million. That's the number of trees the U.S. Department of Agriculture estimates have died during California's current drought*. But as the state experienced its fifth dry summer in a row, a crew of dedicated Broncos turned their expertise and innovative thinking to the problem and devised a system for pulling water vapor out of the air. With just fans, a box of sand mixed with special salts, and some small solar heaters, mechanical engineering undergraduates Andy Ly, Eduardo Melendez, Maximilian Reese, and environmental science major Ethan Hayden have built a prototype that is showing great promise.

Using a fan to draw cool, humid nighttime air into a box filled with a solution of sand and dessicants—a particular type of salt that draws moisture (you're familiar with dessicants; they're in the little mystery packets tucked inside your new Nikes to keep the shoes dry)—the water vapor is condensed overnight. "Then during the day, using the power of the sun and the clear glass and reflective glass on top of the still, we concentrate the energy of the sun to evaporate the moisture we collected overnight. Once we evaporate the water out of the mixture, it condenses and drips down the solar still into a collection container to be used for irrigation or potentially as potable water for drinking purposes," said Melendez.

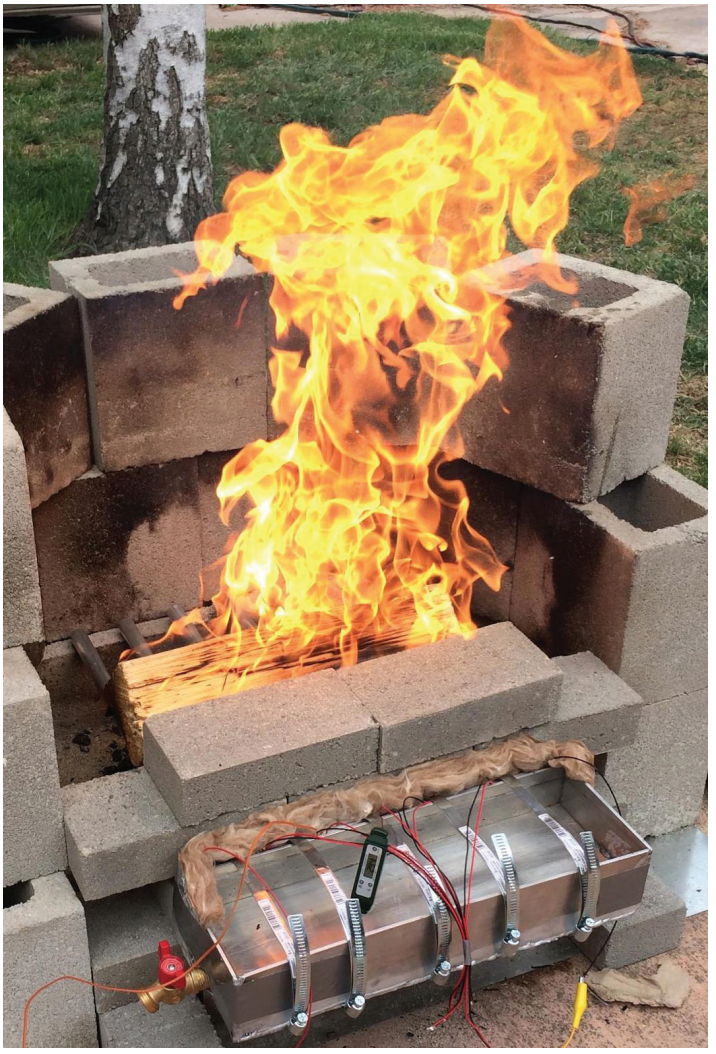


Photo: Heidi Williams

Working prototype of the Cool Stove water pasteurizer

"It's really cool that the dessicant naturally kills all bacteria and viruses," added Reese. "If you're just trying to condense water using a fog collector or some other technologies that take vapor straight out of the atmosphere, you end up with nonpotable water, and you have to do another filtering process on it. With the dessicants, you end up with really clean drinking water."

While the team is excited to have devised a system that is relatively inexpensive and completely scalable, Ly noted "There's so much room for improvement; this is just the start." Maybe, but Van Buskirk is pumped about their success. "You give these students an idea and they come up with a better one. It's great; it's wonderful!"

* Source: USDA's "2014 Aerial Survey Results: California" report

The Best of the Best

Photo: Charles Barry

Michael Brew and Bryant Larsen meet with Tyler Van Herweg in the SCU library.

In Uganda, the word "wakabi" means "best of the best," so when economics major Tyler Van Herweg '15 was looking for a team to help with his idea for facilitating transportation in rural Uganda, he turned to the School of Engineering's Frugal Innovation Lab. He found that help when Silvia Figueira, director of the Lab and associate professor of computer engineering, quickly paired him with computer science and engineering students Michael Brew '15 and Bryant Larsen '15.

Van Herweg had identified a problem while working with a social enterprise in Uganda during the summer after his junior year. "Because of poor infrastructure and high transportation costs, African firms are depressed by about 40 percent. It's a huge issue in Uganda. Motorcycle drivers currently offer ride-sharing services by word of mouth, but many drivers sit idle while farmers are desperately looking for a way to get their produce to market. With so many Ugandans already using 'dumb' phones—cell phones that lack the functionality of a smartphone but enable SMS or texting—to keep track of and move their money, I thought their phones could be used to frugally improve the efficiency of transportation, in turn stimulating the local economy. I applied for and received a Fulbright Fellowship to work on developing a method for connecting boda boda [motorcycle] drivers with small-scale entrepreneurs using SMS to function like a stripped-down version of Uber."

The engineering students quickly got to work designing a mobile app for their Senior Design project. "Our system builds on the existing boda boda process but organizes the procedure," said Brew. "When a new driver starts a shift the app sends a text showing all those in the vicinity who need rides. Data is collected on destination, timing, whether the transport is for people, goods, or a combination of both, and then the driver can phone the client to finalize details."

Larsen said, "We also built in a feature for monitoring the drivers. After the ride, the user is sent a survey to rate the experience, and comments are saved in a database monitored by an administrator."

"For some senior capstones," said Brew, "you might work on a project that you don't pursue beyond what's necessary to fulfill the requirement. With Wakabi, we can actually benefit people. Launching the app into a sustainable business to improve the lives of many is the end goal." He added, "If research validates that the idea works, the sky's the limit."

Van Herweg will be in Uganda September through June, working with social enterprises Solar Sister and BanaPads Limited and testing the app. "It's been a huge lesson learning who to reach out to and how to make ideas become reality. The Frugal Innovation Lab has a track record of success doing projects like this, and these guys make it easy. Entrepreneurs dream of working with people who make the process seamless and rewarding, and working with Mike and Bryant has also lent credibility to the project with the Fulbright folks. Their documentation from Senior Design was such a great help," said Van Herweg.

The project lives on in the Frugal Innovation Lab, too, as computer engineering graduate students Pratyusha Joginipally, Sowmya Chandrashekarappa, Rahul Ramachandra, and Sharadha Ramaswamy continue work on improving the functionality of Wakabi.

Read Tyler's blog: wakabilogistics.com/DiscoveryBlog

TUG OF WAR

Photo: Reynaud Serrette

Typical new home construction in California

Imagine a neighborhood of new residential construction. What does it look like? In California, it's probably a mix of one-, two-, and three-story homes, townhouses, and high density apartments or condominiums—vertical structures with open floor plans and lots of big windows. You may not think too much about what it takes to make those homes seismically safe, but Reynaud Serrette, professor of civil engineering, certainly does. As a researcher in the field of seismic-resistant design of light frame structures using innovative structural components, he is highly sought after by industry partners and design professionals, and his research has led to changes in building codes and the adoption of new products at the state and national levels.

Commenting on the tradeoffs made to keep building costs down, Serrette explains, "It's a tug of war between what architects want as design elements and what engineers need to provide to ensure the homeowners' safety and minimize damage in the event of an earthquake. In California, where land is so expensive, the ranch-style home is a thing of the past; the trend is to build up, rather than out, and that leaves very narrow spaces, often just 9 to 24 inches wide, within which to provide seismic resistance."

To make these complex modern structures work, the builder often needs to incorporate manufactured elements, but Serrette's recent research, which tested elements from three leading U.S. manufacturers, shows that elements currently on the market perform with widely varying success, some providing a much higher defense against damage than others. "Right now," he said, "we have a situation where homes are built to protect lives but not necessarily to limit damage. At the same time, earthquake insurance costs are so high the majority of homeowners simply go without. In the event of a major earthquake, many structures will be left with significant damage. For change to happen, builders need an incentive to incorporate more innovative damage-limiting structural components."

Serrette sees this change off in the distance. "San Francisco and Los Angeles are looking into establishing a rating system for home construction that could affect insurance rates. Buildings incorporating higher levels of safety elements would be rated higher than those meeting minimum requirements. With a standardized ranking in place, builders could keep a healthy bottom line by charging more for higher-rated homes, and insurance companies could offer lowered premiums as the risk of loss is reduced.

"We're not there yet," he said, "but the goal is to make it so homeowners can stay in their homes after an earthquake."

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MR. DAKIN GOES TO WASHINGTON

In the 1939 film classic *Mr. Smith Goes to Washington*, Jimmy Stewart played an idealistic junior senator sent to our nation's capital to represent his state and fight political entropy for the benefit of his constituents. A tremendous success at the time, the film promoted a faith in our country and its people.

Fast-forward to fall 2015 and alumnus Ross Dakin '07 (computer engineering) has gone to Washington, having been selected as a Presidential Innovation Fellow to serve a 12-month term as an embedded entrepreneur-in-residence working with expert federal employees and change-makers to address our country's greatest challenges and improve programs serving more than 150 million Americans.

Tall and lanky, approachable and intelligent (much like Mr. Stewart), Dakin has worked for several Silicon Valley startups and is a member of the School of Engineering Advisory Board. As a Presidential Innovation Fellow, he is excited to have the opportunity to effect change. "DC is chock full of brilliant people," he said; "it's very encouraging (and intimidating). There's a perception problem about government, especially among Millennials, and it's sadly producing apathy. I'm hoping to spread the word back home that government is not about politics—it's about doing together what we can't do alone, and now there are more avenues than ever for technologists to directly contribute."

Since its launch in 2012, nearly 100 top innovators from across the nation have been asked to contribute as recruits in this highly competitive program. As we gear up for an election year and are assaulted with examples of politics at its worst, knowing that technologists and innovators of the highest caliber are being brought to the table to work alongside our nation's leaders goes a long way toward revitalizing faith in our government and its people.

Ross Dakin '07 (left) on the job at the Eisenhower Executive Office Building in Washington, DC

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