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STRUCTURAL & CIVIL ENGINEERS

KHATRI PUBLICATIONS

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L.A. SOFT STORY ORDINANCE IMPLICATIONS FOR CONDOMINIUM OWNERS

◆◆◆ By Dilip Khatri, PhD, SE

LOS ANGELES is on the “Ring of Fire.” The Ring of Fire that circles the perimeter of the Pacific Ocean refers to areas of the high seismic activity because of multiple tectonic plates that have been moving/grinding against each other for millions of years. It’s no surprise that we are in the center of seismic activity with total unpredictability. The earthquake risk element affects every aspect of life in Southern California, most notably our buildings where we live, work, and entertain, because it poses a threat to our very existence.

The Soft Story Ordinance, passed by the City of Los Angeles in 2016, encompasses residential and commercial buildings (four or more units) that have a weak story line which leads to potential catastrophic circumstances: The entire upper level may collapse on the weak first story. In order to minimize this structural calamity, the Soft Story Ordinance requires building owners to upgrade/fix/enhance their buildings to reduce this risk.

Figure 1 demonstrates this principle and shows the collapse mechanism. It’s no different from having a heavy object on “stilts.” A lateral force applied to the upper floors will cause the structure to tip over. The objective of the Ordinance is not to save the building/property. Rather, the prime and single goal is to save the people inside the building. Many property owners don’t realize this objective, and it is important to be clear that the Ordinance is not trying to save property values, it’s main object is Life Safety.

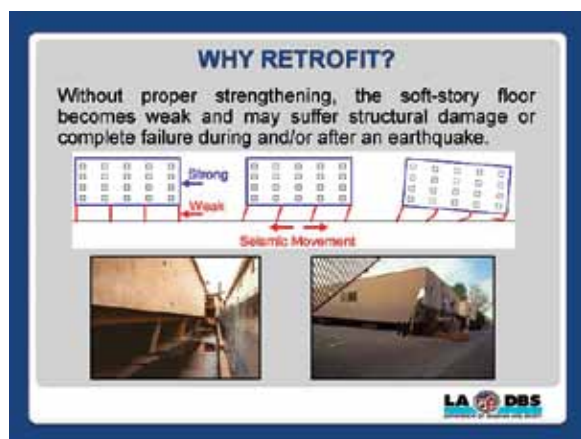


Figure 1: City of LA Slide on Soft Story Failure and Collapse Mechanism

The L.A. Ordinance officially affects approximately 14,000 buildings, but that number is changing because new buildings are being added to the list, and other cities in Los Angeles

County are decidedly passing similar ordinances.

There are several engineering options available to resolve this dangerous condition. At least five repair options are to be considered:

1. New Steel Moment Frames
2. Strengthening existing Steel Moment Frames
3. Strengthening existing Wood Shear Walls
4. New Wood Shear Walls
5. New Steel Flagpole Columns

Figures 2 and 3 show a few schematics of a Steel Moment Frame and Wood Shear Wall.

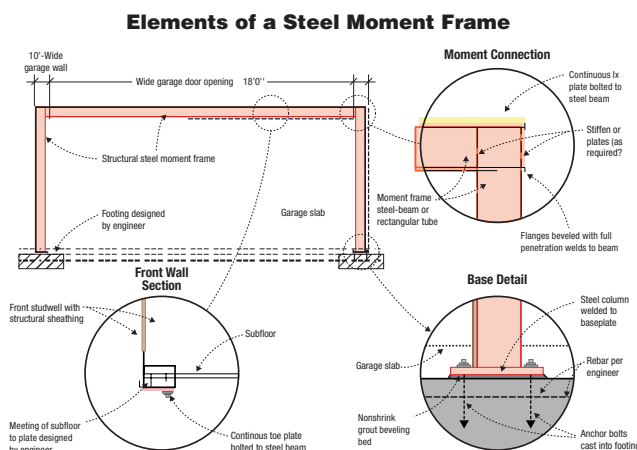


Figure 2: Steel Moment Frame Diagrams



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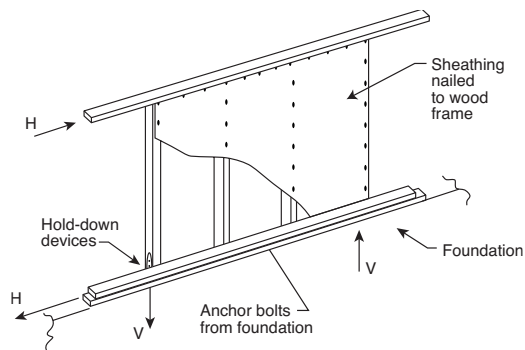


Figure 3: Wood Shear Wall Principle

My advice to owners is to look at each of these options and evaluate the “best choice” from an economic feasibility standpoint. Each property is unique and requires personal attention of a structural engineer and contractor. It’s definitely not a “one size fits all” scenario. Look around, shop around, and do some diligence before you commit to a specific solution/vendor approach. The time lines for compliance are seven (7) years from the date of notice, two (2) years for plans and permits. If you are interested to learn more about the Soft Story Ordinance, this author has produced an online video for your reference: <https://vimeo.com/194302379>.



Dilip Khatri is the principal of Khatri International Structural Engineers, headquartered in Pasadena. His firm is currently working with several HOAs in the Los Angeles area on earthquake retrofitting projects. Dilip can be reached at dkhatri@aol.com.



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CHAMPLAIN COLLAPSE:

STRUCTURAL LESSONS TO BE LEARNED

□□□ By Dr. Dilip Khatri, PhD, SE

CHAMPLAIN HAS BROUGHT THE “UGLY” TO THE FOREFRONT. AN ENTIRE BUILDING COLLAPSES FOR SEEMINGLY “NO REASON?” HARDLY THE CASE; THIS AUTHOR DOES NOT BELIEVE IN “SUDDEN COLLAPSE.” NOTHING ABOUT BUILDINGS IS SUDDEN. EVERY DISASTER OF THIS TYPE IS THE CUMULATIVE RESULT OF PRIOR WARNINGS AND MISCALCULATIONS IGNORED. THINK BACK TO MANY OF THE BAD CIRCUMSTANCES YOU HAVE EITHER LEARNED ABOUT OR BEEN A PARTY TO. MISSED FLIGHTS, MISROUTED LUGGAGE, LOST SPACECRAFT BY NASA, COLLAPSED BUILDINGS, AND CAR ACCIDENTS OFTEN INCLUDE AS A PART OF THEIR STORY SOME ELEMENT OF HUMAN ERROR CAST AS “BAD LUCK,” OR “A SERIES OF SMALL MISTAKES GONE TERRIBLY WRONG.” MURPHY’S LAW IS ACCURATE BUT CAN AND MUST BE MANAGED.

Concrete structures are noted for their longevity and have an excellent record of accomplishment related to fire resistance, earthquake survival, corrosion protection, and providing a “rock solid” feeling of impenetrable existence, or so we thought. But as I learned from a beloved late Professor, Taylor Meloan [Dean, USC School of Business], “*Nothing lasts forever.*” Everything has a timeline.



Four basic materials constitute the building blocks of civil engineering: Masonry, Concrete, Steel, and Wood. Within the United States, there is 344 billion square feet of building space [commercial buildings + residential space]¹. Of that, 257 billion [75%] consists of wood structures [residential space comprising single family homes and multi-family apartments/condominiums]. Masonry/Stone has the longest history as building material that is still commonly used, dating back 5,000 years to the Pyramids of Egypt. Concrete is modern man’s invention to simulate stone/rock and was developed in the 1700s. Steel is the relative newcomer, getting its start in the 1700s and proliferating in the late 1800s with the blending of carbon, silicon, and iron to create iron alloys. Wood has been around for ages (1000+ years) but has never

dominated the architectural horizon because of its low relative strength compared to the other three materials.

These four building blocks all represent different service time horizons. Masonry has a lifespan of beyond 50 centuries in certain recorded instances and continues to be the “everlasting” material [as for humankind, “everlasting” is a philosophical construct]². Concrete has shown to be reliable beyond 200 years but has a diminished performance rating because of corrosion and its limited ability to withstand earthquakes. Steel has performed up to 100 years reliably, but as we observe with our fractured steel bridges, the long-term effects of rust eventually will render every steel building and bridge inoperable. One day our beloved national treasure, The Golden Gate Bridge [100% steel bridge] will reach the end of its life. Wood rarely survives beyond 80 years, but there are examples of 200-year-old historic wood structures that have managed to survive with maintenance. The point is, **EVERYTHING has a timeline.** Every building has a service life. Just like your favorite movie, there is a beginning, middle, and end.

1 University of Michigan, Center for Sustainable Studies: 257 Billion SF of Residential Space (2020); 87 billion SF of Commercial Space (2020)

2 Everlasting: The age of the Earth is 4.5 billion years, and humankind has been walking the planet for approximately 50,000 years. The oldest structures [Stonehenge] are estimated at 10,000 years. For our time horizon, anything over 100 years is exceptional.

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Champlain Towers collapsed after years of neglect. The official cause of collapse remains under investigation, but I personally visited the site, reviewed the structural plans, examined the visible evidence, and reached some basic conclusions. First, the building experienced years of neglect and obvious signs of structural failure in-process were noted by the Association's experts. Secondly, there is no doubt that soil was a major factor in this event. The foundation comprises driven concrete piles of which the depth was not specified on the structural engineer's drawings. Looking at the public documents, the Association Board was faced with a \$9 million repair cost which was knowingly ignored or "tabled for further discussion." As a structural engineer that works with HOAs regularly, I understand this political and financial stalemate that confronts many associations and have experienced this firsthand in many geographical locations. These include but are not limited to such areas as Northern and Southern California, Texas, Florida, and Nevada. The ugly truth from Champlain is that many owners simply assumed their building would continue to serve them faithfully without the need for routine maintenance, periodic testing, and structural examination, and without appropriate ongoing investment in this, their most valued asset: their home.

Cars need an oil change every 3,000 to 5,000 miles. Your teeth need to be cleaned at least once a year. Jacuzzis and pools need to be drained and washed periodically in accordance with

professional recommendations. Italian marble requires special buffing with expertise to keep its luster. Lawns need to be mowed. But what do we do with our building structures? What do we do about them? Do we wait until they crack, fall, or an earthquake brings the whole castle crumbling down? That is hardly the right spirit for life's most critical priorities! As an HOA expert for 30 years, I have seen associations spend millions of dollars on upgrading a putting green while structural repairs on garage roofs near collapse were put off. Structural Engineers do not deliver cosmetics for your facial treatment, we are the bones that keep you walking.

Residential multi-family property owners [i.e., homeowners associations] must face the "ugly" and deal with these issues to put life and limb above their new chandeliers, velvet carpet entryways, stone masonry party walls, new pool decks, and charming facades that are beautiful but do not last, while meanwhile the footings are sinking. The buried residents of Pompei can attest to this lesson.



Dr. Khatri is a Structural Engineer with 39 years of experience in structural design, construction, and project management. He has worked with HOA clients for 30 years and is an active member of CAI in seven chapters. Dilip can be reached at dkhatri2006@gmail.com.

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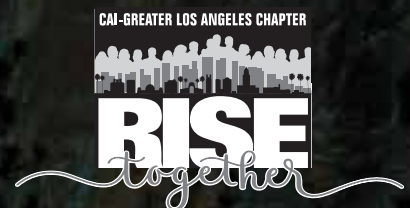
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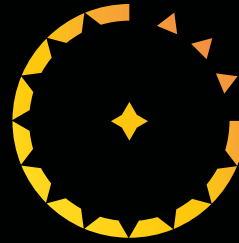
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WATER



WIND



SUN



FIRE

□□□ By Dr. Dilip Khatri, PhD, SE and Kylie DeVries

THERE ARE FOUR ELEMENTS OF OUR ECOSYSTEM AND THE NATURAL WORLD WHICH ARE INEVITABLE: WATER, WIND, SUN, AND FIRE. ALL CIVILIZATIONS, EMPIRES, AND MAN-MADE [OR WOMAN-MADE] MONUMENTS EVENTUALLY SUCCUMB TO MOTHER NATURE'S ELEMENTS. AS A CIVIL ENGINEER FOR 39 YEARS AND HAVING TRAVELED TO SEVEN CONTINENTS, I HAVE LEARNED ONE UNIFORM LESSON: MOTHER NATURE ALWAYS WINS. OUR UNIVERSE WAS BORN 15 BILLION YEARS AGO; THE EARTH IS 4.5 BILLION YEARS OLD; HUMAN CIVILIZATION IS 50,000 TO 100,000 YEARS (GIVE OR TAKE +/- 20,000 YEARS). IN THE PAST 100 YEARS WE HAVE CREATED MORE ISSUES WITHIN OUR PLANET THAN THE PREVIOUS 4,499,999,900 YEARS. HOW IS THIS POSSIBLE? HOW DID WE GET HERE—TO THIS APOCALYPTIC STAGE? OR IS IT JUST ANOTHER HOLLYWOOD MOVIE?

Our media and press have not been entirely honest and factual with us [the public]. Recall the “world emergency of Y2K?” Remember all that hullabaloo? The world was going to stop, traffic lights would fail, power outages were going to cripple civilization, nuclear missiles would be launched, banks would close, people would die, and the world will would spiral into anarchy and chaos. And then... nothing happened. I am still waiting for Ebola, SARS, and the Swine Flu to kill everyone. Where did Mad Cow disease go? What happened to those cows? Salmonella, where are you? Where is the Malaysian Airlines flight 370? Where did that plane go? In 1978, when I was in high school, we were taught that oil would run out by the year 2000 and the world economy would collapse. We were also told that overpopulation would lead to massive food shortages that would result in, you guessed it, everyone dying and collapse of the world economy. Okay, I am still waiting for the oil to run out. Do not believe everything you read in the paper or on the internet. One consistent truth among all these episodes has been that the Press never apologizes and never corrects themselves. It does not matter which channel you watch (CNN, FOX, MSNBC, PBS), you see this nonsense peddled every year.

Amazon natives have lived in harmony with nature for 50,000+ years. African pygmies, Inuit tribes, Himalayan Monks, and Siberian Natives have survived 10,000+ years without modern amenities. Why is Los Angeles running out of water? Las Vegas

may not have power for its casino empire. My God, is this the end? I am unable to answer these postulations, but let us examine the situation with analytics (I.e., from the Engineer’s perspective).

My parents arrived in California in 1968 when I was 3 years old. California’s population was 17 million at that time and a coastal property in Malibu cost \$12,000. My parents bought their first house in Sierra Madre for \$42,000 in 1972, when gasoline was \$0.25/gallon. In 2021, California now has a population of 40 million and everyone is aware of how the cost of living has escalated. California has 1,500 reservoirs for water storage with 850 million - 1.3 billion acre-feet of storage capacity. Dam construction has all but stopped since the early 1990s with no new dams or reservoirs are on the horizon for many reasons linked to environmental regulations beyond this article, but the population continues to grow. California’s water supply is found in areas of lower population density; northern California has 60% of the water shed volume but only 10% of the population. Areas near Bishop and Mono County are the water source for Southern California, among other locations. The Los Angeles Basin is a natural desert. The city of Los Angeles was created by bringing water from other regions to grow Southern California.

As a civil engineer, the first commandment for land development engineering is, **DO NOT DIVERT THE WATER.** Raw land that naturally flows south must remain flowing south on the developed plan. This rule is written into the California Water Code and applies to both surface and sub-surface runoff. The primary reason for this law is, the diversion of natural runoff will cause detrimental effects to others downstream where the water was not intended and lead to drought conditions along the natural drainage course. Imagine that we were to divert the Colorado River at Hoover Dam away from Arizona and Mexico. Certainly, this would lead to war. Yet, the State of California and City of Los Angeles (as well as San Francisco, Sacramento, and others) have done exactly that by bringing water from their natural drainage patterns to populated areas. The results are devastating yet deemed by some to be progress.

My father put it very simply: *“Your poolside event has 4 guests, and it’s a great party. But if you invite 400 people for the same pool, it’s an ecological disaster.”*

We expect to continuing adding more population but fail to address the existing water supply, then complain it is “global warming” and “severe drought.” This author is not arguing against

these two principles, as there is factual evidence that these are compelling forces impacting the planet, but we cannot ignore our own stewardship of Mother Earth which has contributed to this present condition and continues to do so. To blame everything on a sole source (e.g., Global Warming) is to conceal our own mismanagement of resources and poor planning.

The Hoover Dam was built in 1930s and created Lake Meade, with 29 million acre-feet of water supply capacity. In 1930s, the combined populations of California, Arizona, Nevada, Utah, and Colorado was under 6 million. Today this combined population is approaching 60 million. Lake Meade has not grown (the pool is the same size, but the party has grown larger). Interestingly, I travel regularly to the Colorado River at Lake Havasu, south of Hoover Dam, and the water discharge is plentiful with no change in the riverbanks or lake level. This underreported fact leads to the question of why the upstream water levels are dropping while downstream flows remain constant? Unsurprisingly, this entire issue is ignored by the media. The Colorado River is a managed river with legal agreements that guarantee flow rates to Mexico, Arizona, Nevada, California, Utah, and Colorado, and each stakeholder has legal rights to this river, but there are limits. If one party grabs more French fries at the buffet, such as California with its 40 million people, it creates a problem. The water supply is not “all you can eat.”

The San Joaquin Valley has SUNK over 32 feet since the 1930s due to ground water pumping. Water used to feed the burgeoning agricultural industry which made California the 5th largest economy in the world, but it was success that was founded on the exploitation of natural and environmental resources. The San Joaquin Valley is a natural desert with underground aquifers, and it has been artificially transformed into productive farmland. Hooray for California! But let us not hide the fact that this industrial development has posed a huge environmental cost. Water is a finite resource, and it will deplete in supply when abused.

In the City of Los Angeles, the retail cost of water is \$9/HCF (HCF = Hundred Cubic Ft, or 748 gallons), which translates to \$0.012/gallon (interesting to consider when you buy 1 liter of Evian Water for \$6 at LAX, which equates to \$22.68/gallon). Power from LADWP retails at approximately \$0.18 kilowatts per hour (kWh), which is among the highest power rates in the U.S.

In the Las Vegas area, the cost of water = \$1.50/1,000 gal, or \$0.0015/gal (less than one penny per gallon). The power cost is \$0.103/kWh (10 cent/kWh, or roughly 60% of California's cost). In Texas, the power cost is less than \$0.05/kWh (5 cents per kWh).

Let's take a journey to Aruba, the island paradise in the Caribbean with no natural water resources. On this tiny island, comprised of only 70 square miles (about twice the area of Manhattan), there are 110,000 people, not counting the 2 million tourists who visit annually! Aruba is larger than Santa Catalina Island (55 square miles) but has a much larger population (Santa Catalina has 4,000 residents). Aruba's water supply is achieved entirely through the desalination of ocean water, and they will never run out. The retail cost of water in Aruba is \$16/HCF (2.4 cents/gallon), and power is \$0.25/kWh. Aruba is powered almost entirely by diesel generators and a few wind towers.

Dubai, United Arab Emirates (UAE), is on the edge of the Sahara Desert and on the coast of the Persian Gulf with a population of 2.9 million and a land area of 1600 sq. Miles. Los Angeles County, by comparison, is only 4,700 square miles. The cost of water in Dubai is \$17/HCF (2.3 cents per gallon), and their water, like Aruba's is sourced through desalination because they have no ground water source. Power is \$2.40/kWh, which is among the highest rates in the world. Citizens of the UAE are not charged for power as it is considered to be a “gifted right.” Foreigners, however, are charged for it to subsidize the local resident population. Now that's “democracy in action!” What have learned? In my very humble opinion, the lessons are these:

A. Population centers (I.e., cities) need to be grown in areas adjacent to natural resources and not “bring” the water from 1,000 miles away because in the long term, this is not sustainable. The Romans and Greeks knew this as did the Mayans, Arabs, Hindus, Eskimos, and Native Americans. Los Angeles is one of many geographically misplaced cities, along with San Francisco (not only built in an area with no natural clean water source, but also built along the San Andreas fault) and New Orleans (built below sea level).

B. Desert areas are not appropriate for lush, green golf courses. Sorry Palm Springs and Las Vegas, this is not your natural habitat. Move the golf courses to rain forest areas and play in the rain!

C. Land developers need to collaborate with and assist public agencies, because they are lost when it comes to water and power infrastructure. If we are going to add another 40 million people to California, then we need to figure this out now. We cannot keep adding people to the “pool party” and not add more pools!

D. Abandon California—let's move to Costa Rica!

On a serious note, we cannot realistically do A, B, or C and option D is already in full operation for some, whether it is to Costa Rica or elsewhere, but we do need to innovatively add to the existing water supply: Desalination is one solution. Yes, it is more expensive but if you are driving your Lamborghini and paying fuel costs of \$5/gal with taxes, insurance, and picking up Starbucks at \$8/coffee, then we can find funding for desalination. California is adding wind energy and solar power plants to contribute to the power supply, but it is not happening fast enough. Environmentalists' concerns for tortoises, rabbits, rats, and bats veto such projects. If we do not address these issues and realize that population areas need to diversify geographically, then we will run out of water and will become a desert. Oh wait, that's what we were to begin with, isn't it? See? Mother Nature always wins.



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By Ashley Hibler, Social Committee Co-chair

Wow! The Social Committee really pulled out all the stops to produce an Awards Gala surpassing all others! High on the outdoor Treetop Terrace of the Los Angeles Zoo, the Committee carried out a safari theme on and off the stage, complete with realistic lions, tigers and a gorilla. More than 211 CAI-GLAC members and industry friends celebrated 2021 chapter volunteers, presenting them with Industry Excellence Awards. The stage was set for a magical evening when attendees rode a tram through a light show display to arrive at the Terrace. Activities during the event included a cocktail hour and dinner, followed by dancing, photo booth, raffles and rides on an authentic carousel. Our thanks to all the sponsors who supported this event and to the Social Committee members: Co-Chairs Ashley Hibler (McKenzie Rhody, LLP) and Michael Valenzuela (Vista Paint Corporation), Michelle Anderson, CMCA®, AMS® (PMP Management AAMC®), Kizzy Bell Sumo (Prime Association Services), AnneMarie Hernandez (EmpireWorks), Angelique Madrigal (Ross Morgan & Company, Inc. AAMC®), Jocelle Maliwanag (American Heritage Landscape), Lesley Millender-Irwin, CMCA®, AMS®, PCAM® (FirstService Residential AAMC®), Catherine Santiago, CMCA® (FirstService Residential AAMC®), and Emma Zaboth (Roseman Law APC).





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EARTHQUAKE RISK TO COACHELLA VALLEY

By Dr. Dilip Khatri, PhD, SE

ABSTRACT

Earthquakes are synonymous with California like football in Texas and Alabama and hurricanes are for Florida and the Gulf Coast. "We" in California have one serious disadvantage: Uncertainty of timing and location. We do not know when or where the next earthquake will strike. California is highly prone to drastic risk of earthquake. The 1994 Northridge Earthquake exposed the bare reality: only 20% of owners are insured for earthquake. For the Coachella Valley, the proximity of the San Andreas Fault looms on the horizon with less than 5 miles from 20+ cities stretching along I-10.

Los Angeles, San Francisco, Sacramento, and other jurisdictions have recognized the earthquake risk and mandated soft story retrofit ordinances requiring owners to update their buildings to prevent collapse potential. No cities in the Coachella Valley have adopted any ordinances relevant to earthquake structural safety as of June, 2022.

1.0 EARTHQUAKE RISK

The Coachella Valley ("CV") is situated in a beautiful desert landscape with Mt. San Gorgonio and Joshua Tree Monument. CV is located precariously on a band of earthquake faults that are dubbed the "San Andreas Fault". It's not one fault, but rather a "strand" of earthquake faults that split CV into multiple zones of risk because each fault has a different slip-rate. Figure 1 illustrates at least three earthquake "strands" that are part of the single San Andreas Fault Line.

Figure 1: Strand of earthquake faults (Scientific Advances: Research Article; "A revised position for the primary strand

of the Pleistocene-Holocene San Andreas fault in Southern California", Blisniuk, Shcarer, Sharp, Burgmann, Amos, Ryner, American Association for the Advancement of Science, 2021.)

At least three earthquake strand faults are noted with slip rates varying from 1.5mm to 20mm/year. This recent study provides clear evidence that CV is on highly active tectonic plates which are moving in a complex manner. The earthquake risk is undisputed in this region and a serious threat to the infrastructure of CV.

Given the location in Southern California, this should be no surprise. Florida has

"Florida has hurricanes, Texas has tornados and hail, and St. Louis has the "mid-west combo" [i.e., tornados, hail, and earthquakes]. Incidentally, the most seismically active area in North America is not California, but Oklahoma City. "

hurricanes, Texas has tornados and hail, and St. Louis has the "mid-west combo" (i.e., tornados, hail, and earthquakes). Incidentally, the most seismically active area in North America is not California, but Oklahoma City. Due to the excessive oil drilling and fracking, this has been linked to a frequent recurring earthquake activity in Oklahoma which is consistently denied by the State which disbanded their earthquake tracking agency. This author has personally investigated earthquake claims in Oklahoma which have been denied insurance coverage because insurance carriers claim, "...earthquakes don't happen in Oklahoma...". Ha! They do!

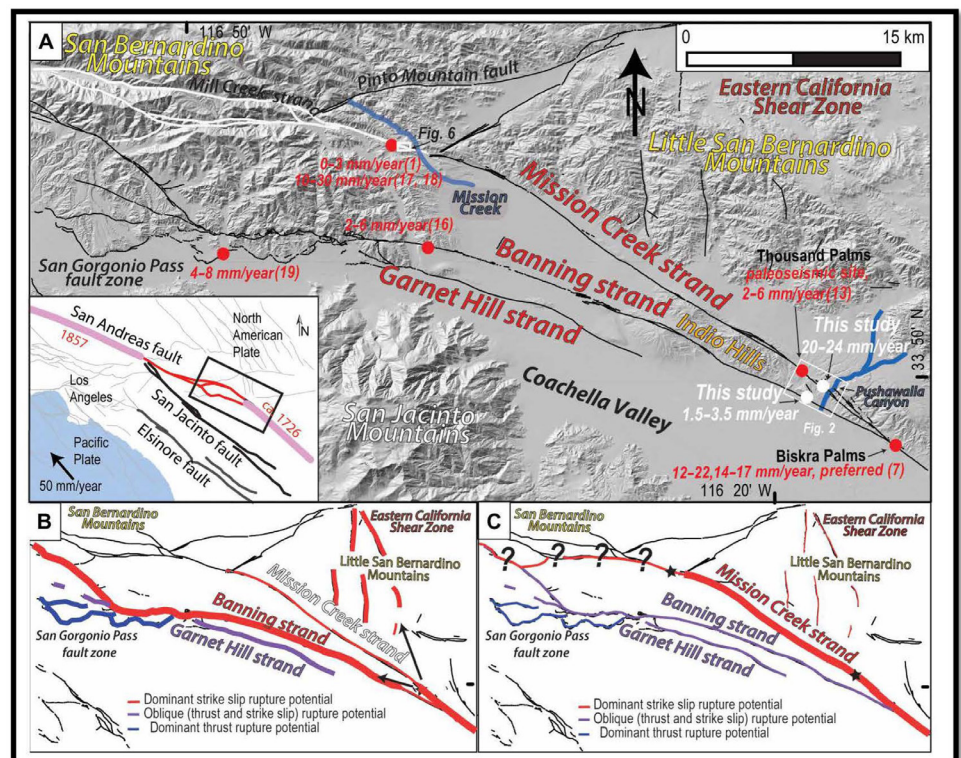


FIGURE 1



FIGURE 2

"California has thousands of buildings that were constructed pre-1979 with an inherent design flaw: Soft Story."

FIGURE 3



2.0 SOFT STORY BUILDINGS

California has thousands of buildings that were constructed pre-1979 with an inherent design flaw: Soft Story. A soft story is a structural anomaly where the heaviest load transfer (along the first floor) is unlikely the weakest element in the building. Figure 2 shows how gaps in the first floor create a weak element that is subject to collapse in moderate/weak earthquakes. Figure 3 shows the collapse of the Northridge Meadows Apartment building in 1994.

FIGURE 2: Soft story failure in San Francisco (FEMA P-801).

FIGURE 3: 1994 Northridge Earthquake caused failure of the Northridge Meadows Apartment building killing 16 people.

The result of these failures is many cities have adopted a Soft Story Retrofit Ordinance. It started with San Francisco, Sacramento, and Los Angeles. This ordinance is now slowly being adopted across L.A. County which comprises 88 cities. The ordinance mandates a structural retrofit of the building to strengthen the lower floor.

As of June 2022, no cities in CV have adopted any soft story ordinance.



FIGURE 4

3.0 SEISMIC RISK TO CV

CV has many soft story buildings. One example is Figure 4.

FIGURE 4: Soft story condition at Palm Springs HOA.

FIGURE 5: A typical beam-column connection that has no lateral tie, no steel strap, no bolts, just vertical weight resting on a bearing plate with a bearing length less than 3 inches. This connection is prone to horizontal movement in an earthquake and could slip off the column causing catastrophic collapse if the movement is just 3 inches or more.

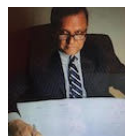


FIGURE 5

4.0 CONCLUSIONS AND PLAN OF ACTION

CV is in a high seismic risk zone. There are no legal mandates, as of June 2022, but owners should consider a plan of action, especially after the tragic event in Surfside Florida.

1. Evaluate your facilities/buildings for seismic soft story condition.
2. Evaluate their existing structural condition for reinforcement, rust, corrosion, and age.
3. Perform a voluntary retrofit plan and allocate funds for this important capital improvement (it's more important than redoing the putting green!). 🏠



Dr. Khatri is a structural engineer with 40 years' experience in structural design, construction, and project management. He has worked with HOA clients for 30 years and is an active member of CAI in 7 chapters. Dr. Khatri completed his PhD from the University of Southern California in Earthquake/Structural Engineering, Masters in Structural Engineering from California Institute of Technology, Bachelor of Civil Engineering from California State University, and M.B.A. from U.S.C. He has published, co-authored, and presented over 100 papers, technical conferences, online seminars, written two textbooks on structural engineering, and is writer/director/producer of "Aspire to the Sky: The Wilshire Grand Story" a documentary film about the tallest building in Los Angeles currently on Amazon and other online platforms. Dr. Khatri is Principal of Khatri International Inc. (www.khatrininternational.com) based in Las Vegas, NV, and Arcadia, CA, and works nationally with HOA clients.

HOA Living MAGAZINE

COMMUNITY ASSOCIATIONS IN THE LA VALLEY CHAPTER

OCTOBER 2022



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Let Your Lawn Go Gold

By CVWD

Homeowners, HOAs, businesses and golf courses are encouraged to skip overseeding lawns this fall. It's a longstanding practice in the Coachella Valley but can be wasteful and unnecessary, especially during the ongoing drought.

Let your lawn go dormant to conserve water and save on seed and extra lawn maintenance. When watered once a month from November to February, most dormant grass grown in the desert will thrive again in the spring.

Also, consider these:

- Current water restrictions prohibit spray irrigation during daylight hours.
- Extra water needed for overseeding can boost your water bill into higher tiers with costly penalties.
- Scalping grass before reseeding kicks up dust, dried grass and pollen into the air causing health problems for some.
- Irrigating nonfunctional turf (decorative mowed grass) is prohibited at commercial, industrial, institutional sites and HOAs. Areas used for recreation or civic events or areas with trees are exempt. Click here for more information on non-functional turf.



Rather than overseeding, take advantage of CVWD's turf conversion rebate program that gives customers \$3 per square foot to replace grass with low-water use, desert-friendly landscaping or artificial turf, [CVWD.org/rebates](https://cvwd.org/rebates).

For gardeners who insist on overseeding, CVWD offers guidelines to help save water.

Other key suggestions include:

- Wait to overseed until mid-November when cooler temperatures call for less water.
- Overseed a small area instead of the entire lawn.
- Water just enough to keep the seeds moist, not soaked.
- Check sprinklers for leaks and proper operation.
- Schedule irrigation time into more frequent two-or three-minute cycles to reduce the chances of wasteful runoff.
- Limit irrigation once seeds sprout.

For more conservation tips: [CVWD.org/conservation](https://cvwd.org/conservation). 



By Sierra Carr, PCAM

Congratulations Robert Coleman on earning his Association Management Specialist (AMS®) designation in August 2022! Robert is with Titan Real Estate Group.

Congratulations Gretchen Redewill on earning her Association Management Specialist (AMS®) designation in July 2022! Gretchen is with Associa Desert Resort Management.

Congratulations to Dilip Khatri, PhD, SE. on celebrating 40 years as a structural engineer. Dilip graduated from college in 1983 with a bachelor's in civil engineering from Cal State LA, at the age of 18. In 40 years, Dilip has worked for NASA, JPL, BOEING (formerly Rockwell International), PARDEE Land Development, a construction company, various consulting firms, as a Professor of Civil Engineering at Cal Poly Pomona, and in his own firm for the past 25 years. Dilip has worked on the B-1 Bomber program, designed space satellites to explore the universe, and a long list of building inspections, evaluations, design of new facilities, restaurants, hospitals, mortuary buildings, and of course HOA clients. Congratulations, Dilip! 

Sierra Carr, PCAM, CMCA, AMS, CCAM, is a community manager with Associa Desert Resort Management. You can reach Sierra at scarr@drmineternet.com. To submit information to Have You Heard?, send an email to hoaliving@cai-cv.org.

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COMMUNITY ASSOCIATIONS INSTITUTE | COACHELLA VALLEY CHAPTER

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CALIFORNIA'S WATER ACCOUNTING

Dr. Dilip Khatri, PhD, SE

Will there be enough water to sustain life in California? The central question pervading our society's existence is WATER. Although this author has great admiration for NASA-JPL's great minds to search for water on Mars, how about finding it here in Southern California? A central issue here is not just California but for the southwest in general: California, Nevada, Arizona, Utah, Colorado, and Mexico. All who share and signed several treaties to share the Colorado River Basin, which is now endangered. Is the sole cause of water distress due to global warming and climate change? Or have we squandered Mother Nature's gift on misplaced priorities?

The Hoover Dam was constructed in 1936 which created Lake Mead with 29 million acre-ft of water capacity for a population of approximately 6 million. The size of the lake is the same, but the population has increased to 60 million. In 86 years, the lake capacity is the same, and the population has increased by ten-fold. California has 1500 dams, and no new dams over the past 30 years, with total water storage capacity of 30 million acre-ft. The demand of the California's population [40+ million] is larger than the countries of Canada [37 million], Australia [25 million], Saudi Arabia [37 million], and boasts the 5th largest economy in the world. My full paper is available and presents the "water accounting" of the State of California and supply v. demand analysis to understand [from an analytical civil engineer's perspective] the use of our most valued natural resource. 📄

Dr. Dilip Khatri, PhD, is a Structural Engineer with 39 years' experience in structural design, construction, and project management. He is principal of Khatri International, a structural and civil engineering firm based in Arcadia, California and Las Vegas, Nevada. Dr. Khatri can be reached at (626) 351-4830 or by email at dkhatri@aol.com.

HAVE YOU HEARD?

Congratulations Robert DeNichilo, Esq. on earning his acceptance to the College of Community Association Lawyers (CCAL) in November 2022! Robert is with the law firm Nordberg|DeNichilo, LLP.

Congratulations to Jennifer Tirado for earning CAI's Community Insurance and Risk Management Specialist (CIRMS™) designation in December 2022! Jennifer is with CondoLogic.

Congratulations to Tracy Young on earning CAI's Association Management Specialist (AMS®) designation in December 2022! Tracy is with Associa Desert Resort Management. 📄

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**Friday, February 10, 9:00
AM Via Zoom - Only \$99**

By Bridget Nigh



CAI has over 50,000 members, but surprisingly, only 1,058 members hold the Educated Business Partner distinction. Becoming an "Educated Business Partner" is a great way to differentiate yourself from the competition in your market. For a onetime fee of \$99, CAI-CV offers an in-person course on Friday, February 10th at 9:00 AM or an online course year-round. Individuals who pass the course, and maintain their CAI membership, will be granted the CAI Educated Business Partner (EBP) distinction, gaining special recognition among thousands of companies and professionals who support common-interest communities—accountants, attorneys, bankers, insurance professionals, landscapers, painters, reserve specialists, software providers and many others. I am looking forward to attending the in-person class this February and hope you will too. 📄



Bridget Nigh is Behr Paint Company's Regional Account Manager for the Coachella Valley and Inland Empire and is a Director on the CAI-CV Board. Bridget can be reached at (714) 365-7427 or by email at bnigh@behr.com.

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COMMUNITY ASSOCIATIONS INSTITUTE | COACHELLA VALLEY CHAPTER



10 *HOA Living Magazine*
wins another national
achievement award!

22 Active Shooter Lunch Program
Friday, April 28th, Sun City Palm Desert

FEATURED COMMUNITY

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Neighborhood
Association**

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- 23** Are You Prepared for an
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- 24** Violence Survival
- 28** What to Consider for
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CAI-CV EDUCATIONAL PROGRAM & MINI TRADE SHOW FRIDAY, MARCH 24, 2023
SUN CITY PALM DESERT

Earthquake & Emergency Preparedness

THANK YOU!

Guest Speaker

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CAI-CV EDUCATIONAL PROGRAM & MINI TRADE SHOW FRIDAY, MARCH 24, 2023 SUN CITY PALM DESERT



OC VIEW

CAI - ORANGE COUNTY
REGIONAL CHAPTER
MEMBER MAGAZINE

MAY | JUNE 2023

**ADUs in Your Association:
An Inevitable Outcome**

**California Balcony Law
Inspection Update**

**The Aftermath of Senate Bill 9:
Single-Family Residential Community No More?**

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YEARS

ORANGE COUNTY REGIONAL
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community
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Figure 1: Before close of escrow.

California Balcony Law Inspection Update

Dr. Dilip Khatri, PhD, SE
Khatri Int. Civil & Structural Engineers, Architects

At the beginning of this year I told my staff this is the “year of the balcony” and certainly this is true. I have a dedicated group who I affectionately refer to as the “Balcony Brothers,” dedicated 100% to balcony inspections because we have been inundated with work to meet the 2024 deadline on this law. As we go through our inspections, I’ve observed lots of interesting facts to share with our audience of clients and property management companies which “enlightens and frightens” simultaneously.

Perhaps the most surprising facts stem from the hidden damage observed at certain properties. We recently inspected a beautiful condominium that sold for over \$1,500,000.00 and the exterior areas looked pristine [see Figure 1] with no signs of potential damage. Then we opened up the areas upon a contractor request and found the hidden damage [see Figure 2].

The damage is substantial and extends beyond the balcony zone into the structural walls and will require significant reconstruction efforts. No doubt the cost of repair will be well beyond the original balcony repair budget, and we’ve only started on one unit. There are still plenty of others to look at next.



Figure 2: After close of escrow

LESSON ONE

Expect the Unexpected

Southern California has long-term moisture problems in every building, regardless of zip code. However, my inspections have shown that the closer to the ocean, with higher humidity, there is an increase in the presence of dry rot and termite infestation. The real culprit is the lack of waterproofing which is endemic throughout this state.



Figure 4: Dry rot and weakened balcony rails that will fall anytime.



Figure 3: Termite and dry rot damage



Figure 5: Walkway with extensive dry rot damage.



Figure 6: Exterior dry rot that signals possible wall damage, but we don't know until this is opened.

We have also observed balcony areas with clear visible damage of obvious unsafe conditions; a clear danger that is not being addressed by some associations. This could be a potential big problem of liability and culpability for both property management companies and owners. Figures 4, 5, and 6 show the “ugly” that no one wants to face.

LESSON TWO

You Can't Hide from Mother Nature

Owners need to face the “ugly” and deal with these issues directly. My job as a consultant and structural engineer is to educate, inform, inspect, and advise. That's the best any consultant can do for their owners. Engineers are your “doctors” and you should listen to your doctor and act accordingly, otherwise the consequences will be dire. Simply deferring maintenance to another day will not make the problem go away. At some point, “another day” arrives.

LESSON THREE

Costs Never Go Down, They Only Go Up

In my 41 years in this industry, I can safely state with one hundred percent certainty that life does not get cheaper. Never have I ever seen construction costs going down. For sure we can argue about the rate of increase with inflation, the Federal Reserve policies, and other financial issues, but the end result is costs WILL RISE. So what might cost \$100,000 today will be more in 2024, and beyond. If you must resolve these matters, then waiting is certainly not a good strategy.

My firm has observed that certain owners use their balconies as “arboretums” with beautiful gardens. I love nature, but if your intent is to create a bird sanctuary for your yoga studio with that \$2 million view of the ocean, no problem. But you need to take appropriate precautions. Make sure the drainage works. Make sure the waterproofing is there. Potted plants are lovely, but they are heavy and they leak water onto the deck. You are literally destroying your own structure (and possibly your neighbor's) with your noble intentions. Garden balconies are beautiful, but if not done right, they will cause structural damage.

Certain owners have converted their balconies into permanent living areas. This is a big “no-no” because the balcony is not designed for permanent living. It is a code violation that exposes that unit owner and the association to potential lawsuits. I've seen this done many times over and it could be simple innocence, but in some situations, owners are in fact renting this space out.

Let's go back to basics: Balconies are your space to “chill.” They're not for AC units or refrigerators or for conducting yoga classes. They are for you to “RELAX,” so let's work together to fix them and use them correctly.

—Dr. Khatri is a Structural Engineer with 40 years of experience in structural design, construction, and project management. Dr. Khatri is Principal of Khatri International Inc. (www.khatrininternational.com) based in Las Vegas, NV, and Arcadia, CA, and works nationally with multi-family properties, residential projects, corporations, institutional clients, government agencies, and property owners.



Figure 7: Potted plants on balcony



Figure 8: Residential rental space on the balcony

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Structural Issues in Nevada Homes

By Dr. Dilip Khatri, Ph.D, SE

Nevada's population is growing and construction is everywhere. I started working in Nevada in 1989 and have been active here as a structural engineer for over 32 years. My observations in this article focus on the issues dealing with wood frame structures specifically for residential buildings: condominiums and homes. My short of list of structural issues pervading the residential market in Nevada are:

1. Termite infestation and dry rot
2. Balcony and stairway deterioration
3. Settlement of foundations from soil collapse and water issues
4. Masonry block walls collapsing from poor and deficient construction and design.

These are the working problems of our residential stock of housing that go ignored for years and then creep up on our ownership to cost hundreds of thousands of dollars, sometimes millions of dollars.

Termites and Balcony Inspection Update

California passed legislation in 2019 initiating a massive inspection of balcony and stairways across the State of California for all community associations. Nevada should do the same. Here are my observations from our inspections on residential balcony and termite issues that follow similar patterns in Nevada.

At the beginning of this year, I told my staff this is the "year of the balcony" and certainly this is true. I have a dedicated group which I affectionately refer to as the "Balcony Brothers" dedicated 100% to balcony inspections, because we have been inundated with work to meet the 2024 deadline on this law. As we go through our inspections, I've observed lots of interesting facts to share with our audience of clients and property management companies which "enlightens and frightens" simultaneously.

Figure 1: Before close of escrow



Figure 2: After close of escrow



Figure 3: Termite and dry rot damage

Perhaps the most surprising facts stem from the hidden damage observed at certain properties. We recently inspected a beautiful condominium that sold for over \$1,500,000.00 and the exterior areas looked pristine [see Figure 1] with no signs of potential damage. Then we opened the areas upon a contractor request and found the hidden damage [see Figure 2].

The damage is substantial and extends beyond the balcony zone into the structural walls and will require significant reconstruction efforts. No doubt the cost of repair will be well beyond the original balcony repair budget and we've only started on one unit, but more will need inspection.

Lesson One: Expect the Unexpected

Nevada and southern California have long-term moisture problems in every building, regardless of zip code. However, my inspections have shown that the closer to the ocean, dry rot and termite infestation increases in the higher humidity. The real culprit is the lack of waterproofing which is endemic throughout this state. For Nevada, the



Figure 4: Dry rot and weakened balcony rails that will fall anytime

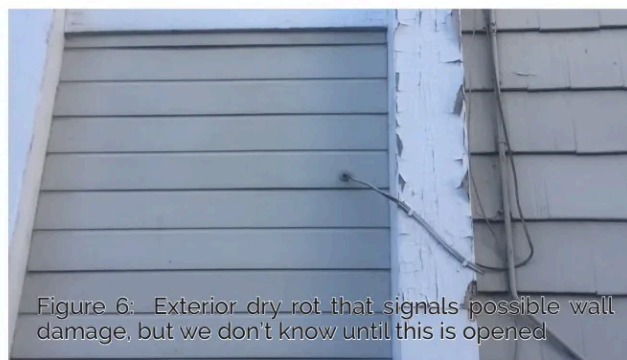


Figure 6: Exterior dry rot that signals possible wall damage, but we don't know until this is opened



Figure 5: Walkway with extensive dry-rot damage.

dry summers and cold winters result in driving termites into the building envelopes with moist temperatures, especially if there is water leakage.

We have also observed balcony areas with clear visible damage of obvious unsafe conditions; a clear danger that is not being addressed by some associations. This could be a potential big problem of liability and culpability for both property management companies and owners. Figures 4, 5, and 6 show the "ugly" that no one wants to face.

Lesson Two: You Can't Hide from Mother Nature

Owners need to face the "ugly" and deal with these issues directly. My job as a consultant and structural engineer is to educate, inform, inspect, and advise. That's the best any consultant can do for their owners. Engineers are your "doctors" and you should listen to your doctor and act accordingly, otherwise the consequences will be dire. Simply deferring maintenance to another day will not make the problem go away. At some point, "another day" arrives.



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Figure 7: Potted plants on balcony



Figure 8: Residential rental space on the balcony

Lesson Three: Costs Never Go Down, They Only Go Up

In my 41 years in this industry, I can say with one hundred percent certainty that life does not get cheaper. Never have I seen construction costs going down. We can argue about the rate of increase with inflation, the Federal Reserve policies, and other financial issues, but costs WILL RISE. So, what might cost \$100,000 today, will be more in 2024 and beyond. If you must resolve these matters, then waiting is certainly not a good strategy.

My firm has observed that certain owners use their balconies as "arboretums" with beautiful gardens. I love nature, but if your intent is to create a bird sanctuary for your yoga studio with that \$2 million view of the ocean, you need to take appropriate precautions. Make sure drainage works. Make sure waterproofing is there. Potted plants are lovely, but they are heavy, and they leak water onto the deck. You are literally destroying your own structure (and possibly your neighbor's) with your noble intentions. Garden balconies are beautiful, but if not done right, they will cause structural damage.

Certain owners have converted their balconies into permanent living areas. This is a big "no-no" because the

“Engineers are your “doctors” and you should listen to your doctor and act accordingly, otherwise the consequences will be dire.”

balcony is not designed for permanent living. It is a code violation that exposes the unit owner and the association to potential lawsuits. I've seen this done repeatedly and it could be simple innocence, but in some situations, owners are in fact renting this space out.

Let's go back to basics: Balconies are your space to “chill.” They're *not* for AC units or refrigerators or for conducting yoga classes. They are for you to relax so let's work together to fix them and use them correctly. 🙌



Dr. Khatri, Ph.D is Principal of Khatri International Inc. based in Las Vegas, NV, and Arcadia, CA

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Subterranean Parking Structural Integrity



By Dilip Khatri, PhD, SE
Khatri International Inc. Structural Engineers

Millennium Tower settlement, Surfside Collapse [i.e., Champlain Towers], Kansai Airport [Japan] sinking, Palm Jumeirah [Dubai man-made islands] and catastrophic structural failures share one common theme: **uneven ground settlement**. The relevance of this is observed in the recent partial collapse of the Iowa Apartment Building and a Manhattan parking structure. Both buildings are 100 years old and had demonstrated cracking in their concrete structures signaling issues of impending failure. **These events have direct impact on condominium structures over subterranean parking in California.**

Many structural failures share one common theme: **uneven ground settlement**. As structural engineers are trained through school, we assume that the “fixed base” of our buildings is FIXED. The effect of settlement on the above ground structure can be dramatic. As a building sinks unevenly, movements and shears are redistributed to stiffer adjacent elements (columns, beams, walls, etc.) which add to their load demand. Like a human being shot in one leg, the other leg is redistributed with additional weight and a person’s center of gravity will become unstable leading to a fall.

Dr. Khatri has researched this topic extensively through the literature and has not found a single paper or research topic that discusses the effect of building settlement on structural capacity on any version of buildings or bridges. There is NOTHING in the structural engineering literature on this topic [as of 10/2023] and it is likely a root cause for many past failures and a pre-existing symptom to predicting future failures.

Consequently, a building will redistribute weight because of stiffness variation from the sinking columns will adversely affect the other columns. Analysis of a simple movement(s) frame confirmed the bending moments increase upwards of

20-35% for a 1-inch deflection and dramatically for 3-4-inches of deflection at a single column line.

Let’s start with a statement found in almost all of our college structural analysis textbooks: “All structures are stable and fixed/pinned at their base, with the foundation never moving.” Figure 1 illustrates a simple 3-story moment frame building with fixed base connections. Points A, B, and C are assumed to be level and never displace vertically or horizontally (small deflection theory). All of our education in structural analysis, design, retrofit, codes, and basic theory is formulated on this critical assumption: the ground never moves, or if it does, the movement is so small to be of no significance.

Realty Check: The ground does move [Figure 2].

Over time, the support to a structure will change due to varying soil conditions, moisture levels, mild earthquakes, and possible landslide conditions [Figure 3]. These factors are not part of our conventional wisdom as structural engineers because we are never taught that this may happen. It’s completely outside of our envelope of expectation. Figure 4 shows an existing parking structure with structural column cracking.

Examining our building codes, structural textbooks, and research efforts for the past 80 years shows that “we” [structural engineers] work from the premise that the building will not move. We establish our design practice using sophisticated analysis methods such as finite element analysis, dynamic analysis, nonlinear analysis, all founded on stable foundations. Certainly for many buildings and bridges, this has proven to be a good working methodology. Iconic structures like the Golden Gate Bridge (90 years of service), the Empire State Building (90+ years of service), and the Taj Mahal (over 400 years) have lasted well beyond their

expectation life-spans and defied collapse through numerous natural events.

But recently there have been structural failures that are baffling investigators and give reason for re-examination of our standard of practice stemming from ground movement. Recent landslide in Rancho Palos Verdes (Southern California) is a prime example of ground movement where no structure can survive [Figure 5]. Many structural engineers would lay the blame on the geotechnical engineers and geologists and claim this is “not our fault”. Not true. Structural engineering is not just the “structure above ground” but includes the foundation and its long-term stability. We should be looking holistically at the entire system, not just “our part” above ground. We should remember that geotechnical engineers and engineering geologists provide information and data on soil conditions with recommendations to structural engineers for our design. They are not design professionals; structural engineers are. Just like architects who perform their scope of design dealing with form, function, aesthetics, lighting, colors, shading, and the ethos of the structure, we have to take responsibility for our expertise and provide cautionary recommendations as necessary during the design phase.

(Continues on page 30)

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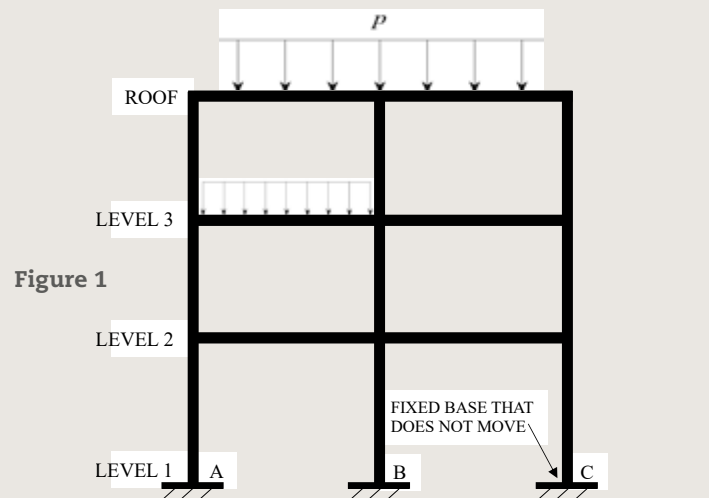


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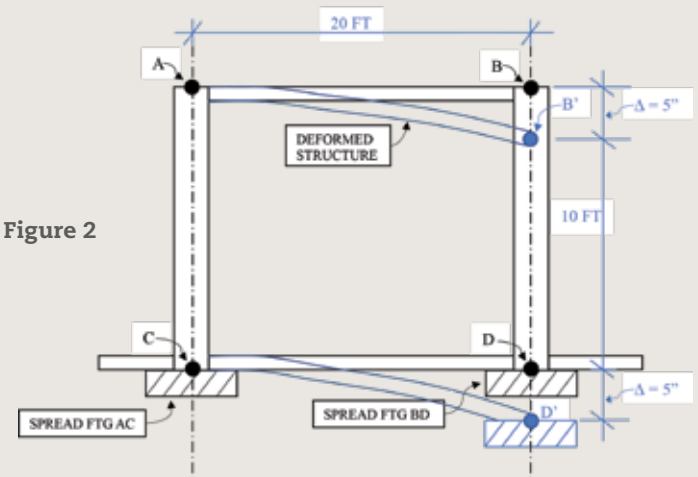


Figure 2

FIGURE 3:

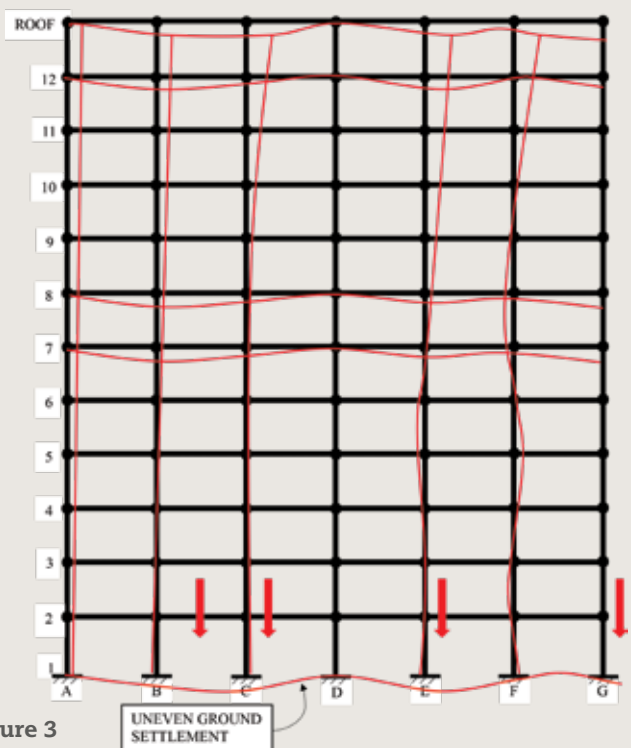


Figure 3

Subterranean Parking Structural Integrity (continued from page 29)

Therefore, Figure 1 from our structural textbooks is not reality, but instead is more like Figure 3. Each base support in two-dimensional space, has three degrees of freedom (DOF) and can displace in two dimensions plus rotate in-plane. The concept of multi-degree of freedom systems is usually part of graduate school structural engineering degree programs, but these principles are still only introduced for the understanding the superstructure, not the foundation movement in a conventional structural analysis.

The vertical loads will shift to the remaining support point as the stiffness degrades at the other reaction point [Figures 2 and 3].

Practical Analysis

Geotechnical reports will give an estimated long-term settlement, often in the range of ½-inch to 1-inch for firm soils, over the life of the structure. This is an estimation based on the soil conditions at the time of completion of construction of the building. Therein lies the basic fallacy: soil conditions can change over time. During design, we assume that the moisture content and bearing capacity will not change over time but they can. For example, seepage from a leaking water main or in-ground swimming pool will certainly affect the soil parameters. Over watering from irrigation will affect the soil capacity. These factors are not included in a soils report because no one is expected to forecast them, but they do occur in reality.

These factors suggest the need for structural monitoring and capacity analysis over time, at least for structures where deterioration leading to failure would have more consequence for the public. We just cannot assume that “everything” will remain static over 50 to 100+ years. Florida has instituted a time line for structural monitoring and recertification of building occupancy on a 10-year schedule. New York City recently experienced sudden collapse of a Manhattan parking structure and has instituted a similar law. California (and all other states) should be considering similar measures, like California’s Balcony Law (Senate Bill 326) requiring structural examination every 6 to 9 years on wood balconies.

Portal Frame Analysis

For simplicity, this paper examines a single bay portal frame [Figure 6]. A portal frame is a snapshot of a larger multi-story moment frame system and illustrates these concepts with a basic analysis of one support that sinks. To model this with a portal frame allows an engineer to analytically determine quantified reaction results when one side of the frame is destabilized. Degrading soil stiffness results in shifting load and moments in the superstructure. Let’s take

this principle and apply it to basic building frame system as in Figure 6.

The dimensions are taken from the plans of a recently collapsed building and are for a one-story version of the garage structure. As Point D deflects downward, the deformed structure above shows the elastic curve and movement of Point B, with assumptions that Points A and C are stable, for simplicity. In reality, we do not know if Point C is stable, but for this analysis we will assume it is.

If we take this concept and extend it to a multi-story, multi-bay structure (**Figure 3**), the analysis becomes more complex because of the variability in the ground movement.

Case Study of Single Bay Moment Frame

The moment redistribution and shifting of the reaction load is evident with a modest 1.28 inch deflection. This affects and magnifies the moment values higher to Point A [N1], as Point D [N3] displaces further and the moment at Joint B [N2] is increased. In principle, the structural theory is proven



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here that ground displacement will affect the moments, shears, and axial loads in the frame structure above. Similar conclusions will apply to other building types (i.e., shear wall structures, braced frames, concrete, steel, and wood frame, etc.).

Examples of Structural Damage

From the textbook to the real world, we are now faced with physical evidence of structural cracking in columns and beams that may threaten the superstructure.

Figure 7 is such a case for a three-story complex with subterranean parking that has extensive cracking in column locations and is currently under citation.

Conclusions

The structural theory of stable foundations ought to be questioned based on recent and historical examples of settlement that will affect the structural distribution of loads. Structural engineers need to recognize these phenomena as potentially damaging, assess root causation, and address these concepts in standards, guidelines, and code provisions.

Our profession should take a proactive stance on this issue and call for research focused on this topic to upgrade and address our codes and standards. Our industry has an unfortunate “slow response” time to institute code changes but we, as practicing structural engineers, should be examining our design practice based on practical analysis, not standards formulated by researchers and theoreticians.

Property managers, owners, and the real estate industry must be aware of these structural risks and adhere to the recommendations of their engineers to prevent further collapses from occurring. ⬆

DISCLAIMER: Dr. Khatri is not part of an investigation team or research group funded by any entity. The examples cited here are for discussion only and do not suggest that these are established/proven conclusions for open cases. Dr. Khatri is an experienced structural engineer with over 40 years of academic and professional education and is not purporting to represent any structural opinions on open failure investigations, their designers, or causes of failure.



Figure 4



Figure 7

Figure 5

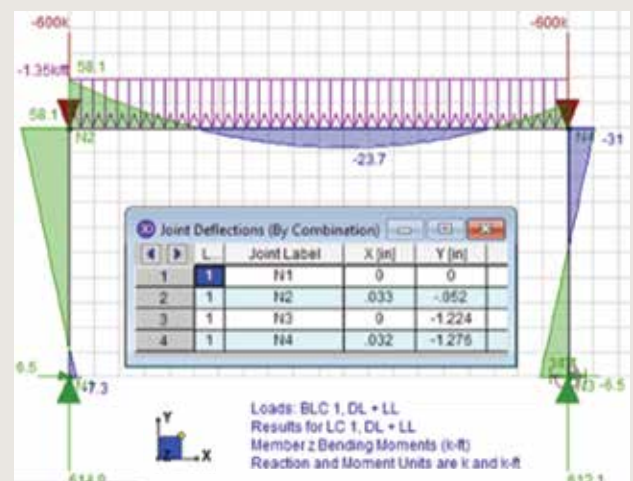


Figure 6

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FLOOD, LIQUEFACTION, AND LANDSLIDE RISK TO ORANGE COUNTY

By Dr. Dilip Khatri, PhD, SE

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ABSTRACT

Traffic is not the only misery of living in the paradise of Orange County (OC). OC is situated along the southern California coastline and has the dubious distinction of the *"highest natural hazard risk"* in the United States (along with Los Angeles County), as shown in the Federal Emergency Management Agency (FEMA) Risk Rating Map (Figure 1). This risk rating compares to all other counties in the United States and puts OC in one of the highest risk zones due to multiple factors: seismic risk due to several fault lines, flood risk, liquefaction potential, and landslide potential.

Each of these environmental risks is compounded by the congested living conditions that create a literal maze of blocked traffic points that will snarl and engulf the OC should any one of these events occur.

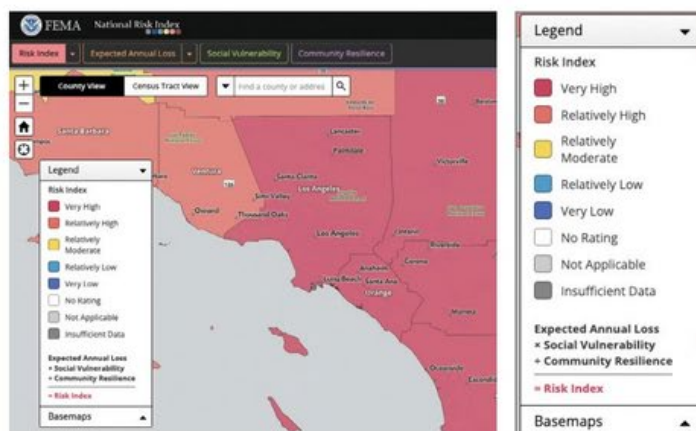


FIGURE 1: FEMA RISK MAP

1.0 FLOOD and LIQUEFACTION RISK

Orange County (OC) is situated in a beautiful landscape along the California coastline. OC is in a topographically flat area that has hills along the eastern side and a rough coastline along the western edge. The ocean is on one side, and dry hills are along the hillside. This leads to a flat zone that is a FEMA-designated flood zone (Figure 2). Flooding occurs when the soil can't absorb any moisture and is fully saturated, and the flood control system (e.g., storm drains, culverts, grate basins) is overwhelmed, then the water has literally "no place to go" and will pond/flood the area.

Normally, we think of places in Texas, Louisiana, Florida, and other areas as synonymous with flooding, but OC is highly susceptible to this natural force and has the additional Liquefaction Risk potential in the event of an earthquake.

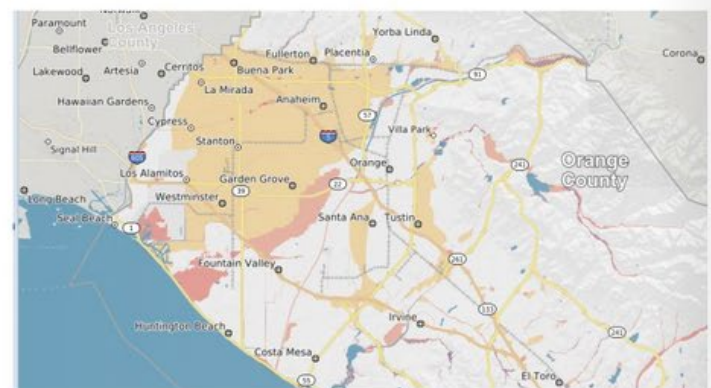


FIGURE 2: OC FLOOD ZONE

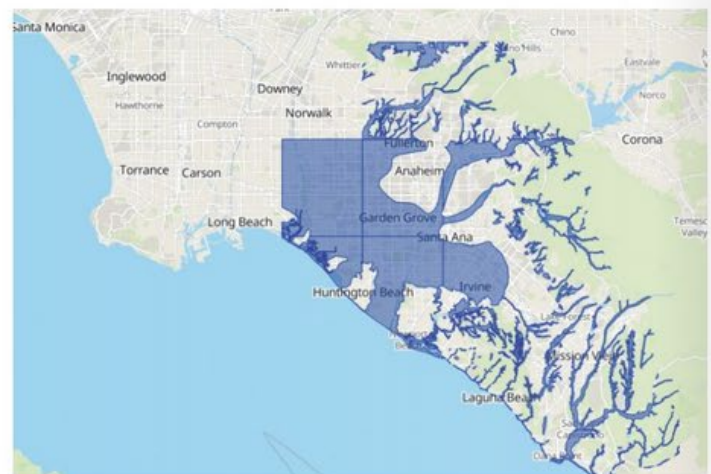


FIGURE 3: OC LIQUEFACTION ZONE

Figure 3 shows the Liquefaction Map of OC, and it is literally a template overlay the flood zone map. Liquefaction is the destabilizing of the underlying soil during an earthquake that leads to building collapse, street subsidence, and vehicles engulfed in sinkholes. OC has the distinguishing characteristics of three strikes: earthquake, flooding, and liquefaction.

Liquefaction effects are depicted in Figures 4 and 5.

FIGURE 4: *Liquefaction-Earthquake settlement damage in Christchurch, New Zealand.*



FIGURE 5: *Liquefaction from the 1906 San Francisco Earthquake.*



2.0 LANDSLIDE RISK

OC is no stranger to landslides. Recent events along the coastline demonstrate the immediate threat unstable soils pose to Amtrak and existing properties. Figures 6 and 7 show the L.A. Times article on the landslide near Casa Romantica. Both the west coast of OC and the east side are landslide-prone because of the existing geology and previous development practices before 1972 that predate the 1971 Sylmar Earthquake.

Pre-1972, the OC Grading provisions (i.e., Uniform Building Code pre-1972) were not stringent in checking for slope stability and soil compaction and creating a minimum 2:1 slope requirement. This era is referred to (among civil engineers) as the “wild-west period” of development and slope grading, which has left thousands of homes in precarious situations because these properties are now approaching 60 years of service. Further complicating this situation is the lack of property insurance coverage that specifically excludes “earth movement” claims subject to reservations (unless the event is triggered by a covered loss).

FIGURE 6: L.A. Times article on the landslide affecting the Casa Romantica restaurant and blocking the Amtrak line.



FIGURE 7: The main rail transportation link from San Diego to Los Angeles is blocked due to the landslide near Casa Romantica.

There are different categories of landslides, as depicted in Figure 8. All of these categories exist in OC. Landslide risk is a topic that no one wants to talk about because it's literally uninsurable and could devastate an entire subdivision in a few seconds. Yet, it is ever present in OC and primarily along the beach/coastline and the hillside areas. The beach has unstable soils with slide potential, which was never resolved in prior grading designs because many of these properties predate 1972. The ones built afterward may/should have updated foundation designs with adequate underpinning but are subject to the

surrounding soils and upstream flows that can undermine their foundations. Everyone loves that beach view, but we must pay attention to the supporting structure and underlying soils to affirm safety and long-term sustainability.

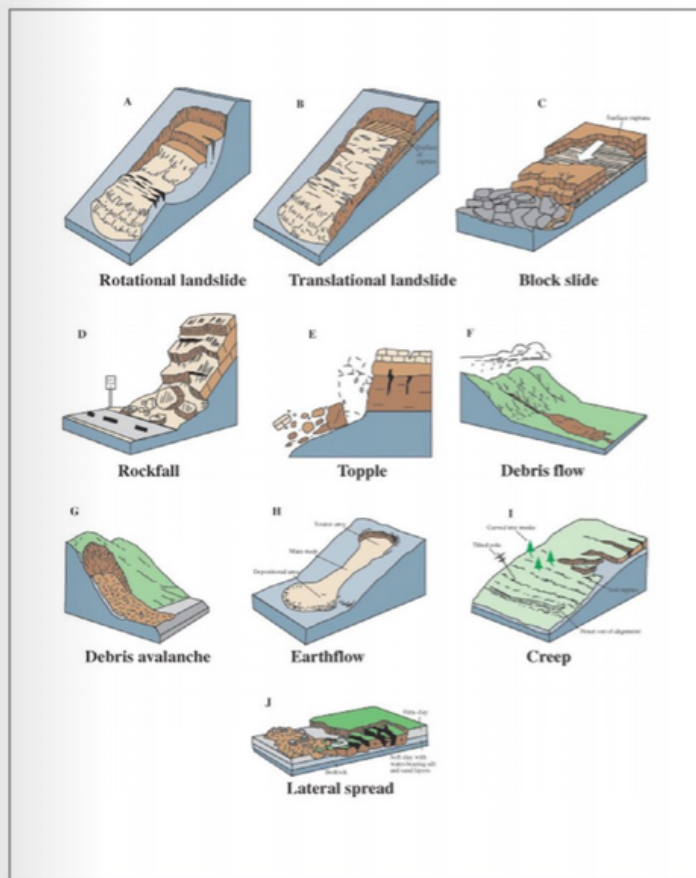


FIGURE 9: Types of Landslides

Hillside zones have a double “whammy”: Landslide potential from the soils constructed underneath their homes AND landslide potential from unstable debris upstream due to recent fires and/or soil erosion. Both are deadly and can impact their properties. Property owners need to be aware of these risks and take mitigation measures to stabilize their foundations, hillsides, and drainage situation.

3.0 RISK MITIGATION STRATEGIES

Homeowner insurance is rapidly becoming expensive, severely limited, and restrictive in coverage. Just this month alone, two major insurance carriers have stopped writing new policies in California: Allstate and State Farm. The remaining carriers will charge a premium and their limitations/exclusions will certainly exclude landslide/earth movement claims. So, what do property owners do?



Dr. Khatri is a Structural Engineer with 40 years of experience in structural design, construction, and project management. He has worked with HOA clients for 30 years and is an active member of CAI in seven chapters. Dr. Khatri completed his PhD from the University of Southern California in earthquake/structural engineering, his master's in structural engineering from California Institute of Technology, his bachelor's degree in civil engineering from California State University, and his M.B.A. from U.S.C. He has published, co-authored, and presented over 100 papers, technical conferences, online seminars, written two textbooks on structural engineering, and is writer/director/producer of “Aspire to the Sky: The Wilshire Grand Story,” a documentary film about the tallest building in Los Angeles currently on Amazon and other online platforms. Dr. Khatri is the Principal of Khatri International Inc. (www.khatrininternational.com) based in Las Vegas, NV, and Arcadia, CA, and works nationally with HOA clients.



THIS RISK RATING COMPARES TO ALL OTHER COUNTIES IN THE UNITED STATES AND PUTS OC IN ONE OF THE HIGHEST RISK ZONES DUE TO MULTIPLE FACTORS: SEISMIC RISK DUE TO SEVERAL FAULT LINES, FLOOD RISK, LIQUEFACTION POTENTIAL, AND LANDSLIDE POTENTIAL.

First is to take a good, hard look at your property location, risk potential, and existing foundation system. Being at the top of the hill with that \$3 million view may actually be more expensive than \$3 million! Risk control involves value engineering the existing conditions to prepare a disaster mitigation plan:

- 3.1 Evaluate the foundation system, whether it is deep piles or shallow foundations.
- 3.2 Evaluate the soils and geology to determine if the bedding plans have slide potential; is there a slope stability issue?
- 3.3 Evaluate the civil engineer drainage situation.
- 3.4 Evaluate the structure of the house/building for seismic risk.

Have a Structural Engineer prepare a risk assessment and then perform a Probable Maximum Loss study (PML). Banks and insurance companies have their PML studies done before they decide to fund your loan or insure you, so why shouldn't you do the same? A PML is the estimated loss value/construction value. Any PML over 40% is likely un-insurable. PML between 20–40% is not so good either. There are mitigation measures to reduce your risk potential (PML) and bring it below 20%. You will likely have to spend funds to reduce your risk potential, and don't expect any “golden stars” from the insurance carrier, because they may or not give you credit for mitigation measures. You have to take the proactive stance to safeguard your property or risk living on the “edge,” literally.

It's better to live aware than be unaware. 🏠

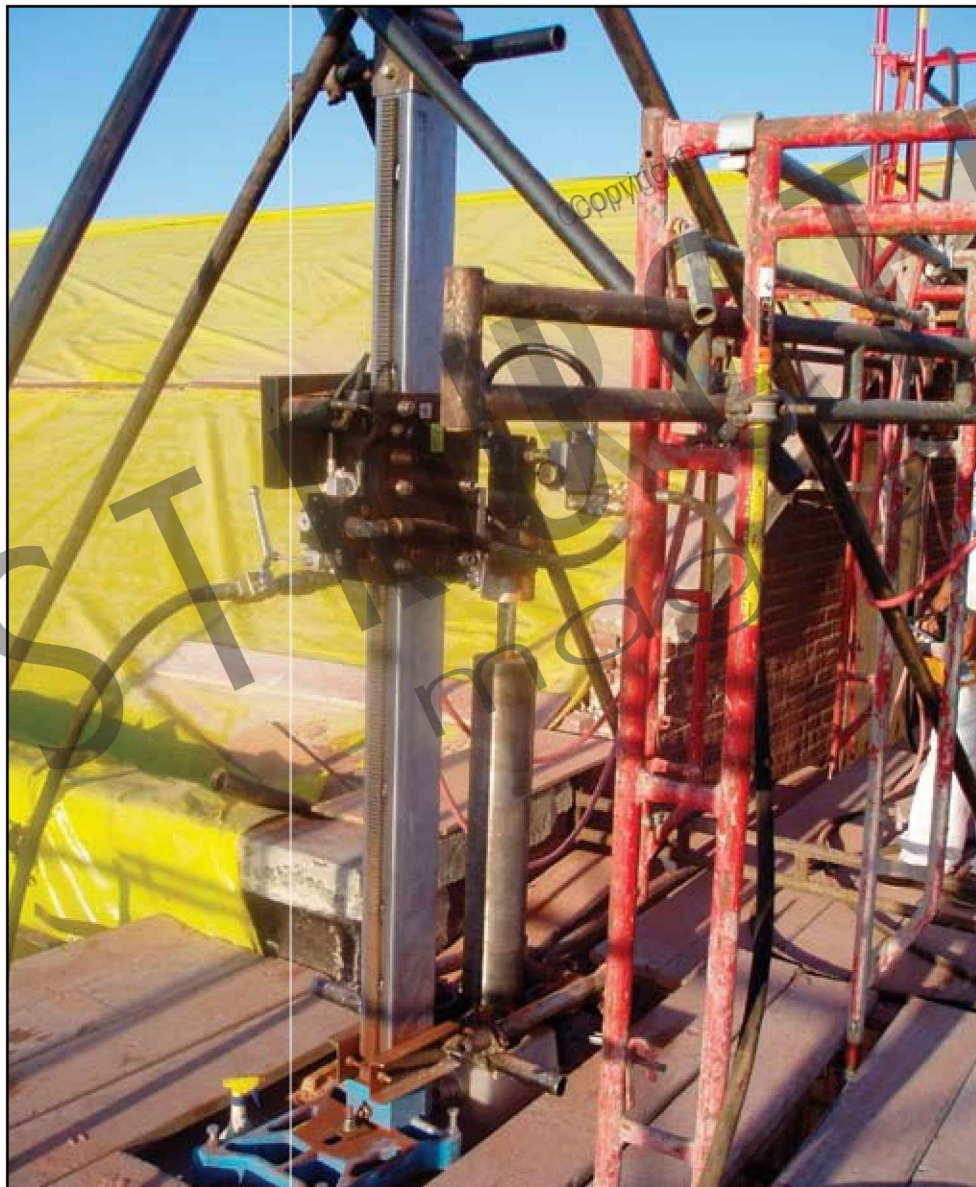
Structure

Magazine Articles

SEISMIC RETROFIT OF THE AFRICAN AMERICAN UNITY CENTER CHURCH

By Dilip Khatri, Ph.D., S.E.

A unique approach to seismic retrofit has been completed in the City of Los Angeles. A 100-year-old structure, comprised of unreinforced masonry elements, has been seismically retrofit using a system of internal moment frame beam-column design to facilitate the upgrade of the structure.



Coring Operation in Brick Wall. Courtesy of Cintec North America.

The building was constructed in 1901 and utilized as an assembly facility for over 80 years. In 1994, the Northridge Earthquake almost completely destroyed much of the unreinforced masonry elements and collapsed a portion of the roof.

The key issues associated with designing a retrofit for this project included:

- 1) Soil Liquefaction: The site is in a designated California Hazard Zone with known soil liquefaction.
- 2) Historic Structure: The building is listed on the National Historic Register.

- 3) City of Los Angeles Building Requirements: Any retrofit "system would have to comply with the strict requirements of the LADBS.

The ability to obtain approvals from the City of Los Angeles proved to be the most formidable issue because, the City required a thorough test program to establish the design value of the retrofit system.

After 7 years of multiple attempts to procure building permits, the owner decided to contract with Khatri International and Cintec America to prepare a unique approach to the seismic retrofit.

Cintec America and Khatri International developed the first internal moment resisting frame system to be installed "inside" the unreinforced masonry structure. Moment frames are a standard lateral load resisting system commonly utilized in a variety of multi-story structures. The concept of the moment frame structure embedded into an unreinforced masonry (URM) shear wall building sounds farfetched, but was developed and constructed at the African American Unity Center. The concept involves the following stages:

- 1) Core drilling vertically to establish 6-inch diameter holes for placement of structural tubes.
- 2) Placement of 4x4x1/2 Structural Tubes inside the vertical core holes.
- 3) Core drilling horizontal 6-inch holes to place horizontal 4x4x1/4 beam tubes.
- 4) Seismic moment frame connections are welded at the horizontal beam and vertical column connections. These are proprietary moment frame connections designed by SidePlate.
- 5) Diagonal reinforcement is placed in a similar fashion. The 2-inch diameter holes are drilled, reinforcement is inserted, and then the holes are grout filled with low pressure.

The risks of performing this type of retrofit are apparent and required the use of highly specialized subcontractors to perform the core drilling. Pointe Construction was selected to do this delicate task.

continued on next page

This project was funded by a grant from FEMA and the Brotherhood Crusade. The project Architects are R.F. McCann & Company and JGM Architects. The project structural engineer and contractor is Khatri International, Inc.



Interior Showing Roof Truss and Prior Retrofit Posts and Wall Anchors.

After completing a typical vertical core, the HSS 4x4x1/2 was lowered using a crane, and then grouted with a proprietary grout to secure it within the core. The moment frame connections were then welded to the horizontal beams using the SidePlate connection system.

Before construction could commence, design issues had to be resolved through the City of Los Angeles Department of Building and Safety. Since a project of this kind had never been completed before, there were many questions and technical issues that required explanation, and a protocol developed to satisfy the City of Los Angeles. The project was plan checked and approved in four months. The City Engineers required the following items:

- (a) Three-dimensional finite element model with dynamic analysis.
- (b) Steel moment frame connections that satisfy the highest standards prescribed by FEMA and the City of Los Angeles.
- (c) Lateral drift analysis to demonstrate that the interior moment frame elements would not cause excessive cracking of the URM walls.
- (d) Demand-Capacity analysis of the walls to show they were enhanced by inserting the moment frame.
- (e) Piles to address the liquefaction issues.

Each of these items was addressed. The City review enhanced the design process by requiring a superior product at the end of the plan check process.

In order to prove the system to the City of Los Angeles, the finite element model of the church was created using the RISA-3D program. Two finite element models were prepared: (a) Unreinforced/as-built FEM, and (b) Retrofit FEM. The idea was to compare FEM (a) with (b) and show that structure's performance was enhanced with internal frame elements. To further complicate the issues, an increased base acceleration was required both by the City of LA and as a result of local liquefaction conditions. The design acceleration of 0.11g is the specified minimum value from the City of Los Angeles Division 88 requirements. (For those non-California residents, Division 88 is the section of the City of LA Building Code that covers URM buildings in this class.) But since this site is in a liquefaction zone, the design acceleration was 0.30g as provided by Earth Systems Southwest (ESSW), the project's Geotechnical Engineer. An increase to 0.30g creates three times the seismic loads as compared to a typical Division 88 requirement. This leads to a higher demand and consequently higher capacity seismic retrofit structure.

Another hurdle was the requirement to utilize a City of LA approved moment frame connection. Recall that before 1994, moment frame connections were standard design elements from the American Institute of Steel Construction (AISC) and were designed following established code procedures learned in our academic training. After the Northridge Earthquake, the City of LA required all steel moment frame structures to comply with the latest FEMA requirements, and also be tested to City of LA standards for strength and post-cracking ductility. This became a supplementary requirement over and above the Division 88 standards. The bottom line, all of the steel moment frame connections were required to satisfy FEMA and the City of LA requirements.

To meet all of these conditions, Khatri International, Inc. worked with SidePlate to utilize their proprietary moment frame connection for tube-tube design. This eliminated the need for additional testing, and cut the project schedule down to two months for plan approval. The overall plan check process took 4 months from submittal to approval.

Khatri International, Inc. engaged Earth Systems Southwest to perform the geotechnical testing, and then created a detailed pile design system to support the structure. The pile system supports the entire building. The internal moment frames are connected to the pile elements via a grade beam structure.

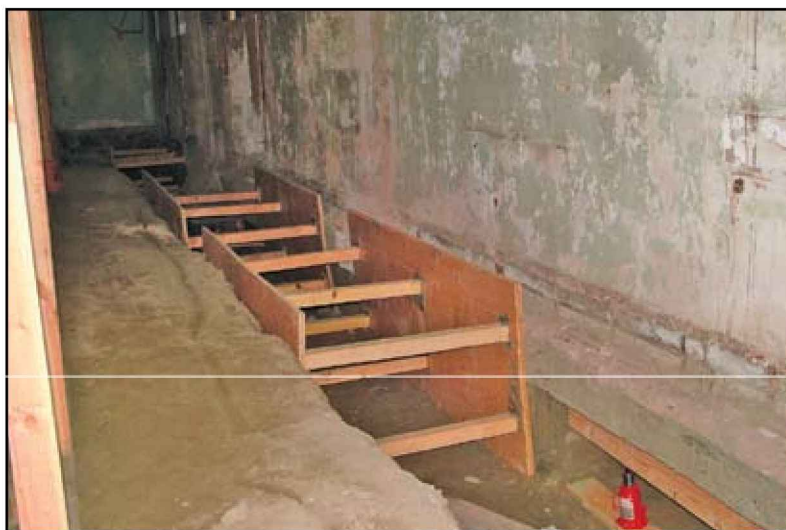
Structure drift limits are set at 0.5% of height (i.e., 0.005h) and are checked in the FEM using the 0.30g design acceleration. All steel is grade 50, HSS 4x4x1/2 for vertical columns, and HSS 4x4x1/4 for horizontal beams. The 12-inch diameter pipe piles are concrete encased 8-inch diameter pipe using a proprietary grout compound for exterior protection of the pipe.

In addition to the internal moment frame elements, diagonal steel bracing with internal reinforcement is utilized on all wall elevations. The 2-inch diameter holes were drilled at diagonal angles (approximately 45 degrees), grade 70 stainless steel rebar was placed, and then the holes were filled with grout. The diagonal reinforcement created an internal shear resisting element for the URM shear walls.

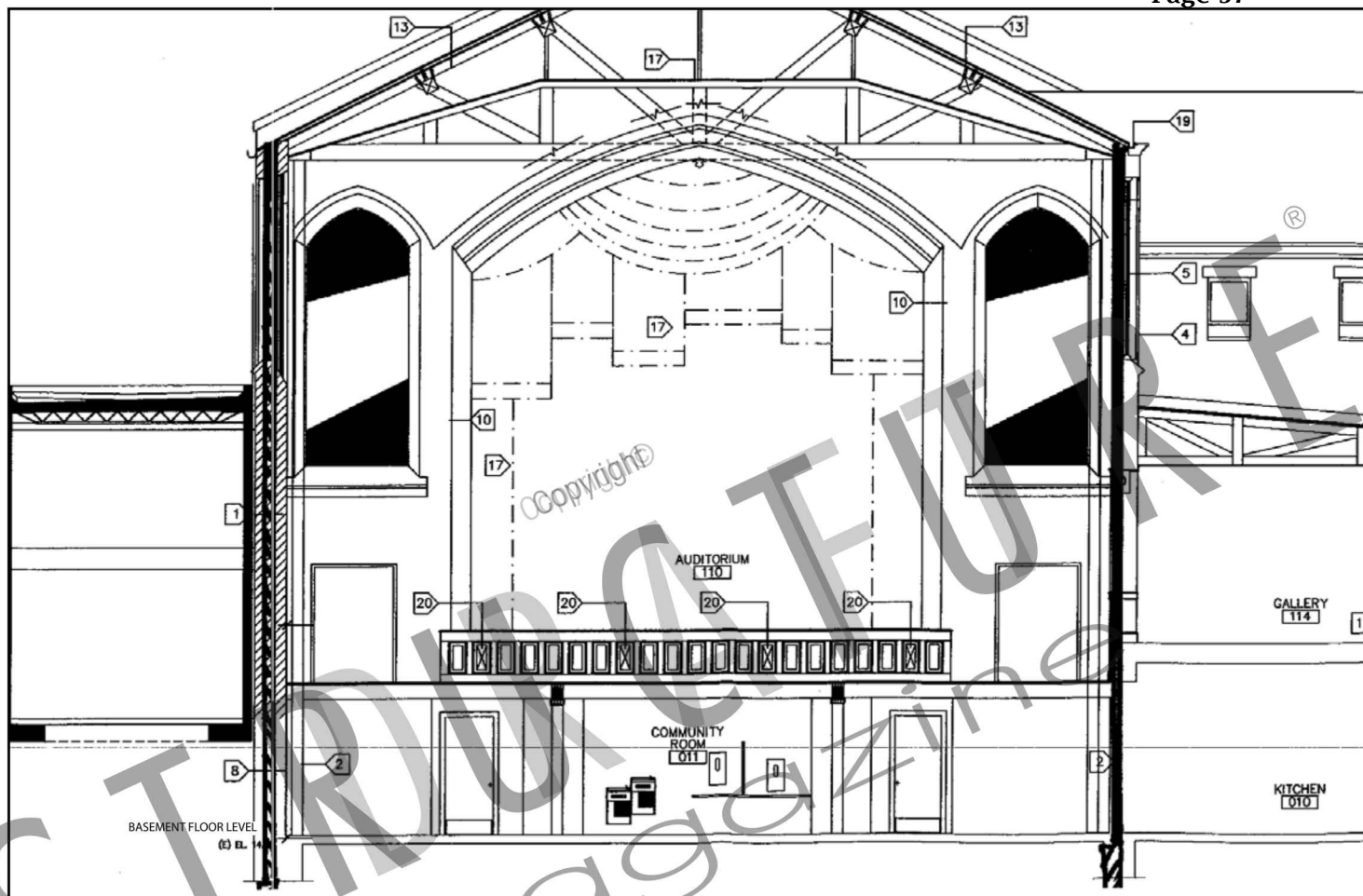
The architectural advantages of the Internal Moment frame system are:

- A) No visible appearance of the steel elements.
- B) All seismic moment frame connections are inside the unreinforced masonry wall, and then interconnected to a new grade beam system below the foundation.

In addition to the seismic moment frame, a new grade beam was installed below the existing foundation and connected a system of 40-foot deep vertical pipe piles.



Formwork for New Foundation.



Schematic Cross Section of Church Sanctuary.

The project construction commenced in January, 2005, and proceeded with the core drilling of the exterior masonry walls. A specialized crane, installed to assist with the vertical core drilling, was required to have a lifting capacity of 6,000 pounds with a total reach of 140 feet. This allowed the crane to pick up core material from the furthest corner of the building. It was also necessary to place the vertical steel tubes using the crane.

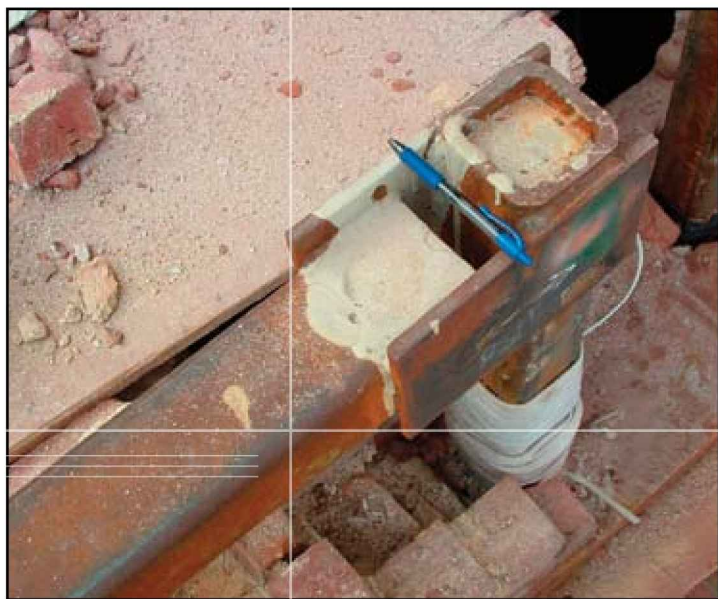
The horizontal drilling was by far the most challenging aspect of this project. The potential of vertical sections of masonry collapsing during

the horizontal core drill were addressed by the author and project team. To alleviate this potential, an innovative shoring mechanism was installed using horizontal plates with vertical tubes. This temporary shoring redistributed the vertical loads away from the exposed section of the core and allowed for the horizontal drilling to proceed unabated. No problems were encountered, and the horizontal drilling proceeded without incident.

Installation of the pipe piles in the basement had many complicated facets of their own. A new grade beam was required to resist high seismic loads, and the beam had to connect to the vertical pipe piles. The 40-foot deep piles consist of an 8-inch steel pipe ($\frac{3}{8}$ -inch thick, Grade 50). The entire pipe was encased within a 12-inch diameter concrete core. Placing the pipes posed several construction difficulties that included a height clearance in the basement area, machinery access, pipe assembly problems, and difficult work/site conditions. A specialized drill rig was utilized to drill the vertical pile holes, and pipes had to be connected in 8-foot segments to work within the access requirements. ■

Khatri International Inc. has prepared a DVD presentation of approximately 40 minutes that shows the highlights of this project, and would be pleased to provide this to interested parties (dkhatri@aol.com, www.khatrinternational.com).

Dilip Khatri, Ph.D., S.E., is the principal of Khatri International Inc. and Khatri Construction Company located in Pasadena, California. He has served as an expert witness for several construction-law firms and as an insurance/forensic investigator of structural failures.



Rigid Moment Resisting Joint. Courtesy of SidePlate Systems, Inc.

The New Fire Safe Building Design

By Dilip Khatri, Ph.D., S.E.,
and Gina Keil Cruz, P.E.

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As we are all aware, the threat of fire to our life safety in buildings is all too common. The United States has a particular concern for this type of threat because of its large proportion of wood framed facilities. This article presents a reasonable alternative plan to create a fire safe building design, within an affordable budget that works for builders. A proposed fire safe building is introduced for potential long term application in the development of new residential and commercial buildings.

Creating a Fire Protective Building Envelope

Wood frame Type V construction has been the focus of our construction market since the end of World War II, and has remained the cost effective solution for the typical home builder. The unfortunate reality is that wood frame houses are susceptible to fire damage, loss, and pose a significant life safety threat to its occupants. California residents know this fact all too well, given the large exposure to wild fire threats across the state.

The key parameter in developing a fire safe building design is to utilize materials that are fire resistant. Concrete and masonry have the best fire rating performance with a minimum 4-hour protection rating. Steel is subject to melting and phase change at 800°F and can easily warp and deform, resulting in structural damage to a building. Wood collapses under heavy fire exposure. The challenge is to create a cost effective fire safe building envelope that can withstand the effects of temperature, heat, fire, and long term exposure to natural elements.

A building envelope utilizing perimeter masonry shear walls creates a 4-hour resistance to an exterior fire event. Masonry is commonly used in fire stations and is a long proven, accepted fire wall ma-

Exterior elevation with reinforced masonry shear wall system.

terial. Utilizing reinforced, fully grouted masonry further adds to the seismic resistance of the shear wall system.

The horizontal diaphragms are designed using precast concrete (such as Spancrete) panels. Spancrete is a proprietary rigid diaphragm system developed by the Spancrete corporation and available nationally. It is approved by the International Code Council Evaluation Service (ICC-ER # 2151).

The roof is designed with prefabricated metal/steel truss system, which is further fire-proofed using an ICC approved fire proof material. Roof sheathing is conventional wood plywood, but this is covered with a Class A roof tile to insulate the plywood from fire exposure.

Wood walls are utilized on the interior non-structural portions as partition elements. No structural loads are carried by any of the wood walls, so these elements are inside of the 4-hour fire protective envelope.

Structural System

A building envelope is created that provides a rigid diaphragm with rigid masonry shear walls. The structure is a boxed structure with stiff walls and

overall structural period less than 0.5 seconds. Reinforced masonry shear walls deliver a "minimum" in plane shear value of 50 psi, which equates to $50\text{psi} \times 7.63\text{ inches} \times 12\text{ inches} = 4,578\text{#/foot}$ for an 8-inch block wall. With reinforced steel that complies with IBC 2006 criterion for high seismic zones, this may be increased to 75 psi maximum:

For,

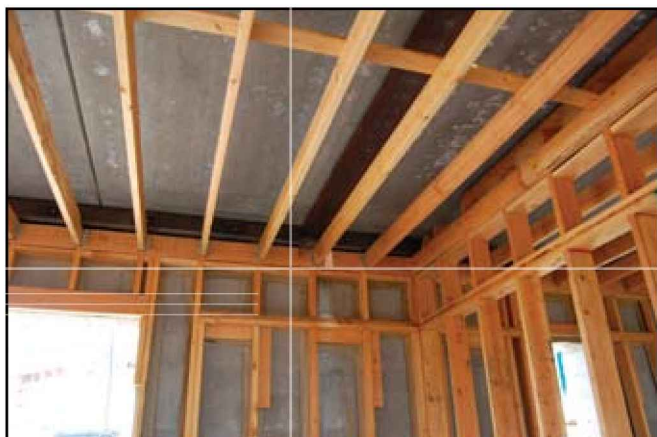
8-inch block: $V_{\text{in-plane}} = 75\text{psi} \times 7.63 \times 12 = 6,867\text{#/foot} = 6.8\text{ Kips/foot}$

12-inch block: $V_{\text{in-plane}} = 75\text{psi} \times 11.63 \times 12 = 10,467\text{#/foot} = 10.5\text{ Kips/foot}$

16-inch block: $V_{\text{in-plane}} = 75\text{psi} \times 15.63 \times 12 = 14,067\text{#/foot} = 14\text{ Kips/foot}$

With these values for in plane shear capacity, no wood structural shear wall can compare or provide comparable strengths.

The shear wall configuration can accommodate a variety of architectural plans, and provides greater flexibility to the designer for more elaborate designs. For example, the architect is not constrained because of limited shear wall height-length ratios and doesn't have to provide hold downs, connection hardware, or diaphragm connectors. Openings can be designed to fit within the masonry allowable values, and because the loads are generally "low" (i.e., less than



Spancrete with steel beam system.



Second floor spancrete diaphragm.



Roof Truss Diaphragm connection.



Interior non-structural wall connections.



Exterior stucco application.

3,000#/foot of shear) for residential structures, the masonry shear wall concept is an excellent choice.

The precast panels provide a rigid diaphragm in combination with the lightweight concrete decking (usually 2 to 4 inches thick). Horizontal reinforcement ties the diaphragm to the perimeter masonry walls. The value of the precast panel diaphragm lies in both its cost and simplicity. Precast panels have been utilized for parking structures for decades, but have always had application for residential and commercial structures. It is common to have 20- to 30-foot span lengths for precast panels, and economical to have 40-foot spans. The panels are precast-prestressed and delivered to the jobsite ready for installation via an onsite crane.

The foundation system utilizes the precast floor panels for the 1st floor and spans from one end of the building to the other. The perimeter foundation support is a continuous grade beam resting on piles. No slab on grade system is utilized which eliminates onsite grading, over-excavation, recompaction, and dirt import/export. The piles are drilled, with cast in place steel W-shapes that further reduce the onsite cost of reinforcement. The final pile design does not incorporate any conventional reinforcement and connects to the grade beam using bolted connections.

It is also possible to utilize a continuous footing system instead of a pile and grade beam, because not all soil conditions require piles. For a continuous footing system, the precast panels rest on the foundation stem wall, just like a regular slab on grade. The difference in this system is that there is a sub floor system over a non-graded, non pad certified fill/cut material. The site development costs are significantly reduced by eliminating the onsite compaction/grading and soil work.

The basic structural advantages include:

- 1) The precast panels eliminate the need for interior structural shear walls, columns, and structural bearing elements which further reduce the overall foundation costs.
- 2) The precast panels create a solid (8- to 12-inch thick) fire barrier between floor-to-floor areas. This functions for fire resistance, but also creates suitable separation for noise abatement, mold/

moisture resistance, termite infestation, and structural/earthquake resistance.

- 3) The rigid diaphragm provides very high in plane shear capacities (2 to 3k/foot) when compared to conventional wood frame diaphragms (0.5 to 0.8 k/foot max).
- 4) There is no flexure/vibration problem in the final floor construction. This is markedly different from wood-frame residential floors that "flex" under normal walking loads.

The only real disadvantage: The precast panels must be precast to precise dimensions that fit with their final field position. If the precast panels do not fit within established tolerances (+/- 2 inches max), then the panels will have to be field cut. This is not impossible, but requires additional field time with impact to crane costs.

Cost and Feasibility

A typical wood frame residential house in California will cost between \$90 – \$500+/square foot, depending on the quality, location, and type of floor plan (*Table 1*).

The structure cost in *Table 1* refers to all structural components, foundation, shear walls, diaphragms, roof trusses, etc... excluding onsite grading and offsite costs. Structure cost is approximate and inclusive of all the materials, labor, transportation and field assembly charges to put the basic building together. The other aspects of the nonstructural and interior elements are everything outside of the basic structure. In simple terms: The difference between the final building cost and the structure cost represents all of the non-structural elements and interiors.

	Finished BLDG*	Structure Cost
Low-cost Affordable Housing:	\$90 - \$120/sq. ft.	\$80/sq. ft.
Medium Cost:	\$120 - \$200/sq. ft.	\$110/sq. ft.
High-end Custom:	\$200 - \$500+/sq. ft	\$120-\$200/sq. ft
*Finished BLDG = Structure Cost + Nonstructural/Interior Cost		

Table 1.

The interesting point of *Table 1* is that the structural system of wood frame Type V construction is nearly the same across the board for all quality level buildings. It stands to reason that if a customer is paying for a premium high end custom home product, shouldn't he/she be entitled to an equivalent system that ensures against basic property loss risk? Most would agree, but the market has never reflected this fact. A \$20,000,000 custom home in Beverly Hills for a movie producer will still use the same wood frame shear wall system with hold downs, wood diaphragms, and conventional foundations as for a community housing project in South Central L.A. The main differences are the finishes.

With the spancrete-masonry fire safe building design, the approximate cost parameters are shown in *Table 2*.

These costs will vary depending on location, labor, and material availability. The point of this discussion is that the final construction cost will be less than the conventional wood frame market with a far superior quality product.

Structural Element	Cost/sq. of bldg
Spancrete Floors	\$20/sq. ft.
Masonry Shear Walls	\$30/sq. ft.
Roof Truss	\$20/sq. ft.
Grade Beam+ Piles	\$20/sq. ft.
Total Structure Cost	\$90/sq. ft

Table 2.

Construction and Application

The photographs printed with this article are of a 6,100 square foot custom residence that is currently being completed in the County of Monterey, California. The structure cost for this building was higher than the estimated \$90/sq. ft. for the following reasons:

- The steel cost rose from \$0.42/# to \$0.75/# during 6 months of the construction phase.
- The design of this building had a primary steel beam in the center of the floor span that split the floor diaphragm into two 20-foot spans. Had this been designed with one 40-foot precast panel span, this steel beam and associated columns would have been eliminated. The cost of this beam was \$90,000. By subtracting this single item, costs would have been well below the normal range for a precast panel building.

The final construction cost for this building are shown in *Table 3*.



6,100 Sq. Ft. Custom Residence in Monterey, California near completion.

The appraised value of this building is \$3,100,000. The owner was very pleased with the final product quality and he now owns the only fire-safe residential building in Monterey County.■

Structure Cost	\$140/sq. ft.	\$854,000
BLDG Cost	\$290/sq. ft.	\$1,770,000

Table 3.

Dilip Khatri, Ph.D., S.E., is the Principal of Khatri International Inc. and Khatri Construction Company located in Pasadena, California. He has served as an expert witness for several construction-law firms and as an insurance/forensic investigator of structural failures. Dilip may be reached at dkhatri@aol.com.

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October 2012 Bridges



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Ambassador Bridge Redecking Fosters Growth between Nations

By Michael Borzok, P.E.

As the single busiest land border crossing in North America, owners of the Ambassador Bridge and the Michigan Department of Transportation needed to improve access from I-75 to enable traffic to flow more freely between Detroit and Windsor, Ontario. To do so, they would need to add new ramps to provide direct access from I-75 to the bridge. In order to receive federal funding, a complete structural assessment of the entire structure was required.

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Collaboration and Innovation Lead to 3rd Service Life for an Iconic Iron Bridge

By Rich Johnson, P.E. and Steve Olson, Ph.D., P.E.

Constructed in 1877, years before the automobile age and the mass production of steel, this iron bridge enabled horses, wagons, buggies and pedestrians to cross the Sauk River. Read how this iconic iron bridge has been relocated to its third location and has come full circle, once again carrying equestrian and pedestrian traffic.

Erratum

A photo credit was inadvertently missing for the cover photo on the January 2012 issue of *STRUCTURE* magazine. The photo was taken by David Lamb Photography (www.davidlambphotography.com). The author of the article apologizes for this omission.

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ON THE COVER

The Ambassador Bridge is critical to trade and tourism between the United States and Canada. It is estimated that 150,000 jobs in the region and \$13 billion in annual production are reliant on the crossing. As bridge traffic is expected to increase in the coming years, it is important for the region's economy that the bridge continue to provide for safe and unobstructed traffic flow between the two countries. The renovation of this bridge is highlighted in this month's feature on page 26.

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Richard L. Hess Retires from STRUCTURE® Editorial Board

Richard L. Hess, S.E., SECB, F. ASCE is stepping down as a member of the STRUCTURE magazine Editorial Board. Richard joined the Editorial Board in the spring of 2005 as an NCSEA representative. He has been a consulting structural engineer in Southern California for over twenty-five years. He is a Past President of the Structural Engineers Association of Southern California and Chair, Existing Buildings Committee.

Jon Schmidt, Chair of the STRUCTURE magazine Editorial Board, had this to say on Richard's departure: "Richard Hess has been a wonderful asset to NCSEA and STRUCTURE magazine during his seven years of service on the Editorial Board. I really appreciate his many valuable contributions and wish him all the best."

Regarding his tenure on the Board, Richard commented: "Having the opportunity to be

on this Board has been a real pleasure and very rewarding, especially because of all the very interesting people from around the country that I have been able to work with. I think that having an Editorial Board consisting of practicing professionals in structural engineering was a brilliant concept that has made STRUCTURE magazine an extremely valuable asset."

Dilip Khatri, Ph.D., S.E. will replace Mr. Hess as one of three NCSEA representatives to the Editorial Board. Dr. Khatri is a Principal at Khatri International in Pasadena, CA. Dilip provides engineering services related to seismic and structural analysis, project management, structural design and forensic structural engineering. In addition to numerous articles and papers published in STRUCTURE and various ASCE journals, Dr. Khatri has published two books (ICC 2003 and 2004) about masonry design. Dilip also served as



Richard L. Hess,
S.E., SECB, F. ASCE



Dilip Khatri,
Ph.D., S.E.

a Professor of Civil Engineering at Cal Poly Pomona from 1991 to 1997.

Jon Schmidt said this about Dr. Khatri's appointment: "It is a pleasure to welcome Dilip Khatri to the Editorial Board. His background and experience as a practitioner, educator, and author will no doubt serve him well in this role, especially given his familiarity with seismic design."

Please join the STRUCTURE magazine Editorial Board in welcoming Dilip Khatri. ■

How to Read Bridges

A Crash Course in Engineering and Architecture

By Edward Denison and Ian Stewart

Reviewed By Brian J. Leshko, P.E.

I must preface my review of *How To Read Bridges* by confessing that I am a Bridge Engineer who "reads" bridges every day. I was intrigued when afforded the opportunity to review this book, which summarizes the introductory aspects of bridge engineering... and is written for readers with various types of backgrounds.

Overall, the pocket-sized paperback book is 250+ pages of informative text, full of interesting historic and contemporary photographs, and sketches of representative bridges worldwide. In addition, there is a Glossary of engineering terms, as well as Resources of books and web sites.

The book is divided into two sections – Part I: Understanding Bridges, and Part II: Case Studies. The first part introduces bridge materials (stone, wood, organic, brick, iron, steel, concrete and glass); bridge types (beam, arch, truss, moving, cantilever, suspension,

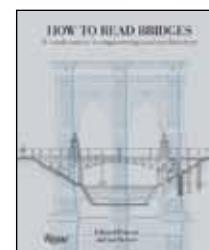
cable-stayed and hybrid); bridge uses (pedestrian, water, vehicular, rail and military); and illustrious bridge engineers (Isambard Kingdom Brunel, John A. Roebling, Robert Maillart, Santiago Calatrava, Gustave Eiffel, and Benjamin Baker).

The remaining 60% of the book is devoted to representative global case studies of the following bridge types: Beam Bridges (6), Arch Bridges (13), Truss Bridges (8), Opening & Moving Bridges (10), Cantilever Bridges (7), Suspension Bridges (13) and Cable-Stayed Bridges (9). Each case study includes a brief introduction describing the inherent design features of the specific bridge type, followed by several example bridges (numbers in parentheses) that include an historic summary, color photograph(s), and descriptive sketches detailing salient aspects of the bridge.

The book provides a good overview of bridge engineering from an historic perspective,

highlighted by iconic structures from around the world. One minor inaccuracy and isolated nomenclature issues were noted by this reviewer; however, neither detracts from the content.

Overall, I enjoyed *How To Read Bridges* and I am glad to add it to my library of bridge books. ■



Brian J. Leshko, P.E., F. SEI, M. ASCE is a Vice President, Senior Professional Associate, and Bridges & Structures Inspection, Management and Operations Program Leader with HDR Engineering, Inc. in Pittsburgh, Pennsylvania. He is a registered professional engineer in 16 states, a FHWA-Certified Bridge Inspection Team Leader, and a former SPRAT-Certified Level I Rope Access Technician. Brian currently serves on the STRUCTURE magazine Editorial Board.

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BRBFs in NYC – Fugettaboutit!

By A. Christopher Cerino, P.E., SECB, Michael Rogatsky, P.E. and Tim Nordstrom, P.E., S.E. While many New York City skyscrapers benefit from the support of billion year-old Manhattan Schist, other sites contend with fill and deep organic layers, saddling low-rise structures with amplified seismic design forces. Seismic analysis for the major modernization program of the Bronx Psychiatric Center resulted in building Seismic Design Category D. Structural engineers suggested using a BRBF system to enhance performance, reduce member size, and reduce cost.

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FEATURE

A Cold-Formed Steel Gym

By Matthew L. Mlakar, S.E. To achieve a goal of constructing a small gymnasium with a modest price tag for the Language Academy of Sacramento elementary school, structural engineers took inspiration from two very different types of optimized designs: typical residential construction and pre-engineered metal buildings.

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FEATURE

A Systems Approach for Structural Framing

By Steve Farkas, M.B.A. and Georgi Hall, P.E., M.S.C.E. Beyond the known benefits of CFSF systems, designers often ask what options are available that are not only efficient and effective, but also increase the overall strength of a structure while reducing the most expensive component of new construction – labor. CFSF systems may be the answer.

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On the cover Cold-Formed Steel Framing (CFSF) offers incredible flexibility, design creativity, and efficient and effective construction technologies. See feature article on page 40.

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STRUCTURAL PERFORMANCE

performance issues relative to extreme events

Seismic Strengthening of Buildings in Los Angeles

By Michael Cochran, S.E., SECB,
Dilip Khatri, Ph.D., S.E.,
Kevin O'Connell, S.E. and
Doug Thompson, S.E.



Los Angeles is no stranger to earthquakes and, like other cities in California, has experienced extensive damage in previous seismic events, which has led to significant advancements in earthquake engineering. Some might say that L.A. has been the epicenter of seismic code development since the 1933 Long Beach Earthquake. Because of its long history with seismic events and their aftermath, Los Angeles has embarked in a leadership role to create a long-term program to educate the public, help building owners to seismically strengthen their buildings, and improve overall community resiliency after the next earthquake.

The impetus for this retrofit program started with a few articles published in the *Los Angeles Times* when a reporter got wind of a study being done at the University of California at Berkeley on non-ductile concrete buildings, which indicated that potential “collapse hazards” exist. This news spread like wildfire, and since then, the *Times* has

been on top of this story with periodic coverage that has raised public interest in the topic of seismic strengthening and community resiliency. Mayor Eric Garcetti has issued a report

to help improve the seismic preparedness of the city which addresses telecommunications, water system infrastructure, and building vulnerability. The report calls for proposed ordinances, several of which relate to buildings and structures:

- 1) Seismic Retrofit of Existing Wood-Framed Soft-Story Buildings
- 2) Seismic Retrofit of Existing Non-Ductile Concrete Buildings
- 3) New Cell Phone Communication Tower Design Requirements

The mayor created an Earthquake Technical Task Force, among several task groups, which brought together people from the City, Dr. Lucile Jones from the United States Geologic Survey (USGS), and structural engineers from the Structural Engineers Association of Southern California (SEAOSC). This task force provided advice and recommendations to Mayor Garcetti as the mayor's office went about writing a report that summarizes some of the city's vulnerabilities to a major seismic event: *Resilience by Design* (www.lamayor.org/earthquake).

The report, released in December 2014, covers major seismic risks to the city's infrastructure, and documents past disaster events that had serious impacts on other local economies. One fascinating observation is the effect that the 1906 San Francisco Earthquake had on California's demographics. Prior to that year, San Francisco was California's largest city (population approx. 400,000), but the earthquake and fire aftermath produced considerable migration south to Los Angeles as the U.S. population moved westward,

approximately doubling the population from 150,000 to over 300,000 in the City in just four years. By 1920, the population of Los Angeles had surpassed that of San Francisco, making it the new economic center for California (*Figure 1*). After 100 years, San Francisco and the bay area have only recently, in the last two decades or so, been able to recover to a similar relative economic status with the development of Silicon Valley and the growth of powerhouse internet software/manufacturing companies like Apple and Google.

In a similar context, the economic damage to New Orleans from 2005 Hurricane Katrina is illustrated in *Figure 2* with a comparison to a similarly sized city with a similar economy and demographic, Nashville, Tennessee. The immediate financial loss suffered by New Orleans (\$80 Billion) is exceeded by its lost potential financial gains over the next 7 years when compared with Nashville.

It has also been observed that when the immediate financial loss from the disaster approaches or exceeds the annual real growth domestic product of the community, it becomes very difficult to rebuild the community as existing resources (infrastructure, building stock, financial services, labor pool, available commodity goods and services, etc.) have been greatly depleted or wiped out. Resulting shortages greatly restrain the recovery effort, often for many years afterwards, as communities attempt to rebuild, in some cases from nothing. It has been ten years since Hurricane Katrina, and New Orleans has still not recovered to its original economic capacity.

The obvious conclusion in both of the above scenarios is that major disasters have long-term economic effects that can be irreversible, or at least take many decades to economically recover.

Los Angeles City and Los Angeles County have the largest population concentration (approx. 3.8 million/10.1 million respectively) in California and constitute a major economic hub within the state, which is a significant component of the United States gross domestic product (GDP) – approximately 10%. A major earthquake in the communities that make up the Los Angeles basin, or San Francisco bay area, could severely cripple the state economy and have a corresponding impact on the U.S. economic output. Mayor Garcetti's initiative to create a seismic strengthening program is a unique approach, different than that attempted by his predecessors, and reflects his willingness to take on a monumental challenge.

The agenda of the program covers many topics beyond just buildings. Telecommunication facilities, water delivery, and power substations are among the lifeline infrastructures that are also addressed in the Mayor's *Resilience by Design* report. But the seismic retrofit of both existing wood-framed soft-story buildings and non-ductile concrete buildings are of the most interest to the structural engineering community.

Wood-framed soft-story buildings and non-ductile concrete buildings are considered to have a high collapse potential during an earthquake, putting the occupants at great risk. The poor performance and loss of life in these existing building types during the 1971 San Fernando, 1989 Loma Prieta, and 1994 Northridge Earthquakes have confirmed their vulnerability.

The creation of the LA Mayor's task groups to look at the threat of loss of life and impact on the economy from building failures in the aftermath of an earthquake afforded the local structural engineering community the opportunity to offer their technical advice on how to improve the performance of these buildings. An important distinction has to be made when participating in a task group such as the Earthquake Technical Task Force. As structural engineers, we can provide the professional technical expertise on how to help mitigate building failures during earthquakes and discuss associated risks associated with doing nothing. But this is where our advice typically needs to stop when working to develop a mandatory or voluntary seismic retrofit ordinance to be adopted by a local jurisdiction.

Besides the technical engineering aspects of any ordinance, there are also the economic, social, and political aspects that must be considered by the government jurisdictions. As engineers, we typically want to see hazard mitigation methods implemented as soon as possible. Here is where we have to learn patience. Time frames for adoption and implementation of any seismic retrofit ordinance have to be left in the hands of the local government officials and staff to determine the amount of time it will take to get community buy-in regarding adopting such ordinances. As the costs increase for any mandated seismic retrofit, the time frame for compliance must also increase so as not to immediately impact building valuations, and building owners need time to strategize the best methods for mitigating the earthquake hazard given their particular property.

There will be occasions when the local jurisdictions decide *not* to move forward on adopting and implementing any mandatory seismic retrofit ordinances. This has been the case in Los Angeles for many years, since the 1994 Northridge Earthquake, with the City only able to adopt a voluntary seismic retrofit ordinance for several vulnerable building types. In such cases, the only thing the structural engineering community can do is attempt to further educate the general public about the seismic risks and the necessity for adopting mandatory seismic retrofit ordinances. Ultimately, the general public has to buy-in to implementing mandatory seismic retrofit ordinances, as elected government official's work on behalf of their communities and cities.

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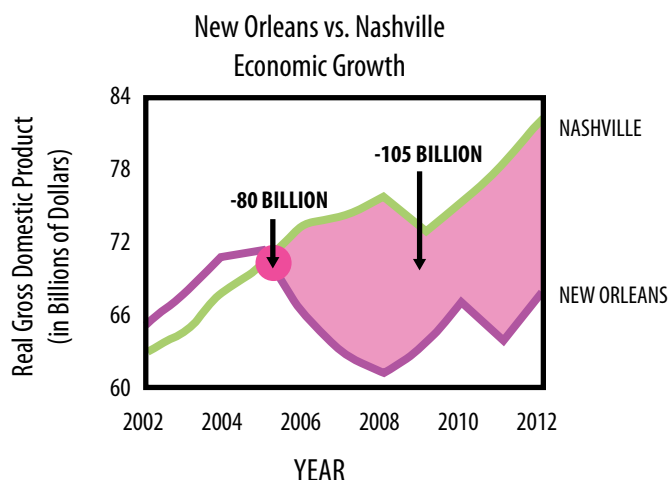


Figure 2. The Gross Domestic Product of Nashville, TN and New Orleans, LA Metropolitan area per year. Data Source: U.S. Bureau of Economic Analysis, Google Data (Los Angeles City Resilience by Design Report, 2014).

Population of Los Angeles vs San Francisco 1890-1920

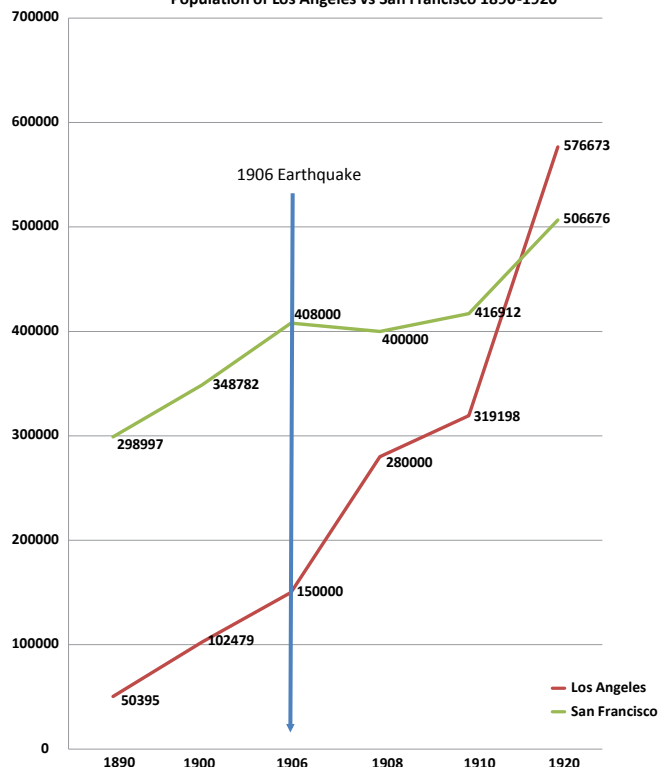


Figure 1. The population of the cities of San Francisco and Los Angeles (U.S. Census Data). The population of Los Angeles grew fourfold in the decade after the 1906 earthquake struck San Francisco (Los Angeles Resilience by Design Report, 2014).

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In the cases of the proposed wood-framed soft-story building ordinance and the non-ductile concrete building ordinance, the Mayor's office task groups did something different than had been done before while developing seismic retrofit ordinances. They engaged the stakeholders, including the apartment building and commercial office/retail/manufacturing building owners, to understand their concerns and get their input regarding seismically retrofitting their buildings. These owners were specifically targeted since their buildings have high occupancy loads. *This was a fundamental change in approach*, as now the building owners were becoming part of the development process, instead of being typically placed in a reactionary position where they may be uninformed about the issues and have to respond to city mandates. Having all parties involved in the initial conversations has led to better developed ordinance language, with a greater chance of successful adoption.

The Mayor's report also addresses adopting a voluntary rating system for estimating individual buildings' earthquake performance.

The voluntary building rating system is designed to encourage building owners to invest in their existing facilities and to consider new construction that exceeds current minimum building code requirements. This will likely make their buildings able to be re-occupied and put back in use sooner after a major earthquake, and thereby help the overall community recover faster.

A building rating system informs the community about building risks such as earthquakes related hazards. It creates a system that evaluates new and existing buildings based on three separate dimensions: Life Safety, Damage (Repair Cost), and Recovery (Time to Regain Basic Function). A rating can be given for each dimension. The concept is to "encourage" building owners to design new buildings to a higher performance level or to perform seismic retrofit projects voluntarily. Strengthened facilities will be more desirable to the earthquake-aware public and their tenants than older buildings that are still vulnerable or new buildings that are not designed to higher performance standards.

An offshoot of such a rating system is that the community can have a better understanding of their building stock's vulnerabilities to natural hazards such as earthquakes. This information allows the community to be able to formulate preparedness plans to help reduce the impact when the next earthquake occurs, and implement recovery plans after an event to help the community recover faster economically.

To encourage the residents of Los Angeles City to pursue *voluntarily* rating of their own buildings, the Mayor's office is proposing to lead by example and is tentatively looking to have some city-owned buildings rated for earthquake performance. The city has consulted with the United States Resiliency Council (USRC) regarding how the city's building department might proceed in rating city-owned buildings. More information about the USRC, building rating systems, and getting one's building professionally rated can be found at (www.USRC.org).

Ordinance Status

The mayor's office is currently working through the details of the ordinances identified in his report with the City Council, and has the goal to adopt and implement them into law before the end of this year. This program initially created quite a stir locally, putting structural engineers in the center of the discussion with owners, public officials, and the general public through extensive coverage by the *Times* and public town-hall meetings around the city. The ordinance adoption process by any jurisdiction can be lengthy, as the ordinances usually must pass through both economic and legal due-diligence reviews by a series of the jurisdiction's own internal committees.

Preliminary drafts of the building seismic retrofit ordinances recommended in the Mayor's *Resilience by Design* report were submitted to the Los Angeles City Council in January 2015. The ordinance requiring construction of new cellular communication towers to be designed for an importance factor of 1.5 passed rather quickly, and was adopted in March 2015. In September 2015, both the wood-framed soft-story building and non-ductile concrete building ordinances were heard by the City Council and forwarded to the city attorney's office for final review. It is anticipated the City Council will vote on the approved ordinance language from the city attorney's office sometime in October.

SEAOSC has been actively involved with the mayor's office and the Los Angeles City Building Department to provide support in developing the technical engineering recommendations for these seismic retrofit ordinances. The seismic retrofit ordinance compliance timelines, currently under consideration by the City Council for implementation, range from five years for wood-framed soft-story buildings to thirty years for non-ductile concrete buildings. It seems like a long time, but the big issue with earthquakes is that we simply do not know when the next "big one" will hit, and without

moving forward towards better performing buildings and a more resilient community, we will be no better off than if we did nothing. We can't afford to do nothing.■

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Douglas Thompson, S.E., is president of STB Structural Engineers, Inc. in Lake Forest and he a past president of the Structural Engineers Association of Southern California (SEAOSC). He has authored several articles and publications, including the light-frame design examples in the Seismic Design Manuals, the Guide to the Design of Diaphragms, Chords and Collectors and Four-story/Five-story Wood-frame Structure over Podium Slab. He was also a member of the Mayor's Earthquake Technical Task Force for the City of Los Angeles. He can be reached at doug@stbse.com.

City Council Update

On October 9, 2015, the Los Angeles City Council adopted both the mandatory Wood-Framed Soft-Story seismic retrofit and the mandatory Non-Ductile Concrete Building seismic retrofit ordinances. The Los Angeles City Department of Building and Safety now begins the task of implementing both of these ordinances, and notifying the building owners identified as owning either of these two types of buildings that they are required to comply with these mandatory ordinances. It is likely that first notices will be sent out to the building owners towards the end of this year or the first few months in 2016.

STRUCTURAL FAILURES

investigating failures, along with their consequences and resolutions

Snow Load Collapse of a Manufacturing Building in Oregon

By Dilip Khatri, Ph.D., S.E.

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A snowstorm in November 2014 hit Northern Oregon and was subsequently followed with freezing rain and arctic temperatures of -20°F . This event caused a large manufacturing plant's roof to collapse, resulting in extensive structural damage to the facility. Of the 400,000 square foot plant size, approximately 80,000 square feet (20% of the facility) collapsed and shut down the plant's operations. Structural damage extended to approximately 100,000 square feet of the facility, which was observable by visual means. In this article, the author explores the cause of the failure, collapse load analysis, and provides a brief overview of the structural system that was designed in the 1940s which remained in operation until the date of this event. The U.S. and Canada have thousands of buildings built over 60 years ago that are aging, deteriorating, and experiencing long term fatigue which are prone to failure/collapse. This article explores these issues and offers

methods to evaluate existing facilities, which require attention before such fatal events can harm occupants.

The November 2014 snowstorm was a combination of sudden snow fall, arctic like temperatures, and freezing rain that caused the roof

of this steel moment frame facility to collapse. Fortunately, this failure occurred in the early hours of the morning and no fatalities were experienced. *Figures 1 through 5* show the extent of the damage and loss of inventory. The building was constructed in the 1940s and comprises approximately 400,000 square feet of space, which was designed through successive permits over several decades. In its entirety, the design of this facility ranges from the 1940s-1960s vintage, and remained in operation until the 2014 storm event.

The ownership of the facility was advised to reduce their occupancy/use of the remaining facility (i.e., "undamaged" sections) until further investigation could be completed. This meant the entire building of 400,000 square feet was approximately 50% shut down due to



Figure 2.



Figure 1.

the possibility of extenuating damage beyond the immediate collapse zone. Specifically, approximately 80,000 square feet was a total collapse, and an additional 120,000 square feet remains suspect or partially damaged, pending further analysis/study. Since this forensic investigation is ongoing, and this is an active file, the details of this study are still confidential. The focus of this article is on the collapse zone, specifically, and recommendations for other facility owners (and their design firms) to take note that such events can occur in their areas, to similar structures that may experience large sudden loading.

Forensic Investigation of the Roof Collapse

As can be observed from *Figures 1 through 5*, and after doing a collapse load analysis, the reasons for the failure are attributed to several causes:

- 1) Excessive snow/ice loading due the storm event that exceeded the capacity of the steel moment frame system.
- 2) Plastic Hinge Failure at several locations in the steel moment frame system, including compression flange failure of the top chord of the truss.
- 3) Footing failure at the base reaction.

The structural analysis of the steel moment frame system shows the collapse load is approximately 5 to 7 psf of snow/ice load. This varies somewhat based on the assumption of load distribution. If we assume uniform loading, then the answer will be slightly different from unbalanced snow/ice loading because the load distribution changes the stress concentration points. *Figure 6* shows the structural model using RISA 3D and the resultant moment diagram. However, the conclusion from the structural analysis definitively shows that the analytical collapse load agrees reasonably with the estimated ice load at the approximate time of failure during the storm event. The structural analysis also confirms that the collapse load is far below the required design requirement of 20 psf as a minimum snow load capacity, and well below current code requirements, which would exceed 50 psf in certain areas of Northern Oregon.



Figure 3.



Figure 5.

Survey of the Structural Alignment

As part of the structural investigation, the forensic analysis of the cause of failure was performed using analytical methods (RISA 3D) and additionally with a physical geometric survey of the remaining structural frames. In many investigations, engineers can visibly observe the movement of a structure, but in certain cases the misalignment/movement may be too small to detect by visual observation. In these situations, engineers should consider retaining a professional surveyor to perform a physical geometric alignment survey of the structure to provide accurate three dimensional coordinate data of the facility's main structural frames.

In this case, the structural frames span approximately 100 to 120 feet in length, which translates into deflection criteria of about $L/180 \sim 6.7$ to 8 inches. This may seem visually observable, but in mathematical terms it's about 0.5% (0.005) of the length and cannot necessarily be observed with the naked eye. In fact, our investigation utilized a laser system, which in some cases could not measure this alignment because it occurs in three dimensions. The frames

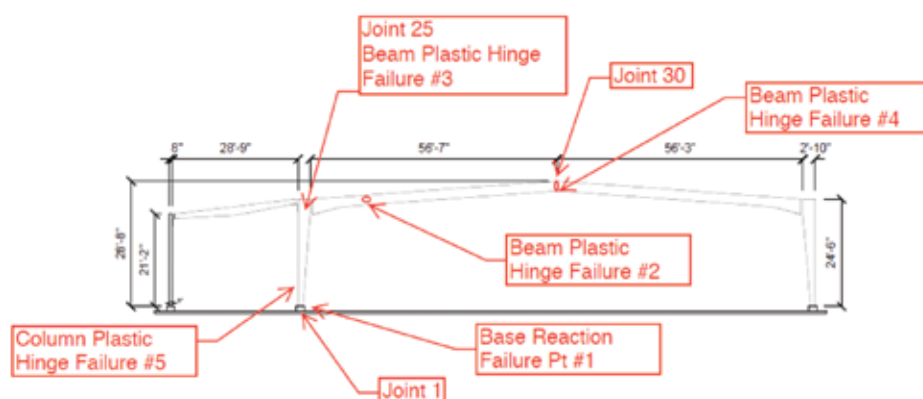


Figure 6.

can move in three translational directions (x,y,z) and this is very difficult to determine with crude measurement devices such as a plumb bob, laser level, or visual means. The alignment survey of this facility showed certain frames had serious misalignment issues that render them potentially unsafe. This was further compounded by the fact that the collapse load analysis showed the failure deflection was less than 2 to 3 inches on certain moment frames. A low collapse load capacity, which translates into a low deflection tolerance, means that these structural frames are a collapse hazard in storm events and must be retrofitted/repared.

Conclusions and Application to Other Similar Facilities

There are thousands of facilities similar to this one that are spread across the U.S. and Canada. They are old and designed for a different era of application, and should be investigated for possible premature collapse hazard conditions. The tools utilized in this investigation are readily available and may be implemented to evaluate existing facilities

with similar construction so as to forewarn owners of potential hazardous situations.

The use of Forensic Analysis combines the analytical tools of structural modeling with the physical survey tools of measurement devices that can assist structural engineers to better evaluate such failures and prevent new ones from occurring. In this case, the owners are exploring several retrofit schemes to repair the remainder of their facility to retain their occupancy/use, and maintain the safety of their employees. ■



Figure 4.

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FEATURE

San Marcos High School

By Hossain Ghaffari, Ph.D., P.E. The San Marcos High School project transformed the existing single-story complex to a state of the art multi-story high school complex. The new Campus features several separate structure that utilized tilt-up and cast-in-place concrete, and structural steel construction. Tilt-up construction offered solutions to two critical concepts where a concrete façade was used.

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FEATURE

Houston's Hobby Airport Gets New International Upgrade

By David W. Hillery, P.E., Matt Henderson, P.E. and Raxit Patel, P.E. In 2015, Houston's William P. Hobby Airport added its first international terminal with 280,000 square feet of new space and five new boarding gates. Additional features included renovations to existing spaces, 16,000 square feet of additional concession space and space to allow 800 arriving passengers to be processed through 16 passport inspection stations. While new structures were constructed and connections from the older to the newer features were being made, all airport-related traffic, concessions and other businesses had to be maintained without interruption.

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On the cover The Columbia University Medical and Graduate Education Building utilizes state-of-the-art concrete construction technologies, including bonded post-tensioning, slab void formers, and high strength materials to create a world-class medical education facility in New York City. Photo by Matthew Melrose/Leslie E. Robertson Associates. See Spotlight article on page 59.

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INSIGHTS

new trends, new techniques
and current industry issues

Smart Structures

By Dilip Khatri, Ph.D., S.E.

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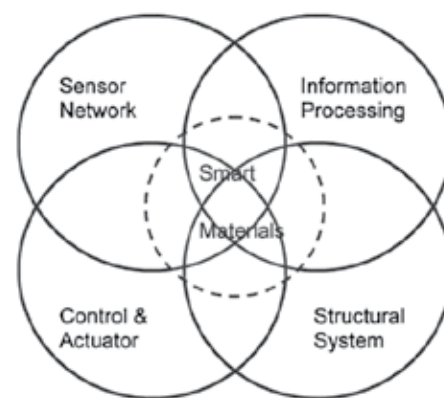
Structural Engineering is an evolving field. Our profession continues to innovate with brilliant new technology, materials, and analysis methods, at an ever increasing pace. I can remember when I started as a junior structural engineer in 1983, the introduction of personal computers was just beginning to take place, along with the finite element method for structural analysis. This was a significant step forward from the previous generation of engineers who grew up on slide rules. After 33 years, I'm still learning.

What are *Smart Structures*? Think of the human body. It is by far the most advanced and technologically "Smart Structure" that exists. Let's recap what a conventional structure is: A building is subjected to a lateral wind pressure load and reacts by transmitting these loads through its structural system (e.g., steel/concrete/masonry/wood) to the foundation. The structural stiffness response is the same regardless of the wind pressure. Whether it's a hurricane force

wind or a mild 10 mph wind gust, the building's stiffness, damping, and structural response are identical. Reaction forces, internal stresses,

and deformations will change, but the stiffness distribution remains constant. This is a conventional structure.

A Smart Structure will adjust the stiffness, damping, and material properties to respond to the loading, and shift the internal stiffness accordingly as it pertains to the demand. Think of the human body – when you are thrown a baseball, your brain sees the ball and assesses the velocity and consequent impact force. Based on this determination, you will raise your hand and your arm will respond with the appropriate stiffness to catch the ball. If it's a slow pitch, then you will take it easy in the catch. If it's a

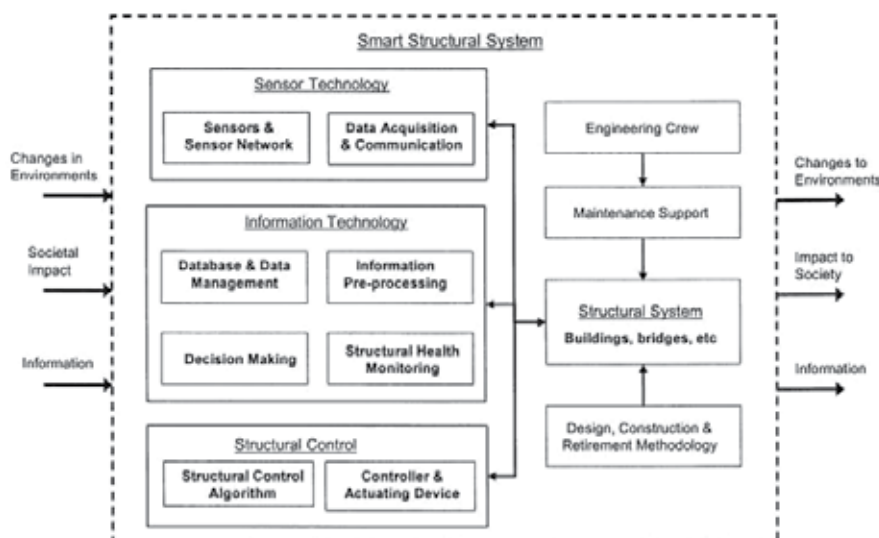


fastball, then your body will react accordingly to provide a stiffer resistance to prevent missing the ball. Similarly, your legs adjust to the reaction of your body.

Over the past 20 years, the research into Smart Structure Technology has been intense, and many research papers have been published on the topic with interesting applications towards building systems. Two excellent reference papers are provided by Zhang and Lu, and Song & Sethi (full references for these texts are included in the online version of this article, www.STRUCTUREmag.org). The development of Smart Structure Technology emanates from the aerospace and mechanical engineering disciplines, and is moving to the civil and structural engineering industry. The basic tenants of a Smart Structural System are:

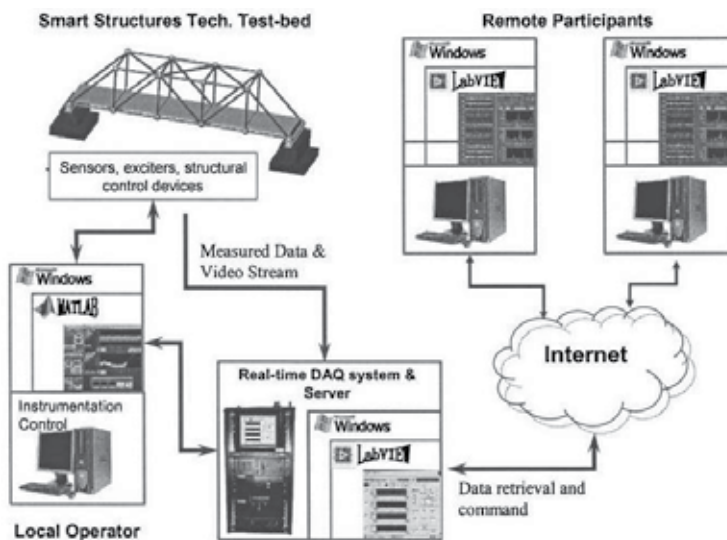
- 1) Records and reports defects and damage to the owner/engineer
- 2) Mitigates the impact of dangerous events such as earthquakes, explosions, hurricanes, fire, wind storms, etc.
- 3) Self-heals and self-repairs

Going back to the human body, it's amazing to think that our own physical structure does all of these tasks brilliantly.



Smart Materials go one step further by responding to external stimuli with an internal change in the material properties to prevent damage/collapse. There are smart materials in development: piezoelectric materials, shape memory alloys, magnetostrictive materials, magnetorheological fluids, and other “self healing” materials.

The *Smart Structure System* uses internal sensors (i.e., accelerometers, stress sensors, and deflection measurement) to assess the impact force/demand and then routes this information to a central processing unit (computer) which will adjust the damper/stiffness devices in the building at critical locations to respond to the force. The entire process occurs in just milliseconds, and the intent is to create a structural system that *adapts* to its environment. Although there are significant hurdles towards practical implementation of this technology, such as the loss of power in an event which would disable the system, the idea poses innovative advancement for the structural profession. The mechanical and aerospace engineering fields are leading the way here, and this reminds us of the 1980s when the introduction of fiber composites, personal computers, and finite element analysis were just coming into the horizon for structural engineers. ■



Basics of Piezoceramics Materials

Piezoceramic material refers to the substances that have the following unique property: an electric charge produced when a piezoelectric substance is subjected to a stress or strain (direct effect), and conversely a mechanical deformation, i.e., the stress or strain produced when an electric field is applied to a piezoelectric substance in its poled direction (converse effect). Hence, the direct piezoelectric effect is useful in sensors such as accelerometers and the converse effect is useful in actuators such as ultrasonic motors. The most commonly used piezoceramic is lead zirconate titanate (PZT). (Song et al., ASCE Earth & Space, 2004)

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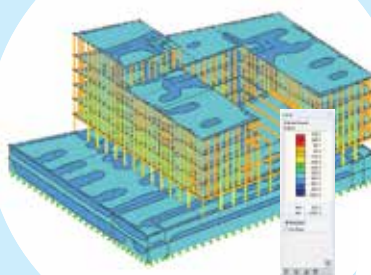
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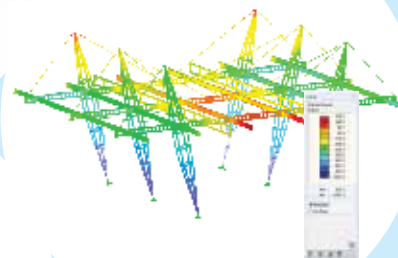


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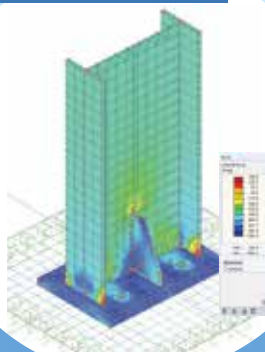
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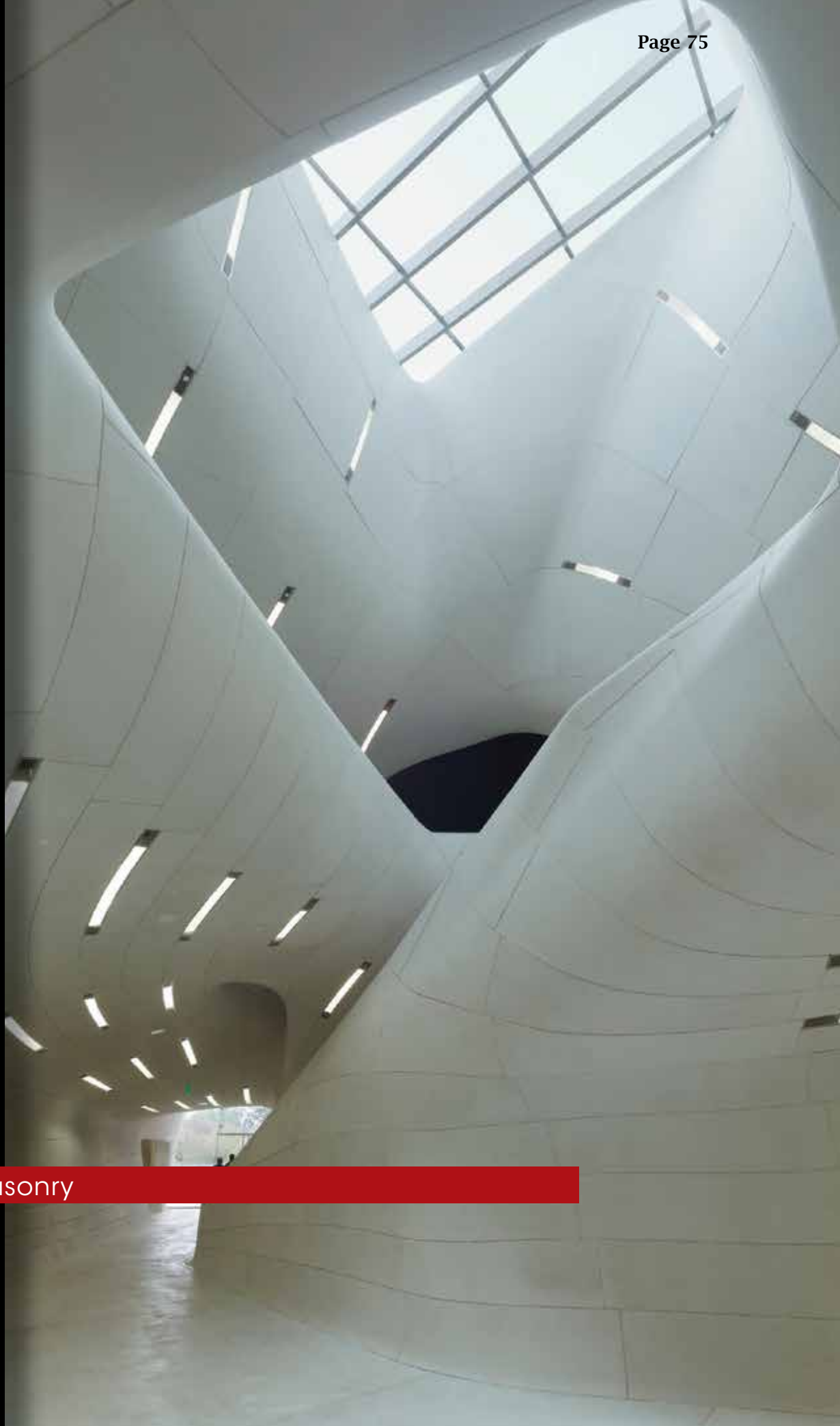
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FEATURE

Louisiana Sports Hall of Fame and Northwest Louisiana History Museum

By David L. Kufferman, P.E. In 2003, the Louisiana Sports Hall of Fame was accepted into the Louisiana State Museum system, which set the stage for the creation of a new museum building. The most distinctive feature of the new building, completed in 2013, is the undulating cast stone surface on both its interior and exterior.

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FEATURE

Restoring the Foundation of Justice

By Thomas E. Forsberg, P.E. When the roof on the historically significant County courthouse leaks, what do you do? Of course, you patch it. When the “patch method” no longer works, a new approach is to thoroughly examine the roofing and dome structure and recommend corrective work, and, remove and restore Justitia (the Statue of Lady Justice) perched atop the County courthouse dome.

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On the cover ‘When Virtual becomes Reality: Cast Stone Meets the Information Age in Louisiana’... The cast stone atrium of the Louisiana Sports Hall of Fame and Northwest Louisiana History Museum. See the feature article on page 30.

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Public Perception of Structural Engineers

By Dilip Khatri, Ph.D., S.E.

Who are we to the Public? Do they know or care about what we do? Sadly, the public doesn't know who we are or what we do. Structural engineers have allowed our clients (architects) to define the meaning of "buildings" and thus have grabbed credit for our work for the past 100 years. An architect represents every project, with no space/room for the technical accomplishments that make those projects happen. This is not to say that we should be angry with architects. By no means does this article imply or suggest that we should direct any criticism towards our partners in the creative design world. The focus of this article is on us, on our profession, because we are the cause of our own problem.

Let's start with two examples of structural engineering accomplishments with zero public recognition. The Empire State Building, New York City's symbol and America's icon of the "Empire State" and a nation on the rise, was designed by the architects Shreve, Lamb, Harmon. Mr. William Lamb has received accolades of credit for this building, which was cited as the 8th Wonder of the World. Where is the name of Homer Gage Balcom? He was the genius structural engineer that created the structural system to pioneer this first, tallest building of its kind. No one remembers H.G. Balcom.

More recently, the Disney Concert Hall, lauded as an artistic masterpiece, was designed by Frank Gehry. Not a mention of the extensive computer modeling and seismic analysis that went into this curvilinear steel membrane nightmare that made no sense to anyone, until a structural engineer could translate it from Frank Gehry's sketches into working drawings. The Disney Concert Hall was a "pipe dream" that would have never happened without the hard work of John A. Martin & Associates transforming a design plan from a "doodle sketch." Yet, there is not a mention of them by the Honorable Frank Gehry in any of his speeches or public recognition.

I could go on for pages and pages, but let's focus on the solution.

Structural engineers have three prominent character traits (among others) that prevent them from gaining recognition:

- 1) *Lack of Image Recognition:* Our professional culture does not demand "Image Recognition". We regard ourselves as "above" all that nonsense, and we don't seem to care whether our name goes on the plaque in front of the building or is mentioned in a press release. We are, by nature, a very humble profession considering our accomplishments.
- 2) *Too Busy to be Bothered:* We are so busy with taking care of our workload and meeting deadlines, the idea of public participation seems ludicrous and impossible. We don't participate in public events in a leadership role, so consequently the public doesn't get to know us.
- 3) *We do not engage the Press:* The Press loves to interview architects, and they love the attention. We don't invite the Press to any of our events and are scared of anything in the media with our name on it due to fear of consequences or a bad photo.

Our culture starts with our college experience. When we were students, we were among the hardest working on campus – engineering is tough. I'll be the first one to admit that I hated my humanities courses and general education. Political science and psychology were low points in my college experience. Now, after 33 years in the business, I wish I had paid attention to these subjects earlier in my life, as I find they dictate my success now with as much (or more) value than my engineering skills. I've never had a client walk away from me because I couldn't design a beam or column, but they will walk away if they can't get along or communicate with you.

Recognition and public awareness have to be built over years of participation in the public arena. We are a long way off. The media doesn't know we exist. Watch the news after a major hurricane or earthquake; they seldom interview a structural engineer to ask his/her opinion. They will talk with a firefighter, a

paramedic, or a priest, but don't have a clue who we are.

So what do we do?

First, the younger generation needs to stay in the profession. The average professional tenure in civil engineering is only around 14 years, according to the U.S. Department of Labor. We need to attract and keep our best and brightest engineers for the long haul.

We need to collectively change our attitude when it comes to public recognition. We need to seek it, demand it, and eventually create a public relations channel so that every great project allows our industry to be recognized. I have many ideas on this topic. Others will as well. Now is a good time to spark the conversation and raise awareness on this important issue.

Think about real estate brokers. They have a professional license but minimal education compared to engineers. They demand a set commission and have no problem taking full recognition for their work. They sell the buildings that we design! They only sell them! They don't design them! Yet, everyone knows who a real estate broker is and has a public image of what a broker wears, drives, and looks like. As a reward, brokers and agents can demand higher commissions for their work.

I'm not advocating that we become like brokers. But a little salesmanship will help us. We need to partner with our architect clients to share in the recognition. One day, everyone will know who the structural engineer was that designed the White House, the Burj Khalifa, the Empire State Building, the Hoover Dam, the Golden Gate Bridge, and all of the other countless monuments and icons that dot the world because of our efforts. ■

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26 NCSEA Excellence in Structural Engineering Awards

The winners of the 2016 NCSEA Excellence in Structural Engineering Awards program were announced at NCSEA's Structural Engineering Summit in Orlando in September. The program annually honors the best examples of structural ingenuity from around the world. STRUCTURE magazine is pleased to provide overviews of these unique projects.

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34 Challenging Foundation Built in the Heart of New York City

By Douglas P. Gonzalez, P.E. and Joseph L. Yamin, P.E. Locating and designing this 21-story state-of-the-art hospital building on a congested urban site in Manhattan proved challenging, especially for foundations and ground level construction.

On the cover Walter P Moore was named a 2016 Outstanding Project Award winner in the NCSEA Excellence in Structural Engineering Awards program for the new SFO Air Traffic Control Tower. The 220-foot-tall tower is surrounded by an integrated three-story FAA office building with blast-resistant walls. See page 26 for an overview of all of this year's winners.

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Fatigue Analysis of Concrete Structures

By Dilip Khatri, Ph.D., S.E.

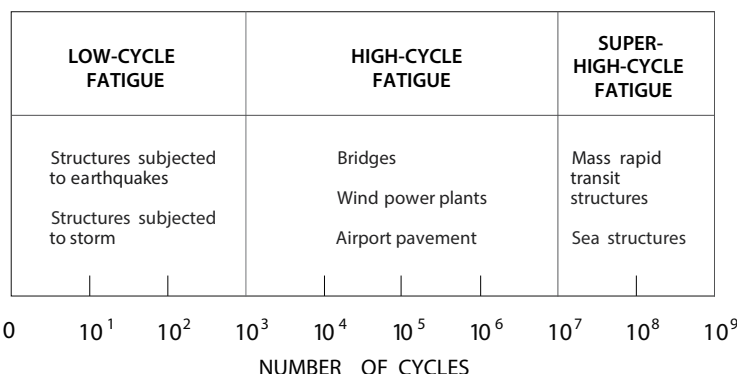
For many structural engineers, the subject of fatigue analysis has been limited to a few simplified evaluations based on the American Institute of Steel Construction (AISC) *Steel Construction Manual* that says less than 2,000,000 cycles implies no problem. For concrete structures, the presumption of any fatigue loss was never even a design consideration in typical coursework or practice. Therefore, professional structural engineers in the U.S. have never actually been trained in understanding the effects of fatigue and fracture mechanics, except Northridge Earthquake's impact on welded steel moment frame connections.

The industrial age (1920 to 1960) saw a proliferation of new buildings, bridges, and infrastructure elements built under this methodology. As the profession continues to evolve into more esoteric, analytical, and focused areas, structural engineers realize that the issue of fatigue is more than just a textbook discussion and has very real implications on the long term considerations of structures. Structures are now passing 50 years. Some have well over 100 years of service life and are beginning to show severe signs of long-term wear and tear. This is particularly true of bridges of both steel and concrete where cracking, corrosion, and fractures are limiting the extended life of these vital arteries of our economy. Why is fatigue analysis important? Here are the fundamental reasons:

- 1) Fatigue loading leads to fractures, cracking, and eventual collapse/failure because the structure will likely fail before it reaches its yield point. Even though the structure is elastic, it still poses a life-safety threat to occupants.

- 2) Designing for strength, ductility, dynamic response, strain compatibility, and serviceability are fundamental but have no correlation to fatigue analysis. A structure can be compliant with all of the basic tenets of structural design and still fail in fatigue. Increasing the strength (i.e. yield strength/stiffness) does not necessarily contribute to better fatigue strength.
- 3) Fatigue failure is the result of a high number of cycles with low to moderate stress over an extended period that eventually fractures the material and causes failure. These fractures will grow and ultimately undermine the structural strength of the member and the system.

The purpose of this brief introduction to fatigue analysis is to raise awareness. It is an important part of design for the long-term performance of concrete and steel structures.

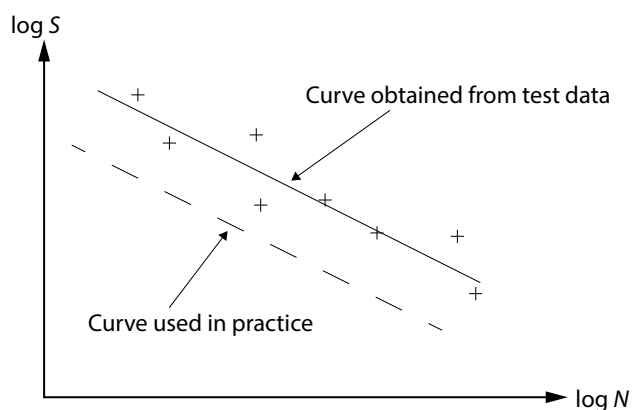


Spectra of fatigue loading in structures.

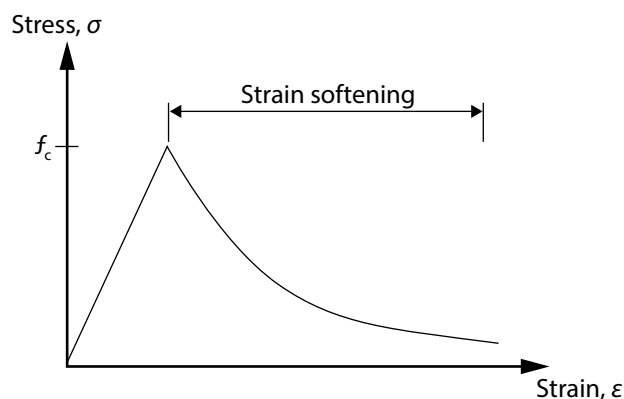
Fatigue in Concrete Structures

Concrete fatigue is due to long term low amplitude force or stress, with many cycles occurring over the life of the structure, that leads to concrete fracture. This can happen in tension, shear, and compression failure zones. Concrete fatigue is addressed by one internationally accepted code: *FIB Model Code 2010*, part of *Eurocode 2*. The basic tenets of fatigue analysis and analytical models are contained in this document. The principle of fatigue analysis relies on an empirical design model:

- 1) A stress-cycle (S-N) curve is developed based on cyclic fatigue load test data. This is the Envelope of Failure for the structure.
- 2) The analysis is based on summing the various fatigue loads to determine if the final structure "fits" within this Envelope.



S-N curve for fatigue analysis.



Strain softening in the concrete structure.

- 3) The basic rule is the Palmer-Migren Summation or the Minor's Rule method of fatigue analysis.

With concrete material, the fatigue cracking is not physically visible; because concrete experiences a strain softening at high cycles, the crack propagation will continue un-noticed.

Think about all of the concrete structures that are impacted by this type of loading:

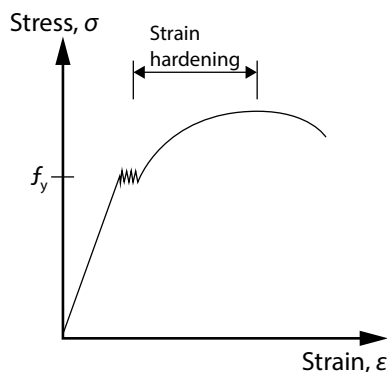
- Bridges
- Concrete Buildings (mostly commercial structures)
- Hospitals
- Pavements
- Theaters
- Stadiums

Fatigue in Steel Structures

Steel structures experience strain hardening with high cycle fatigue, so failure patterns are different. With steel, the critical points are stress concentrations, welds, and bolted connections.

Steel structures with fracture failure mechanisms that are impacted by fatigue loading include:

- Steel Bridges
- Reinforcement in Concrete Structures
- Steel Moment Frame Buildings



Strain hardening in steel structures.

Wind Tower Projects

The author's experience with fatigue analysis comes from 20 years of practice in the wind energy industry. In this field, the topic of fatigue check surpasses the normal strength design issues and usually governs on wind tower projects. The reasons are obvious; the wind tower supports a functioning machine (wind turbine) that will generate 20 million cycles of loading over a 25-year service life. It stands to reason that when structural engineers think of bridges, which are expected to last for 75+ years (sometimes over 100 years), fatigue analysis should be

considered in their design methodology. The same principle applies to buildings and other structures.

Long Term Considerations

The U.S. should seriously look at our design codes to incorporate this relevant topic into our design process. Currently, there is minimal guidance. Bridge codes (AASHTO) do have some requirements for fatigue analysis, but these are not as sophisticated as European codes. As for buildings, there are no requirements for these considerations. As we see more of our structures surpass 80 to 100-year service lives, we will recognize the importance of fatigue analysis as part and parcel of structural design. ■

Dilip Khatri is the Principal of Khatri International Inc, Civil and Structural Engineers, based in Las Vegas, NV, and Pasadena, CA. He was a Professor of Civil Engineering at Cal Poly Pomona for 10 years. He serves as a member of the STRUCTURE Editorial Board and may be reached at dkhatri@gmail.com.

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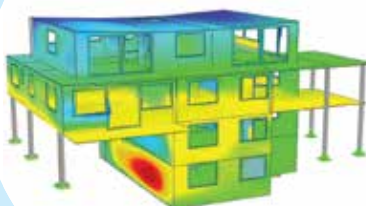
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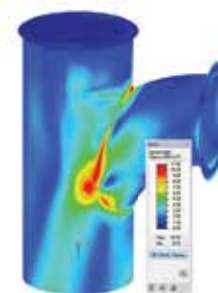


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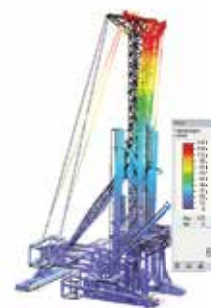
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2017 NCSEA
Structural
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How Big is Big?

By Dilip Khatri, Ph.D., S.E.

I would like to discuss the idea of “big” structures and explore some interesting facts about these landmark structures that have defined the egocentric ambitions of countries, rulers, and people.

What is Big? Developers, builders, architects, engineers, and the public have been pondering that question for thousands of years. From the Egyptian Pharaohs that wanted us to remember them through their Pyramids to today’s modern high rise buildings, there is apparently a demand within the human psyche to be the “Biggest.” This race started in the 1930s with the Chrysler Building (1,046 feet height, 1.195 Million square feet [MSF], built in 1930) and the Empire State Building (1250 feet, 2.25 MSF, built in 1931), to the current title holder, Burj Khalifa (2717 feet tall, 3.31 MSF, completed in 2010). But wait, the race never ends! There is a host of new contenders on the horizon to take the title of “World’s Tallest” every year.

I became intrigued with the topic of “Big, Tall, Large” after a recent trip to Romania, where I visited and toured the Palace of Parliament Building (Parliament Building) in Bucharest. The City’s claim that this is the second largest government building (3.95 MSF) peaked my curiosity, and I had to go for a tour of the facility. I learned that the U.S. Pentagon tops out at 6.5 MSF and is the world’s largest government building. Comparing these two structures with the Burj Khalifa and several other high-rise buildings, the concept of “Big” gets blurred very quickly. If we look at floor area, the largest building is the New Century Global Center (18.9 MSF) in Chengdu, China, with the Dubai Airport Terminal (18.44 MSF) not far behind.

So why this fascination with being the “Biggest?” The simple answer: Ego. Governments around the globe are no different from children at play with blocks. As children, we used to play with Legos®/blocks and try to make a really tall tower and proceed to show off our “Tallest” tower. Then, someone would walk by and knock the tower down. This almost sounds like the real world!

Today, we hold Bridge Building Contests, with popsicle sticks and glue as building

materials, to see which is the strongest and can hold the most weight. Awards are handed out for these competitions. This seemingly standard educational exercise actually fosters the idea that *Big is Best*. However, it did not start with our generation; it has been with us for centuries.

The Pharaohs built their Pyramids, not for eternal fame, but to take their treasures with them into the next life. After a few thousand years of pillaging the Great Pyramids, Egyptians learned that making a big statement about your wealth and not following up with security is a bad idea. So, they decided to hide their treasures inside a Tomb, instead of making big landmarks which stood as advertisements to thieves. “Hey, I’ve got a lot of treasures and they are right here.” No doubt, this was a fundamental shift in philosophy from “Bigger is Better” to “Less is More.” I learned these facts after making a personal visit to Cairo, Luxor, and the Valley of the Kings.

Fast forward to the modern world. The developers of the Burj Khalifa and the soon to be constructed Jeddah Tower are in direct competition with each other to outdo *Bigness*. The Chinese aren’t far behind, with massive construction projects underway in Shanghai, Beijing, and Hong Kong. Governments, nations, and wealthy individuals have an urge to create their “space,” an area that defines their existence and proclaims their identity for future generations. In my opinion, it’s an attempt at immortality. There are a few of us who would like someone to



The Burj Khalifa.

remember us when we are no longer here and say, “Oh wow, that was a Good Dude,” or something like that.

Nowhere does this become more relevant than in personal residences. One of the world’s largest residential spaces is the Royal Palace of Caserta (2.53 MSF, Naples, Italy) and outstrips the Palace of Versailles (720,000 sq. ft.) by three times, even though it is not as famous.

Structural Forum is intended to stimulate thoughtful dialogue and debate among structural engineers and other participants in the design and construction process. Any opinions expressed in Structural Forum are those of the author(s) and do not necessarily reflect the views of NCSEA, CASE, SEI, C³ Ink, or the STRUCTURE® magazine Editorial Board.

It's hard to believe that one palace for one family is larger than the Empire State Building. They must have a lot of cousins! In contrast, the White House is just a tiny 54,900 square feet.

As I went on my tour of the Parliament Building in Bucharest, I was amazed that out of almost 4 MSF, only about 20% of the building was in actual use. The rest of it was cold, uninhabited, and suffering from neglect. The tour guide admitted that the expense of heating and lighting the building exceeds the Government's budgetary capacity. I learned that the purpose of the Parliament Building was to satisfy the egocentric objectives of its former ruler, Nicolae Ceausescu, who wanted to make this building his personal residence. Unfortunately, he was a brutal dictator that exploited his country's resources to complete his fascination and, in the end, was overthrown and shot by firing squad.

In the final analysis, what does this all mean for Structural Engineers, Architects, Designers, Builders, and Design Professionals? We all know that each one of these examples creates a plethora of design issues, problems to be solved, and construction difficulties that have been resolved through years of toil, torment, and thought-provoking Saturday evenings by many engineers, architects, and

builders several times over. People have an urge to be famous for one reason or another, whatever that may be. And, successful people have a special desire to out-do, out-build, out-perform, and out-shine other successful people in whatever category they can find. After many international tours to some fascinating destinations and visits to landmark structures, I have learned that it is not what is "Big" that matters; instead, it is what purpose your life served in the grand plan of making this world a better place. That's my personal lesson.

However, I have some positive thoughts for developers of large buildings. I want to say **Thank You**. Thank You to all those egomaniacal personalities that want to create, with their personal signature, the most unique space. If it were not for these individuals, design professionals would simply be busy designing more hospitals and schools. Instead,



Royal Palace of Caserta.

you make our profession challenging while we fulfill your dreams of immortal grandeur, even though others are always working on something Bigger, Taller, or Larger.■

Dilip Khatri is the Principal of Khatri International Inc, Civil and Structural Engineers, based in Las Vegas, NV, and Pasadena, CA. He was a Professor of Civil Engineering at Cal Poly Pomona for ten years. He serves a member of the STRUCTURE Editorial Board and may be reached at dkhatri@gmail.com.

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30 The Appleton Pedestrian Bridge

By Marian C. Barth, P.E. and William Goulet, S.E. This 750-foot long bridge is a contemporary, curving, "ribbonlike" structure located on the banks of the Charles River in Boston. Its geometrically challenging form and iconic slenderness called for unique solutions from structural engineers.

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On the cover Considered one of the Great Bridges, the Great Belt East Bridge, Denmark, replaced a ferry crossing from mainland Europe to Scandinavia. With a main span of 5,328 feet, it is the third-longest bridge span in the world. Read about this and other Great Bridges in the *Outside the Box* article on page 10.

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Dilip Khatri Retires from STRUCTURE's Editorial Board

Dilip Khatri, Ph.D., S.E., is stepping down as a member of the STRUCTURE magazine Editorial Board. Dilip joined the Editorial Board in the fall of 2012 as one of NCSEA's representatives. Dilip is the Principal of Khatri International Inc, Civil and Structural Engineers, based in Las Vegas, NV, and Pasadena, CA. He was a Professor of Civil Engineering at Cal Poly Pomona for 10 years.

Barry Arnold, P.E., S.E., SECB, Chair of the STRUCTURE magazine Editorial Board, had this to say about Dilip's departure: "Dilip has served faithfully on the Editorial Board for 5 years. Dilip's dedication and commitment to the magazine and the profession are commendable and he will be missed."

Regarding his tenure on the Board, Dilip commented, "Working with STRUCTURE magazine has been a truly rewarding experience. I have learned so much and made new friends in the process. My time on the Board has sharpened my writing and editorial skills for use in future endeavors. I am grateful to this Board for welcoming me and allowing me to grow professionally. Thank you sincerely to this great profession that has done so much for so many."



Timothy M. Gilbert, P.E., S.E., SECB, will replace Mr. Khatri as an NCSEA representative. Timothy is a Project Specialist for TimeknSteel Corp. in Canton, Ohio, who has been practicing engineering for over 30 years. In his current role, he is responsible for overseeing the civil and structural engineering for new facilities and facility modifications. Timothy also is a member of the Structural Engineers Association of Ohio (SEAO) and is currently Past President and Chair of the Licensure Committee. He is a corresponding member of the ASCE Committee on Licensure and active with the ASCE-SEI Professional Activities Committee.

Barry said this about Mr. Gilbert's appointment to the Editorial Board: "I am pleased to welcome Tim to the Editorial Board. He brings plenty of experience with writing and editing, and comes highly recommended by his peers. The readers of STRUCTURE magazine will recognize Tim's name because of the many articles he has had published in the magazine. He will be a wonderful addition to the STRUCTURE magazine team."

Please join STRUCTURE magazine in congratulating Dilip Khatri on his service and welcoming Timothy Gilbert to the team. ■



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By Cawsie Jijina, P.E., SECB, and Steve Reichwein, P.E., S.E., SECB When completed, 20 Times Square will encompass 378,000 square feet of floor space, rise 550 feet above the street, and have used 2,000 tons of Structural Steel and 21,400 cubic yards of reinforced cast-in-place concrete.

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By Kelly Cobeen, S.E., Terrence Paret, and Owen Rosenboom, Ph.D., P.E., S.E. San Francisco's landmark Hibernia Bank Building recently underwent an ambitious historic renovation and seismic retrofit. The seismic resistance provided by the massive granite and brick masonry walls had allowed the building to survive the 1906 earthquake relatively unscathed.

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Foreign Engineering Graduates in America

By Dilip Khatri, Ph.D., S.E.

America is a nation built by immigrants. The United States accepts approximately 1,000,000 legal immigrants per year. The U.S. is the most welcoming of all countries and a primary destination for foreign migrants, more than the other top five industrialized nations' immigration rates combined (Germany, United Kingdom, France, Canada, and Switzerland).

One source of U.S. immigration is through an influx of foreign graduates. However, there is a misconception that foreign graduates are impacting the engineering profession negatively and costing U.S. tax dollars. The focus of this article is to open

a dialogue on this sensitive topic, share some facts on the numbers/scale of foreign engineering graduates, and examine the national immigration debate as it relates to the engineering profession.

There are several avenues for a foreign graduate to obtain work in the U.S. I am a product of U.S. immigration policy, as my parents came to the United States from India in 1968 when I was only three years old. My parents arrived with \$1,500, no car, and no job, but with admissions to the Masters Program at California State University, Fresno, where they both completed Masters Degrees and became teachers.

Migration to the United States has only intensified since that time. A few statistics are important in putting immigration and how it relates to the engineering profession into a perspective of scale. The current U.S. economy consists of a \$20 Trillion G.D.P., with approximately 157 million workers in a total population of 310 million. The Civil Engineering population totals roughly 255,000, with approximately 100,000 Licensed Professional Engineers (PEs) in all 50 States and 10,000 registered Structural Engineers (SEs).

One avenue for foreign engineering graduates to obtain work in the U.S. starts with an employment period via the H-1B program. Established in 1992 for highly skilled/educated professionals, H-1B often leads to permanent immigration status and eventually to U.S. citizenship. The program assists employers seeking to hire nonimmigrant aliens as workers in specialty occupations; as such, the H-1B Visa is targeted to Engineering, Computer Science, Scientists, Doctors, Researchers, and other highly qualified talent. Congress sets the quota at about 85,000 annually (of which 20,000

are reserved for Masters Graduates). There are approximately 450,000 applications each year, which overloads the U.S. Citizenship and Immigration Services (UCICS) website within 3 days of the annual application date. Lottery luck dictates those accepted for H-1B status. From these 85,000 H1-Bs, the vast majority are in Computer Science, Information Systems, and Software Development. In fact, the foremost proponents of the H-1B program are Microsoft, Facebook, Apple, and Google, who sponsor the highest number of applicants.

H-1Bs are often and incorrectly viewed as accepting lower pay than their American counterparts.

In terms of Civil and Structural Engineering, the H-1B applicant pool is very small (less than 1,000 based on available USICS Data). The overall impact on the employment market is a trickle when compared to the total employment of 157 million U.S. workers. Likewise, the economic impact for the structural engineering profession is minimal due to the low numbers admitted compared with the size of the industry.

One myth prevalent in the engineering industry when it comes to foreign engineering graduates is related to salary. H-1Bs are often and incorrectly viewed as accepting lower pay than their American counterparts. From my own experience, having sponsored H-1Bs in my company over the past 15 years, I can attest that this is a falsehood. The H-1B program was explicitly set up to protect both U.S. and H1-B workers. Employers must attest to the Department of Labor that they will pay wages to the H-1B nonimmigrant workers that are at least equal to the actual wage paid by the employer to other workers with similar experience and qualifications, or the prevailing wage for the occupation in the area of intended employment – whichever is greater. As such, the paperwork and plethora of reporting often make hiring H-1B workers difficult for small businesses. Large employers sponsor H-1Bs because they are generally Masters/ Ph.D. graduates with specialized training/education that can be difficult to find among the local population.

Visit a University Engineering Graduate School and you will find a majority of international students. In fact, many Ph.D. engineering students are foreign applicants that arrive on Student Visas and eventually seek to stay through the H-1B program. The H-1B provisions intend to help employers who cannot otherwise obtain

needed skills and abilities from the U.S. workforce by authorizing the temporary employment of qualified individuals. Certainly, a preferred solution to filling specialized engineering positions would be to encourage our own citizens to pursue advanced degrees and specialize in technical topics. Unfortunately, the data shows that there is no shortage of homegrown American talent for Construction Management, Project Management, Executive MBAs, and Hedge Fund Managers. Conversely, numbers are very small for homegrown talent pursuing a Ph.D. in

Nonlinear Finite Element Analysis of Rubberized Concrete, Dynamic Soil-Structure Interaction, or Nonlinear Dynamic Response of Performance-Based High-Rise Buildings to Seismic ensemble excitations using the Power Spectral Density Method.

In the meantime, Foreign Engineering Graduates help to fill a void of expertise, positively impacting the engineering community.

In summary:

- 1) The impact of foreign graduates is minimal on the total U.S. Economy and minuscule on the Civil and Structural Engineering Industry.
- 2) Incoming graduates run research programs and contribute positively to the economy by providing specialized expertise that currently does not exist in the U.S.
- 3) Foreign Engineering Graduates do not cost more, and they specialize in areas that are least pursued by our own citizen engineering population.

In the end, remember that foreign graduates eventually become taxpayers and contribute significantly to our economic growth. It would be unwise to lose their financial contribution and intellectual investment in our society.■

Statistics cited in this article were obtained from U.S. governmental data (USICS and U.S. Department of Labor) and industry organizations (ASCE, NSPE, NCEE, NCEES).

Dilip Khatri is the Principal of Khatri International Inc, Civil and Structural Engineers, based in Las Vegas, NV, and Pasadena, CA. He was a Professor of Civil Engineering at Cal Poly Pomona for 10 years. He served as a member of the STRUCTURE Editorial Board and may be reached at dkhatri@gmail.com.

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August 2018 Steel/Cold-Formed Steel

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Education Crisis in America: An Insider's Perspective

By Dilip Khatri, Ph.D., S.E.

In this competitive international economy, the demand for educated talent is growing. As such, it makes sense that the United States should strive to reduce the expense of education. However, the current trend reflects skyrocketing costs.

In 1983, the author graduated from California State University Los Angeles (CSULA) with a Bachelor of Science Degree in Civil Engineering in 3 years (12 quarters), and the total tuition cost was approximately \$1,200 plus books (\$100/quarter). Overall, including books and miscellaneous expenses, the estimated total degree expense was about \$3,000. Adjusted for inflation, that would be about \$6,000 in 2018.

At CSULA today, the cost for the same 4-year degree is approximately \$68,000 (\$17,000/year excluding living cost). At a University of California (UC) Campus, the cost is approximately \$104,000 (\$26,000/year excluding living cost). At the University of Southern California, a private college, the cost is \$240,000 (\$60,000/year). These estimates assume someone will graduate in 4 years, which is highly questionable because of the availability of courses and student overcrowding. (Note – readers are encouraged to verify exact tuition numbers with the universities.)

In America, the expectation is that life will get “better” for our children; that they will have the same opportunity to pursue higher education and that our present generation will contribute to the prosperity of future generations. So, what happened?

The author has been on several sides of this debate, having been a Faculty Member in the Civil Engineering Department for 9 years at California State University, Pomona (CalPoly Pomona). In 1997, the author left academia to start his own firm in the private sector. In addition, he also worked for NASA- JPL/CALTECH for 3 years early in his career, so he has worked in both the public and private sectors over the past 34 years and brings a unique perspective on the issue of Education in America.

Firstly, for public universities, there is a serious problem with costs and educational priorities. The top 4 positions in the State of California with the highest paid compensation are all

Head Coaches, with pay packages exceeding \$3 Million/year. Professors in Health Science are not too far behind, with total compensation packages exceeding \$1.8 Million/year. Most of these compensation packages are derived from “other pay” which is linked to revenue generation from research grants (for Health Science faculty) and sports revenue (for the coaches). From the perspective of a business leader and pro-capitalist, there is no problem with coaches

Today, based on the author's research, a graduate with a college degree has over \$80,000 of student debt at the start of their life and doesn't even own a car, let alone a house.

making \$3 Million/year. BUT – if the university is deriving revenue from this resource, then *they should also pay their workers* (i.e., athletes) who bear the risk of play, break their bones, and suffer long-term effects of brain damage from concussions. Student-athletes are paid zero. It is easy to make money when you do not have employee costs. The entire college sports system, run by the NCAA, is operating under this questionable shadow of profit taking without expenses.

Current educational priorities are a problem nationally but, in the author's experience – which is based in the California higher education system – there are three priorities that public and private universities expect from new faculty:

- 1) Publish anything anywhere
- 2) Bring external, Publicly Funded Research
- 3) Bring external, Privately Funded Research

Note that student education and their welfare is nowhere to be found on this priority list.

International students have also become a significant market for campuses nationwide. In California, foreign tuition rates are approximately double that for local students; for U.C. Berkeley, this is over \$50,000/year for an international student. This results in universities increasing foreign student populations while ignoring local students. The math is simple; if they are going to collect twice as much per student, then those students get higher priority.

So, what are the results of this system? The author's son attended a California University for 4 years and graduated without any debt, due

to his father's support and desire that he not fall into the student loan trap. His Chemistry and Physics classes were over 400 students/class; his instructors were mostly part-time lecturers and graduate students. Some full-time and fully-tenured faculty taught his upper division engineering courses. Why are there not more full-time faculty teaching courses? The reason is that Universities have become “profit centers.” Where are the students in all of this? Nowhere.

They are expected to take loans to fund a system only concerned with its own interests.

In contrast, we have some of the best higher education institutions in the world. Their focus at the Master's and Doctorate levels are the best because these are research-based universities; whereas undergraduates are viewed only as an income source and part-time nuisance. However, the costs are outstripping the American Family Budget and are not sustainable. Today, based on the author's research, a graduate with a college degree has over \$80,000 of student debt at the start of their life and doesn't even own a car, let alone a house.

Where do we go from here? Some politicians have suggested that we find a way to fund tuition for students so that a college education is available for everyone. However, how do we pay for it? There is no simple answer to that question. It seems that, as the wealthiest nation on earth, it would be possible to find a way to make college accessible for ALL who wish to pursue a degree. As a start, universities need to separate out profit incentives such as sports, research funding, and other extraneous activities that are not part of Education. If universities want to pursue these revenue-generating activities, then they should set up separate, private corporations that should be taxed and regulated as part of the private sector. Let education be where it should be – a non-profit venture for the benefit of students. ■

Dilip Khatri is the Principal of Khatri International Inc, Civil and Structural Engineers, based in Las Vegas, NV, and Pasadena, CA. He was a Professor of Civil Engineering at Cal Poly Pomona for 10 years. He served as a member of the STRUCTURE Editorial Board. (dkhatri@gmail.com)

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On the Cover Satellite image of a hurricane approaching the U.S. (Elements of this photo were supplied by NASA.)

Art of Approximation

By Dilip Khatri, Ph.D., P.E.

Measure the distance between two points using a ruler, and you may read “12 inches.” This implies that the relative accuracy is to the nearest inch. If I write “12.00 inches,” then this implies accuracy to nearest 1/100th of an inch. For a foundation, the accuracy of $\pm \frac{1}{2}$ an inch may be appropriate. The tools of that construction trade do not have a high level of precision (i.e., a backhoe, shovel, or excavator). In contrast, for an Aircraft Wing on a fighter jet, the accuracy may be measured in Mills (0.001 inches) or 1/1000th of an inch. Understanding the level of accuracy required for a given task involves familiarity and judgment.

Structural Engineers approximate wind and earthquake loads based on data provided by seismologists, then use factors of safety on materials to design buildings that will hold our world’s inventory for an unknown period of time, giving our client’s a vote of confidence that will assure their tranquility. We represent the trust of society, the honor of integrity, and are responsible for millions of people’s lives because our structures store their memories, house their loved ones, and transport the world’s treasures across the nation’s highways. At both the beginning and the end, it is all based on approximation because engineering is a system of approximations, based on judgment, experience, and past errors that become lessons learned.

Where can a young engineer learn such skills? The first way is to learn from interaction with experienced engineers. Another way is to spend time on construction sites familiarizing oneself with the tools, fit-ups, and methods of the workers. When in doubt, review drawings produced by others and recommended tolerances for construction such as those in ACI 117 or AISC 303. The best learning experience for young engineers is to get construction experience. Work on something “real,” build “stuff,” get your hands dirty, and immerse yourself in the trades before becoming an “office junky.” You will experience how the paper design turns into a real structure.

Masters level students now graduate with extensive training and theoretical background on Finite Element Methods. Feats of analysis

that were impossible in earlier generations are now done in matters of seconds using powerful software, hardware, and sophisticated algorithms. No doubt, impressive progress from this author’s days when the PC was just emerging on the horizon, and the first four-function calculator was being sold for \$100. However, how can we teach the “common sense” and “engineering judgment” to guide us in design, and know that the answers provided by the software are right?

Teaching our engineering students about Strain Energy Density, Non-Linear Dynamic Analysis using the Galerkin Method, Bete Reciprocal Theorem, Heisenberg’s Uncertainty Principle, Fourier Transform, Jacobian Matrix, and the Duhamel Integral Formulation are useful tools for engineering analysis. But where’s the judgment? Universities cannot teach it because it is not really from textbooks and you cannot learn it from Timoshenko’s Treatment on Plates and Shells. You have to “live it” and learn through osmosis with experienced engineers in the profession who have designed many structures over many years.

The profession of Structural and Civil Engineering deserves its own School to match that of other professions: Dentistry, Medicine, Architecture, and Law. We need a practice degree at the Master’s Level that is a “Master of Structural Engineering” that teaches Structural Engineering Design and is taught by Professional Structural Engineers from industry. These teachers can introduce students to “Instinct,” the Engineer’s ability to see the structure perform in the extreme event and foresee the failure before it happens, then intuitively design for it so that it does not happen. They can teach scale, both in terms of proportions of members and the production of drawings which describe the structure.

They can teach Judgment, the “common sense” to “feel” the right answer. Yes, “feeling” whether an answer is right is also part of the engineering experience. Our judgment matters because an undersized footing will lead to a sinking building, an over-reinforced concrete roof system will cause sudden collapse when overloaded by snow, and a poorly designed bridge truss will lead to hundreds of deaths. These are skill sets that are best conveyed by practicing engineers or those with extensive design experience. Practicing Engineers have this wealth of experience, accumulated through years/decades of toil working with construction contractors, owners, building departments, and perhaps lawyers on projects that went well, wrong, sideways, and sometimes won an award. All of this matters, because Wins and Losses are both learning experiences that should be shared. Classroom learning is limited to textbooks, charts, tables, graphs, and research papers. There is a boundary to your educational envelope when you limit your circle to only Ph.D. level educators, and you lose the perspective of the real world.

Research is still essential, as are tenured Ph.D. professors, grants, publications, and experimental testing of components and systems. Our profession is being asked to stamp and qualify older structures with retrofit systems that are unproven and be even more economical with designs. We need researchers to help bridge the gaps in our understanding, but we also need them to understand that their students need us too. ■

Dilip Khatri is the Principal of Khatri International Inc, Civil and Structural Engineers, based in Las Vegas, NV, and Pasadena, CA. He was a Professor of Civil Engineering at Cal Poly Pomona for 10 years. He previously served as a member of the STRUCTURE Editorial Board. (dkhatri@gmail.com)



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DECEMBER 2023

STRUCTURAL ENGINEERING

Excellence AWARDS



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structural FORCES

Building Settlement

Considering the effects of ground movement on internal structural forces.

By Dilip Khatri, Ph. D., S. E.

Many structural failures share one common theme: *uneven ground settlement*. As structural engineers are trained at a university, they assume that the "fixed base" of our buildings is FIXED. However the effect of settlement on the above-ground structure can be dramatic. As a building sinks unevenly, moments and shears are redistributed to stiffer adjacent elements (columns, beams, walls, etc.) which add to their total load demand. Like a human being injured in one leg, weight is redistributed to the other leg, and a person's center of gravity shifts and the body can become unstable, leading to their fall.

Consequently, a building will redistribute weight because of stiffness variation from the sinking columns, which adversely affects the other columns. Analysis of a simple moment frame confirmed that the bending moments would increase 20% to 35% for a 1-inch deflection, and deflections will dramatically increase to 3 to 4 inches at a single column line.

Let us start with a statement found in almost all of our college structural analysis textbooks: "All structures are stable and fixed/pinned at their base, with the foundation never moving." *Figure 1* illustrates a simple 3-story moment frame building with fixed base connections. Points A, B, and C are assumed to be level and never displace vertically or horizontally (small deflection theory). Our education in structural analysis, design, retrofit, codes, and basic theory is formulated on this critical assumption: the ground never moves, or if it does, the movement is too small to be of any significance.

Reality Check: The Ground Does Move

Over time, the support of a structure will change due to varying soil conditions, moisture levels, mild earthquakes, and possible landslide conditions. These factors are not part of our conventional wisdom as structural engineers

because we are never taught that this may happen. It is completely outside of our envelope of expectation.

Examining our building codes, structural textbooks, and research

efforts for the past 80 years shows that "we" [structural engineers] work from the premise that the building will not move. We establish our design practice using sophisticated analysis methods such as finite element analysis, dynamic analysis, and nonlinear analysis, all founded on stable foundations. Certainly, for many buildings and bridges, this has proven to be a good working methodology. Iconic structures like the Golden Gate Bridge (almost 90 years of service), the Empire State Building (90+ years of service), and the Taj Mahal (over 400 years) have lasted well beyond their expected lifespan and defied collapse through numerous natural events.

But recently, there have been structural failures that are baffling investigators and give a reason for the re-examination of our standard of practice stemming from ground movement. A recent landslide in Rancho Palos Verdes, California is a prime example of ground movement which no conventional structure could have survived. Many structural engineers would lay the blame on the geotechnical engineers and geologists and claim this is "not our fault." Not true. Structural engineering is not just the "structure above ground" but includes the long-term stability of the foundation. We should be looking holistically at the entire system, not just "our part" above ground. We should remember that geotechnical engineers and engineering geologists provide information and data on soil conditions with *recommendations* to structural engineers for our design. *They are not building design professionals*; structural engineers are. Just like architects who perform their scope of design dealing with form, function, aesthetics, lighting, colors, shading, and the ethos of the structure, structural engineers have to take responsibility for our expertise and provide cautionary recommendations as necessary during the design phase.

Therefore, *Figure 1* from our structural textbooks is not reality but instead is more like *Figure 2A*. Each base support in two-dimensional space has three degrees of freedom (DOF) and can displace in two dimensions, plus rotate in-plane. Each DOF

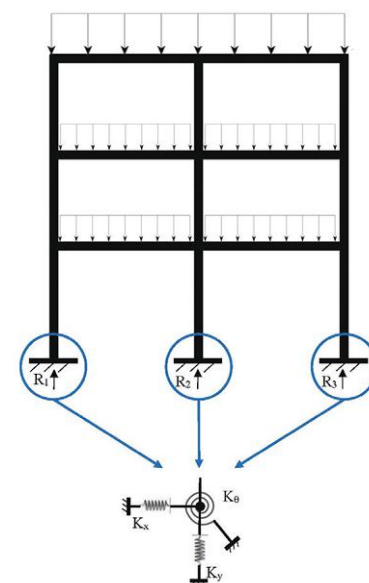


Figure 2a Multi-bay moment frame with flexible foundation reactions.

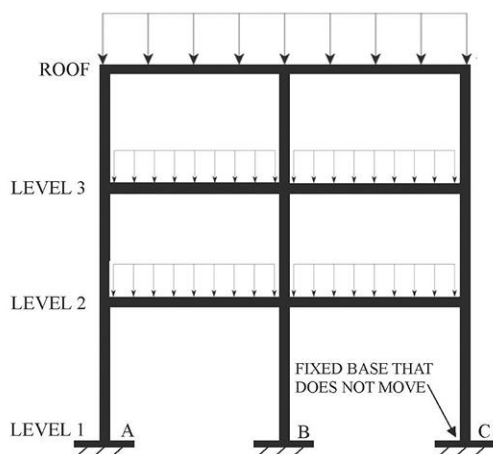


Figure 1 Typical multi-bay moment frame with vertical loads.

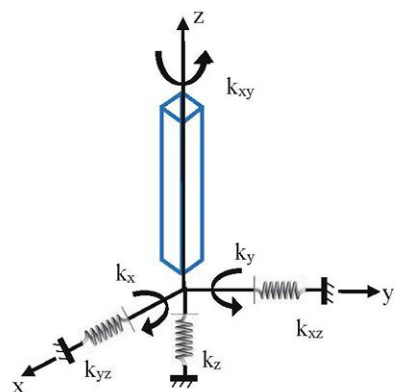
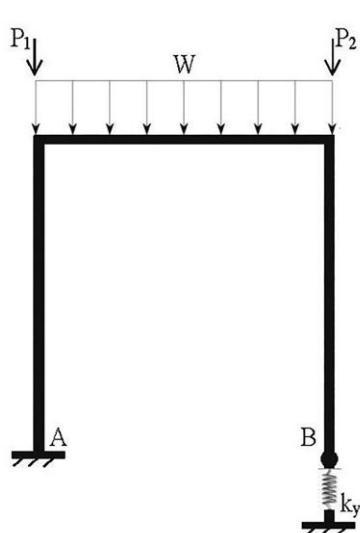


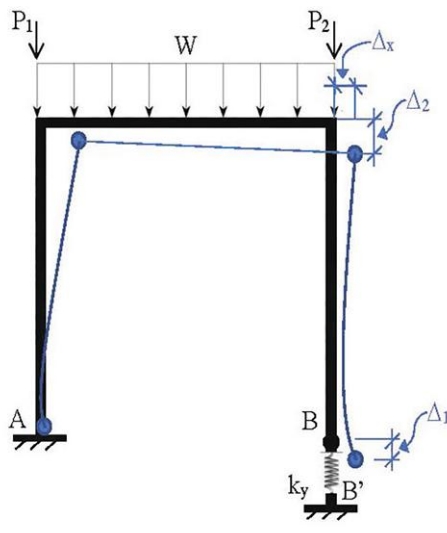
Figure 2b Base reactions with six degrees of freedom.

k_x = Horizontal x-axis Linear Spring Constant
 k_y = Horizontal y-axis Linear Spring Constant
 k_z = Vertical z-axis Linear Spring Constant
 k_{xy} = Torsional x-y Plane Spring Constant
 k_{yz} = Torsional y-z Plane Spring Constant
 k_{xz} = Torsional x-z Plane Spring Constant

Each node has 6 degrees of freedom (DOF)



Figures 3a Single bay moment frame with one degree of freedom.



Figures 3b Single bay moment frame with one degree of freedom deflection plot.

has a stiffness coefficient. Figure 2B illustrates three dimensions where the structure has six DOFs: three linear elastic springs and three rotational springs. The concept of multi-degree of freedom systems is usually part of graduate school structural engineering degree programs, but these principles are still usually introduced only for the understanding of the superstructure in conventional structural analysis, but not *foundation movement*.

For simplicity, we look at Figure 3A and examine the behavior as k_y degrades. When k_y degrades, see Figure 3B, the frame

will deflect from Point B to B', and the reactions will shift to Point A as the frame redistributes the vertical loads to the stiffer column.

This basic structural redistribution of loads is observed in Figure 4A for

design, we assume that the moisture content and bearing capacity will not change over time, but they can. For example, seepage from a leaking water main or in-ground swimming pool will certainly affect the soil parameters. Over-watering from irrigation will affect the soil capacity. Dewatering on adjacent construction sites can lower the water table. These factors are not included in a soils report because the geotechnical engineer is not expected to forecast them, but these factors do occur in reality.

These factors suggest the need for structural monitoring and capacity analysis over time, at least for structures where deterioration leading to failure would have consequences for the public.

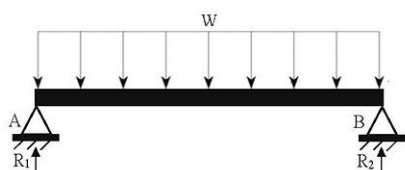
We cannot assume that "everything" will remain static over 50 to 100+ years. For example, Florida has instituted a timeline for structural monitoring and recertification of

a simple beam. As the vertical stiffness of Point B degrades, see Figure 4B, the load reaction at Point A will increase. The vertical loads will shift to the remaining support point as the stiffness degrades at the other reaction point.

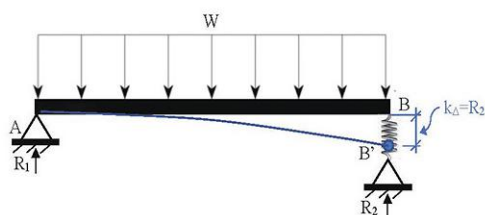
Equilibrium is the fundamental equation that keeps every structure standing. The balance of the forces and moments is formulated from Newton's Law. When one support loses its capacity to accept the vertical force demand, then that force (mass multiplied by the acceleration due to gravity) has to be transferred to other supports. *It must go somewhere, and so the redistribution of the loads (and stresses) in the structure is automatic and follows the basic laws of physics.* If we revisit our textbooks and recall the classical method of Moment Distribution (developed by Hardy Cross), this analysis method illustrates the re-distribution of moment to balance at the frame joints.

Practical Analysis

Geotechnical reports will give an estimated long-term settlement, often in the range of 1/2-inch to 1-inch for firm soils, over the life of the structure. This is an estimation based on the *soil conditions at the time of completion of the construction of the building*. Therein lies the basic fallacy: *soil conditions can change over time.* During



Figures 4a Simple beam with fixed pinned supports.



Figures 4b Simple beam with one degree of freedom base reaction.

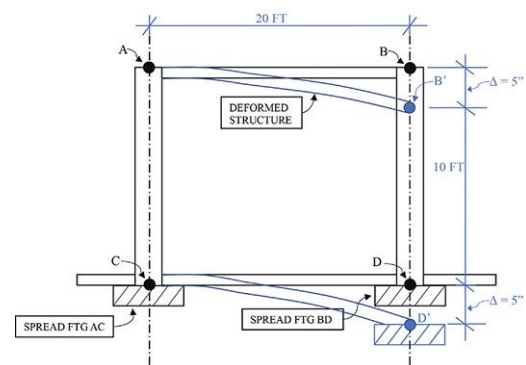


Figure 5 Schematic view of a real structure with foundation elements and deflection plot.

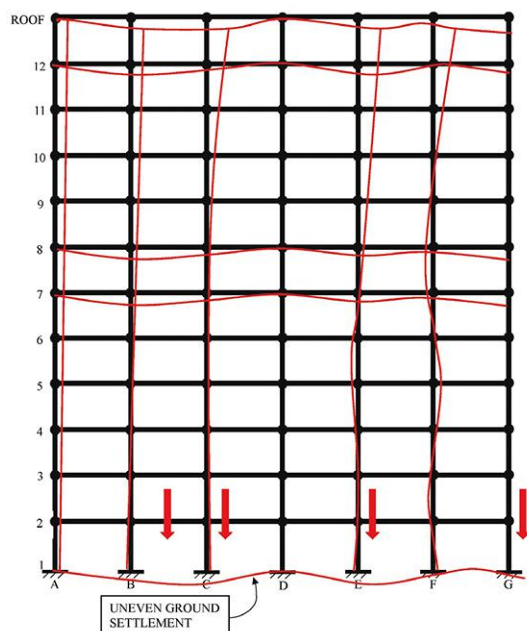


Figure 6 Multi-bay tall building with varying ground settlement reactions.

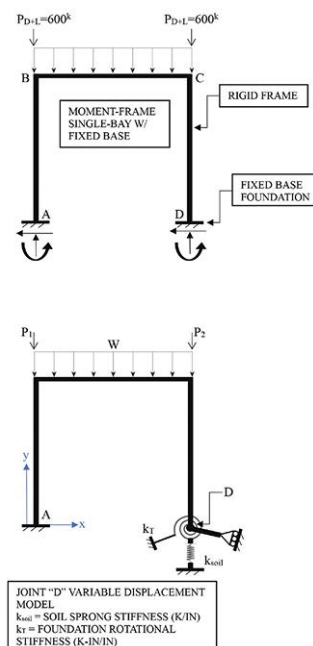


Figure 7 Single Bay moment frame with fixed base and then adjusted with three degrees of freedom.

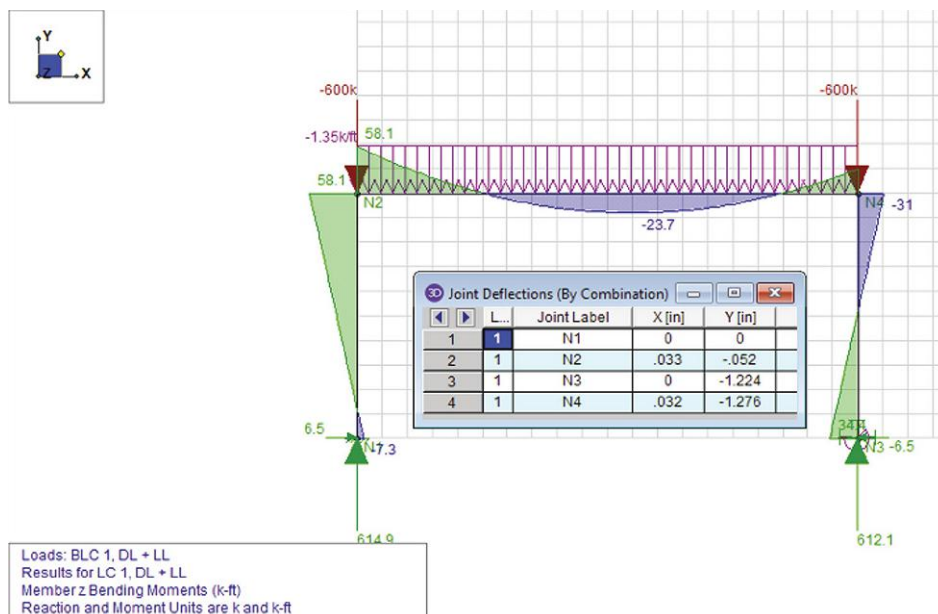


Figure 8 Structural analysis using RISA-2D for varying stiffness at right reaction.

building occupancy on a 10-year schedule. New York City recently experienced a sudden collapse of a Manhattan parking structure and has instituted a similar law. California (and all other states) are considering similar measures, like California's Balcony Law (Senate Bill 326), which requires structural examination every 6 to 9 years for wood balconies.

Portal Frame Analysis

For simplicity, this paper examines a single-bay portal frame. A portal frame is a snapshot of a larger multi-story moment frame system and illustrates these concepts with a basic analysis where one support sinks. Modeling this with a portal frame allows an engineer to analytically determine reaction results when ground movement occurs at one side of the frame. Degrading

soil stiffness results in shifting load and moments in the superstructure. Let us take this principle and apply it to a basic building frame system, as shown in Figure 5.

The dimensions were taken from the plans of a recently collapsed building and are for a one-story version of a garage structure. As Point D deflects downward, the deformed structure above shows the elastic curve and movement of Point B, with the assumption that Points A and C are stable for simplicity. In reality, we do not know if Point C is stable, but for this analysis, we will assume it is.

If we take this concept and extend it to a multi-story, multi-bay structure (see Figure 6), the analysis becomes more complex because of the variability in the ground movement.

Case Study Of Single Bay Moment Frame

Let us look at a single-bay frame taken from a recent collapse (see Figure 7), which has Cases A and B.

Case A:

Conventional portal frame analysis with stable foundation support

Case B:

Portal Frame analysis with degrading foundation stiffness at Point D

Case A provides a symmetrical moment diagram and is in many textbooks, so it is not presented here. Case B is shown with actual vertical loads from the building calculation but with no lateral loads.

The moment redistribution and shifting of the reaction load is evident with a modest 1.28-inch deflection, see Figure 8. This affects and magnifies the moment values higher at Point A [N1] as Point D [N3] displaces further, and the moment at Joint B [N2] is increased. In principle, the structural theory

is proven here that ground displacement will affect the moments, shears, and axial loads in the frame structure above. Similar conclusions will apply to other building types (i.e., shear wall structures, braced steel frames, concrete frames, wood frames, etc.).

Examples Of Structural Damage

From the textbook to the real world, we are now faced with physical evidence of structural cracking in columns and beams that may threaten the superstructure.

Figure 9 is such a case for a three-story complex with subterranean parking that has extensive cracking in column locations and is currently under citation.

Figure 10 is a 22-story steel high-rise that has areas of water damage in the subterranean parking area, as shown in

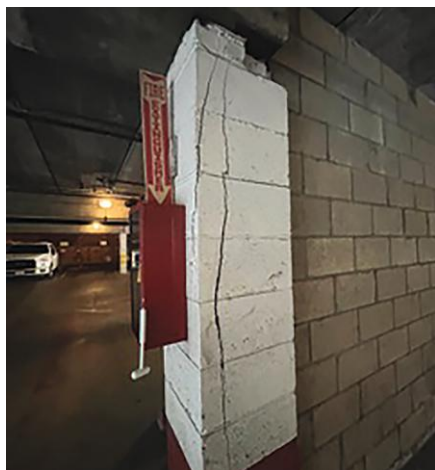


Figure 9 Subterranean parking structure with structural cracking indicates potential ground settlement and/or lateral movement.



Figure 10 High rise building resting on 4 levels of subterranean parking.



Figure 11 Corrosion effects on steel frame moment connection in parking structure.

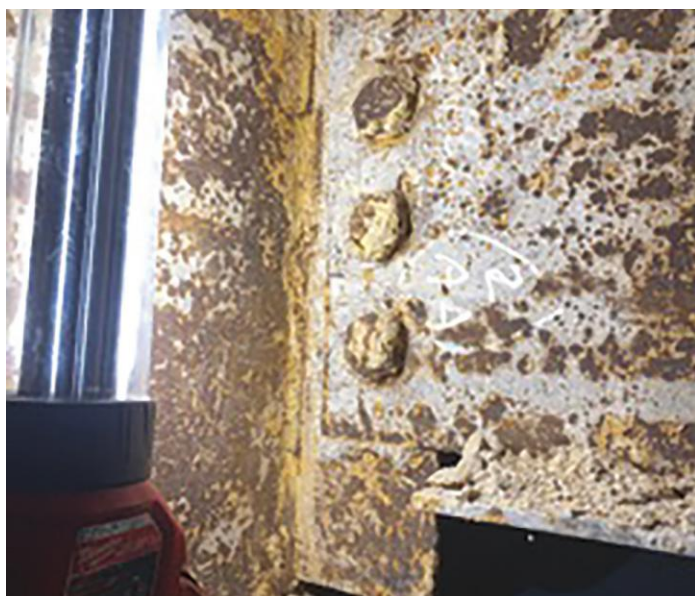


Figure 12 Corrosion damage to steel moment bolted connection. Deflection checks are important to determine if amplified moments could cause cracking.



Figure 13 Subterranean parking column cracking with no seismic lateral connection on the beams.

Figure 11. Examination of the structural connections is one part of the investigation. Structural engineers are also investigating whether ground displacement has led to asymmetric moment distributions and amplified stresses in the moment frame joints.

Figure 12 shows a beam connection with deterioration that passed testing, but this is not sufficient to conclude if the structure has displaced vertically. A physical survey should be part of the investigation process.

Figure 13 illustrates a potential column overstress that may be due to settlement and/or water damage.

Conclusions

The structural theory of stable foundations ought to be questioned based on recent and historical examples of settlement that have affected the structural distribution of loads. Structural engineers need to recognize these phenomena as potentially damaging, assess root causation, and address these concepts in standards, guidelines, and code provisions.

Our profession should take a proactive stance on this issue and call for research focused on this topic to upgrade and address our codes and standards. Our industry has an unfortunate "slow response" time to institute code changes. Still, we, as practicing structural engineers, should be examining our design practice based on practical analysis, not standards formulated by researchers and theoreticians.■

DISCLAIMER: The author, Dr. Khatri, is not part of any investigation team or research group funded by any entity. The examples cited here are for discussion only and do not suggest that these are established/proven conclusions for open cases. Dr. Khatri is a structural engineer with over 40 years of academic and professional experience and is not purporting to represent any structural opinions on open failure investigations, their designers, or causes of failure.

Dr. Khatri, Ph. D., S. E., is a consulting engineer and owner of Khatri International Inc., based in Las Vegas, NV and Arcadia, California. He has been a structural engineer for 41 years and is licensed across the USA, Canada, and Australia. He may be reached at dkhatri@aol.com.

STRUCTURE

NCSEA | CASE | SEI

AUGUST 2024

STEEL

Biomimicry in Design

INSIDE: Biomimicry at The Leaf 30

Circular Construction 10

Washington Univ. Research Building 48

Changes to ASCE 7-22 Flood Loads 53

Arizona Bill Ensures Continuation of Board of Technical Registration

Arizona lawmakers passed Bill HB2253, ensuring the continuation of the Arizona Board of Technical Registration (BTR), with Governor Katie Hobbs signing it into law on June 18. This decision ends the uncertainty that arose when the bill stalled in the Senate, threatening the BTR's existence beyond July 1, 2024.

The BTR regulates licensure, applications, renewals, complaints, and disciplinary actions for structural engineers and other professionals in Arizona. Its continuation is vital for maintaining high standards and protecting the health, safety, and welfare of Arizona citizens. The passage of HB2253 ensures the BTR will continue its crucial role in safeguarding public interests and upholding professional standards in Arizona. Moreover, the preservation of the BTR underscores the importance of professional regulation, which benefits structural engineers nationwide by reinforcing the significance of rigorous licensure and regulatory oversight.

NCSEA, as part of the Structural Engineering Licensure Coalition with CASE and SEI, supported the SEA of Arizona in advocating for the bill.



NCSEA Foundation Board President Tricia Ruby Honored With Humanitarian Award

Tricia Ruby, President of the NCSEA Foundation Board, is the recipient of the 2024 Horace H. Rackham Humanitarian Award from the Engineering Society of Detroit (ESD). This prestigious accolade recognizes outstanding humanitarian achievements through technical accomplishments or exceptional contributions to civic, business, public-spirited, or humanitarian endeavors.

Ruby is a strong advocate for diversity and inclusion within the engineering and construction industries. Her leadership roles in the NCSEA Foundation and ACE Mentor Southeast Michigan highlight

her commitment to these causes. Her dedication has earned her multiple awards, including the AFP Distinguished Volunteer Award and the ACEC National Community Service Award. Ruby was presented with the Rackham Award, ESD's highest honor, at the organization's annual dinner on June 26.



Tricia Ruby

STRUCTURAL ENGINEER SPOTLIGHT SERIES



NCSEA
FOUNDATION

Free Webinar Series Spotlights Inspiring Structural Engineers

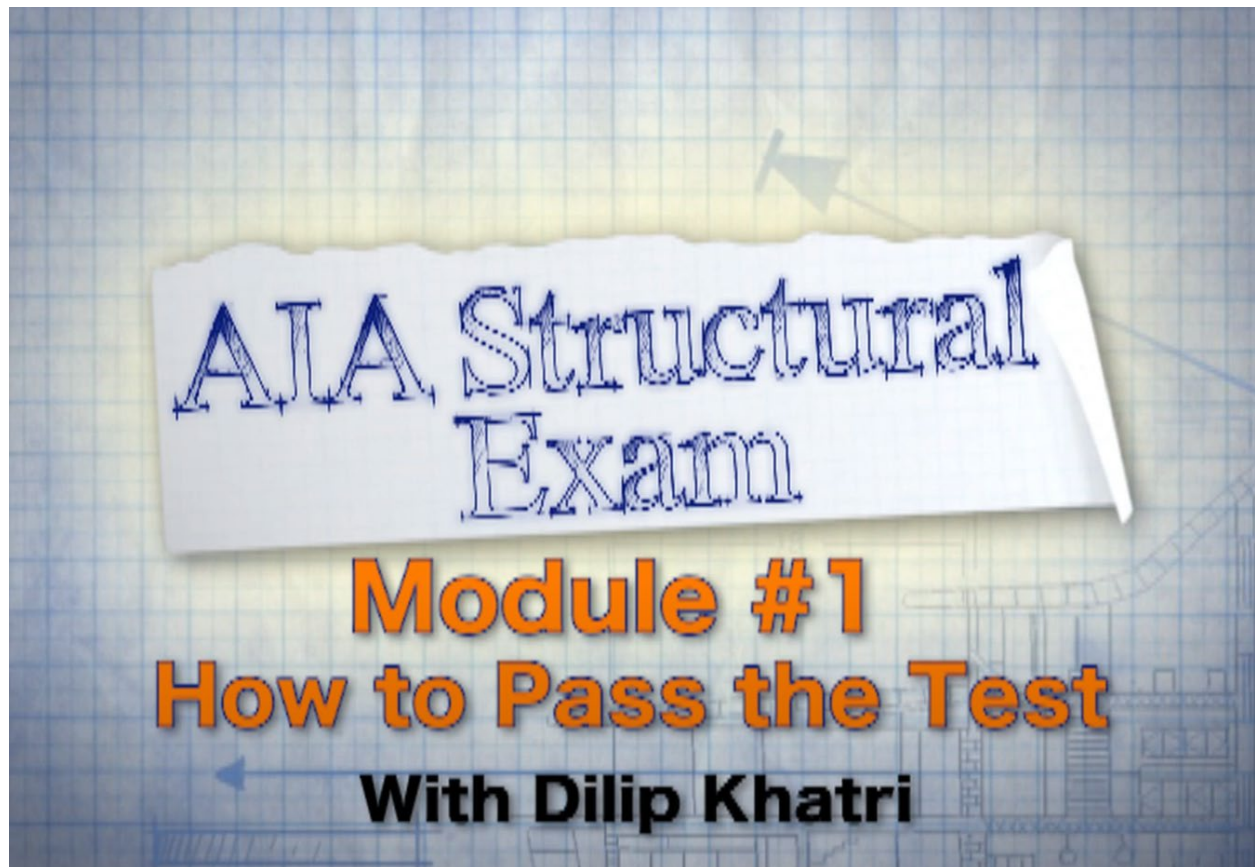
The NCSEA Foundation recently announced the launch of the "Structural Engineer Spotlight Series: Something From Nothing," a webinar series created by esteemed filmmaker Dilip Khatri. The series showcases the remarkable journeys of members from the Structural Engineers Association of Southern California (SEAOSC) as they rise from humble beginnings to become influential figures in the field.

The series kicked off with Episode 1 on July 19, featuring Lorena Arce, who shared her journey, struggles and achievements. Episode

2, airing on Aug. 16, will highlight Adena Geiger's story of moving from Iran, navigating a rigorous education process and earning her master's degree in civil engineering. It concludes with Episode 3 on Sept. 20, featuring Daryl Frigillana's path to becoming a structural engineer. Each webinar will take place at 10 a.m. PT/12 p.m. CT/1 p.m. ET and will include a live Q&A with the featured engineer. The webinar series is made possible by the NCSEA Foundation and is complimentary to attend.

YouTube Videos

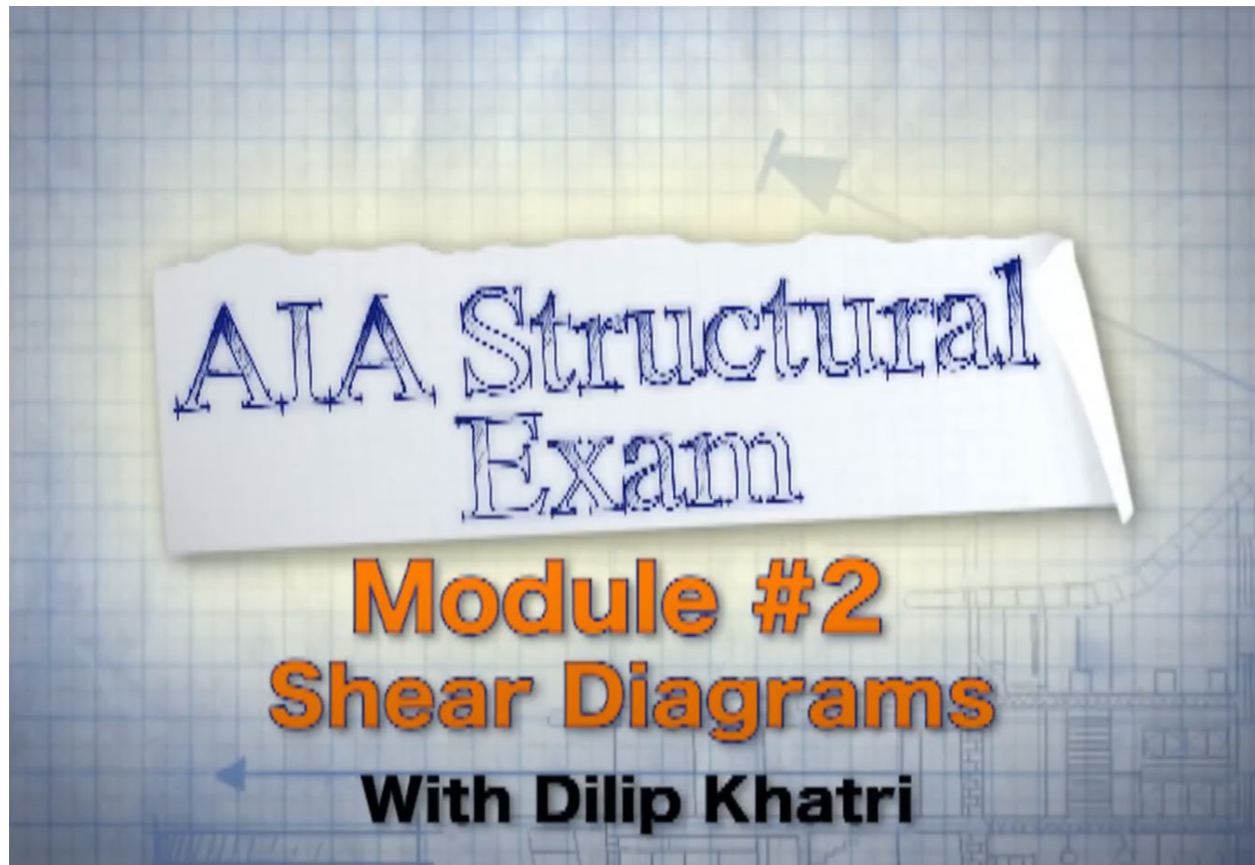
AIA Structural Exam Module #1 – How to Pass the Test



<https://www.youtube.com/watch?v=KsroawNCMJA&t=3s>

November 1, 2015

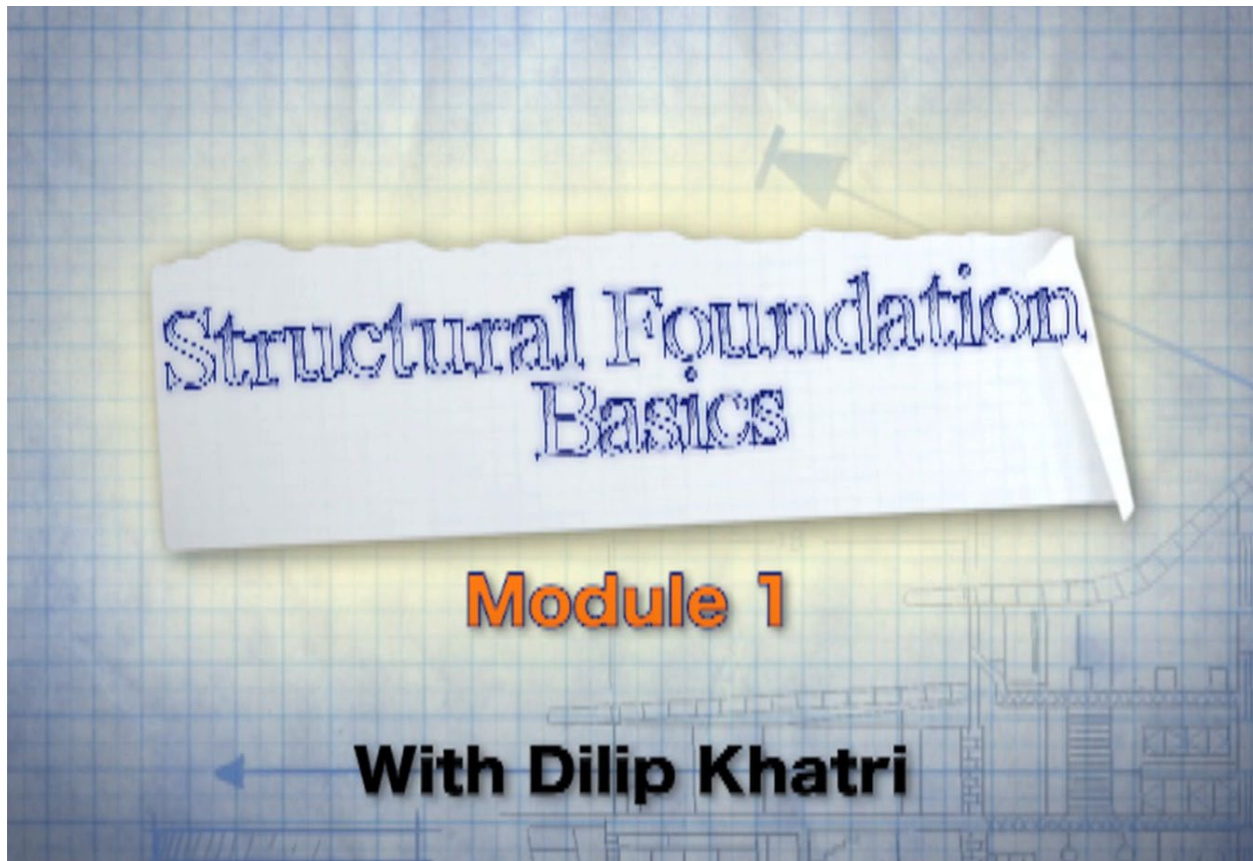
AIA Structural Exam – Module #2 – Shear Diagrams



https://www.youtube.com/watch?v=uO_57imlLac

November 1, 2015

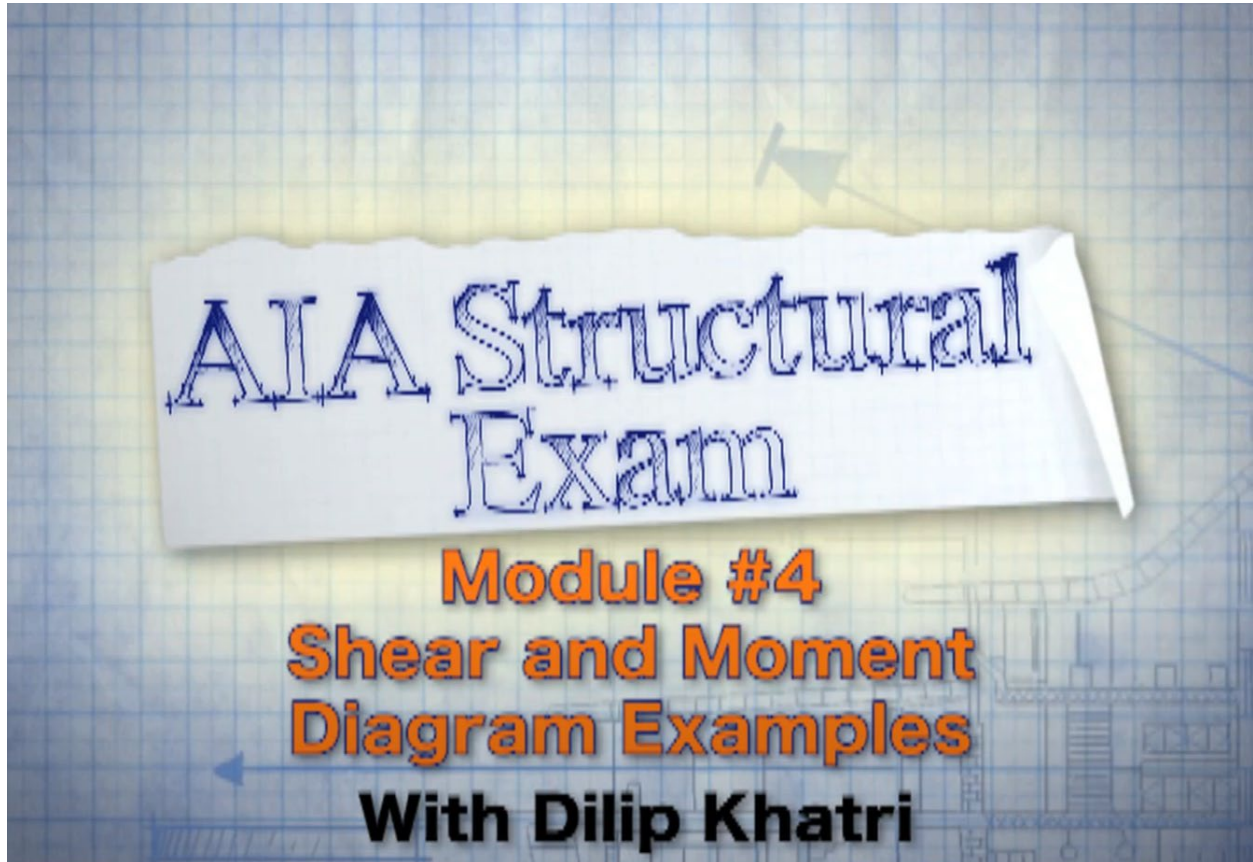
Structural Foundation Basics – Module 1



<https://www.youtube.com/watch?v=9Lp9d8EU8OY>

November 1, 2015

AIA Structural Exam Module #4 – Shear and Moment Diagram Examples



<https://www.youtube.com/watch?v=Mblno8v-cbY>

November 1, 2015

Building the Dream Version 2



BUILDING THE DREAM

<https://www.youtube.com/watch?v=PAp6rehU3L8&t=187s>

November 10, 2016

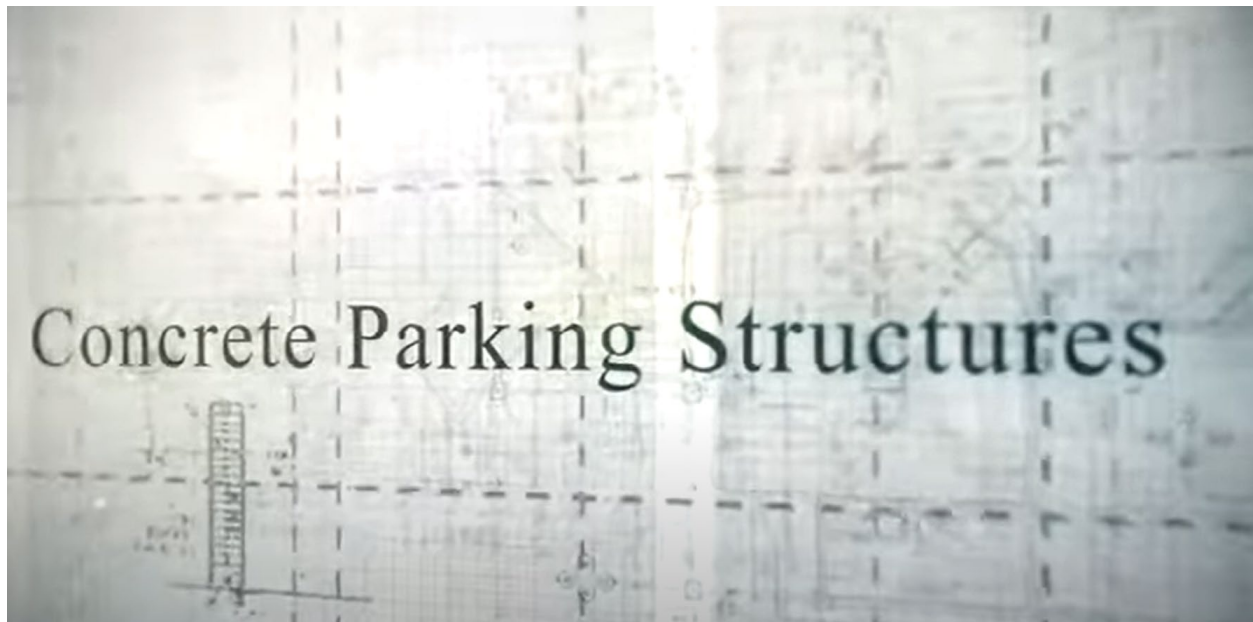
**Making Los Angeles a Safer Place: Earthquake Retrofit of
Buildings**



<https://www.youtube.com/watch?v=We4RQ2kYU4s&t=33s>

December 4, 2016

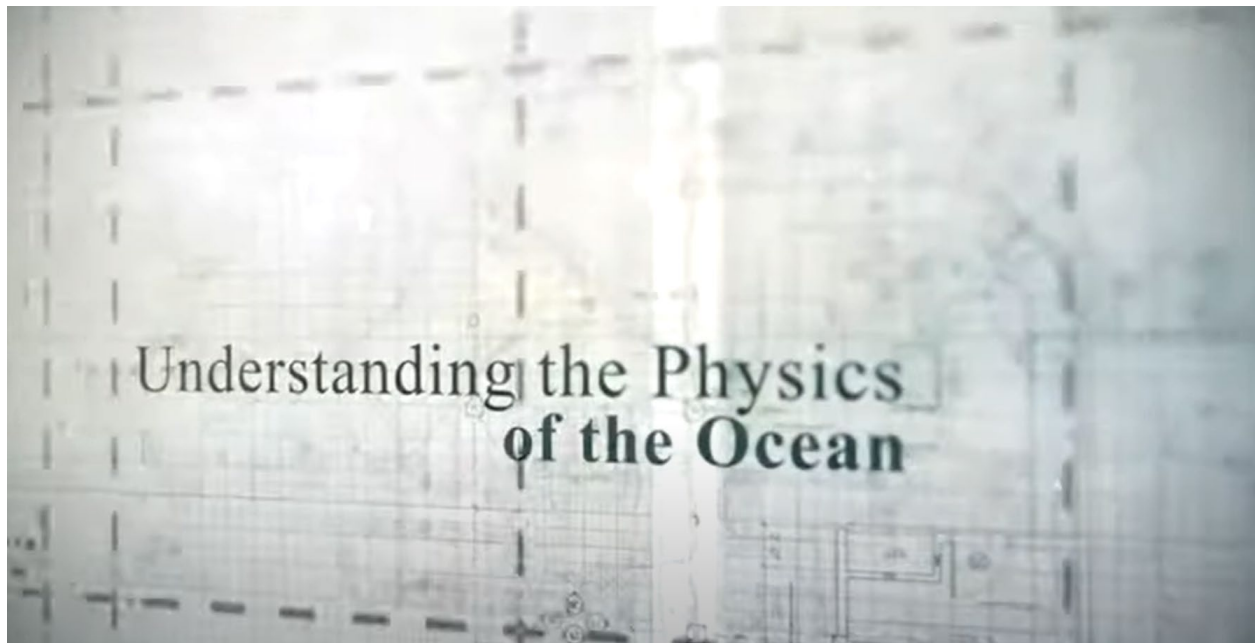
Concrete Parking Structures



https://www.youtube.com/watch?v=u_Mbm xhm_ws&t=11s

April 8, 2017

A Note on Sea Level Rise



<https://www.youtube.com/watch?v=skTVRGWFQy0&t=11s>

April 8, 2017

Wood Design Basics by Khatri



<https://www.youtube.com/watch?v=TEafeqq8aYs&t=12s>

April 8, 2017

Hello from Dilip Khatri, PhD, SE



<https://www.youtube.com/watch?v=PwVuyEKhqKQ>

January 24, 2018

Aspire To The Sky: The Wilshire Grand Story – Official Trailer



<https://www.youtube.com/watch?v=9hMtDZbsrAw&t=7s>

January 4, 2019

**American Wind Energy Association: “Avoiding
Catastrophes”; Presented at the 2020 AWEA O&M
Convention**



<https://www.youtube.com/watch?v=d20pNYhst9U&t=74s>

April 4, 2020

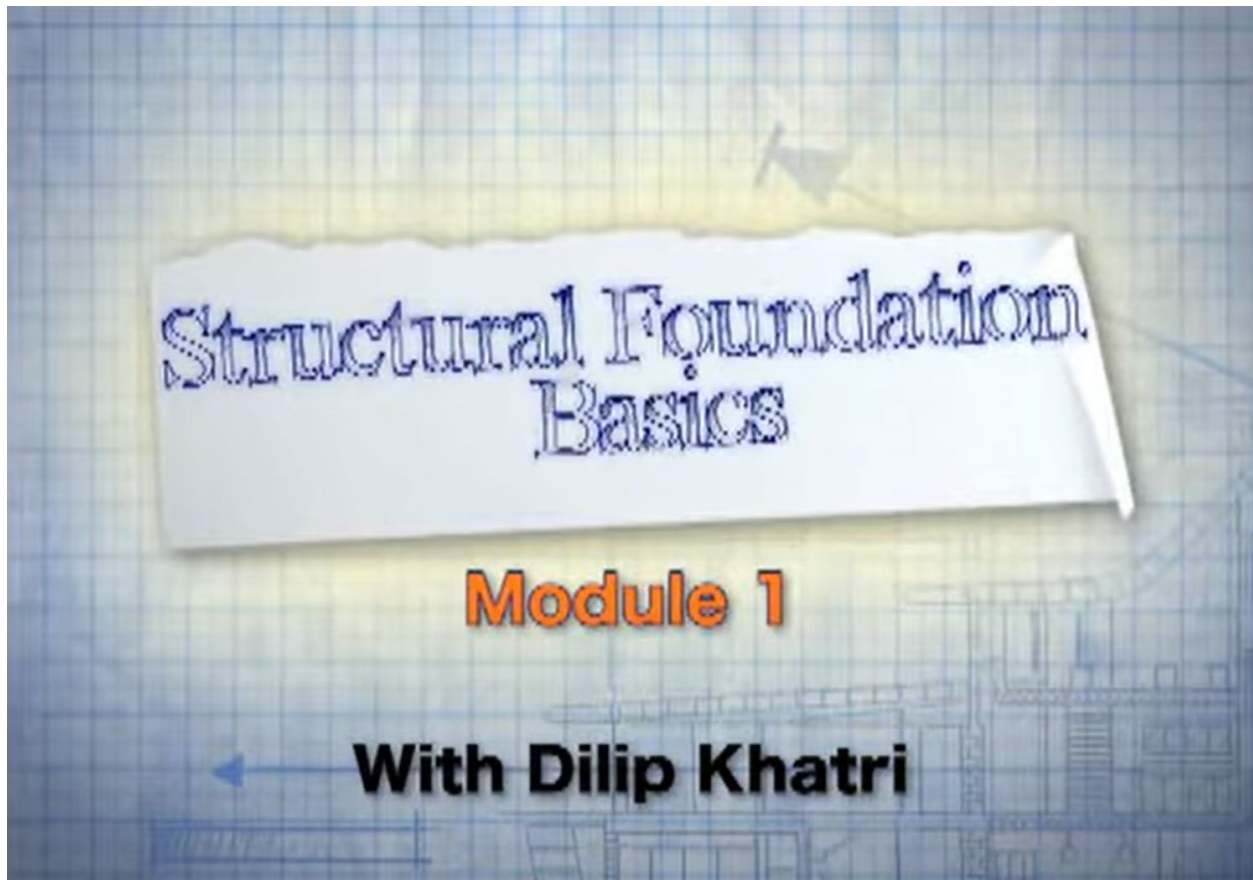
Roof damage investigation



https://www.youtube.com/watch?v=zLj_N6yYmuc&t=46s

May 13, 2020

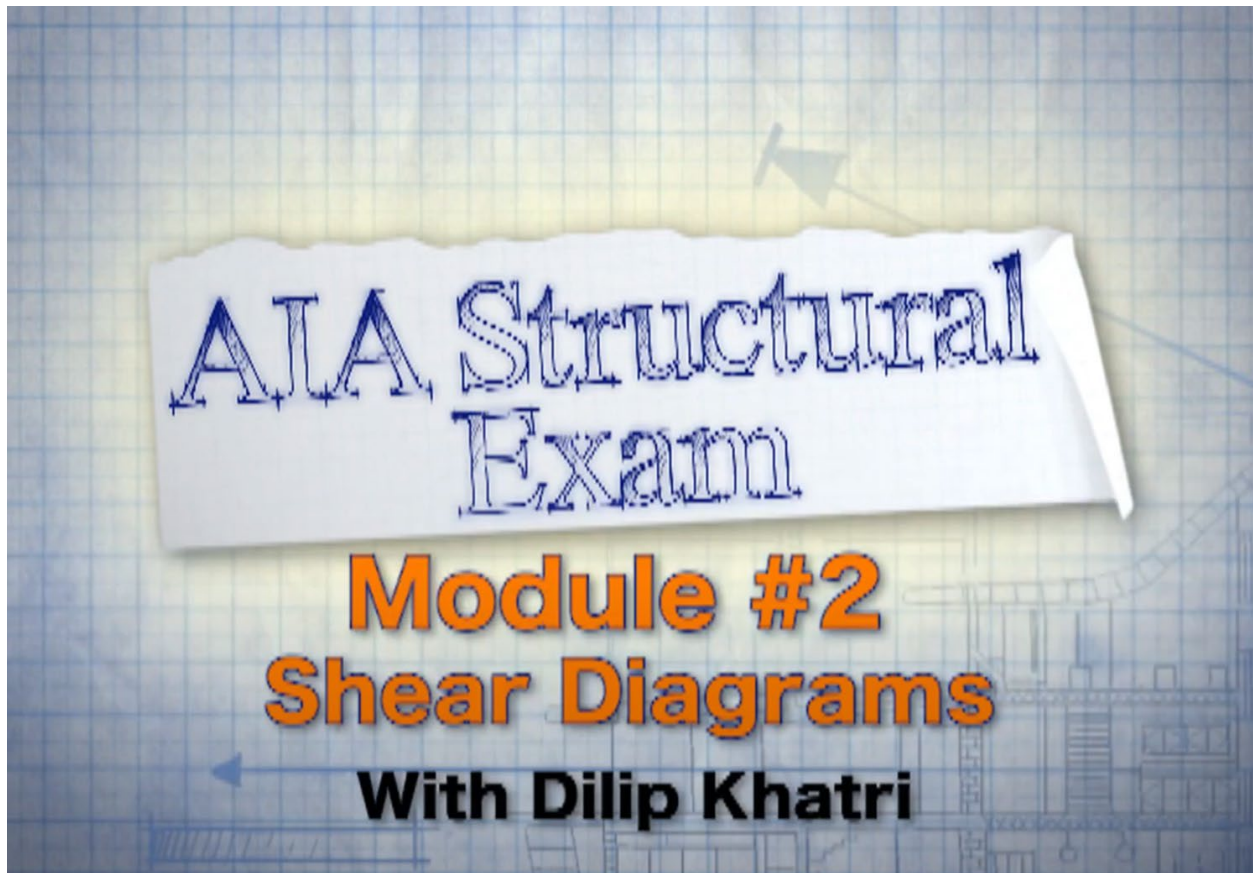
Structural Foundation Basics



<https://www.youtube.com/watch?v=bvytg2YsyEQ&t=13s>

July 12, 2020

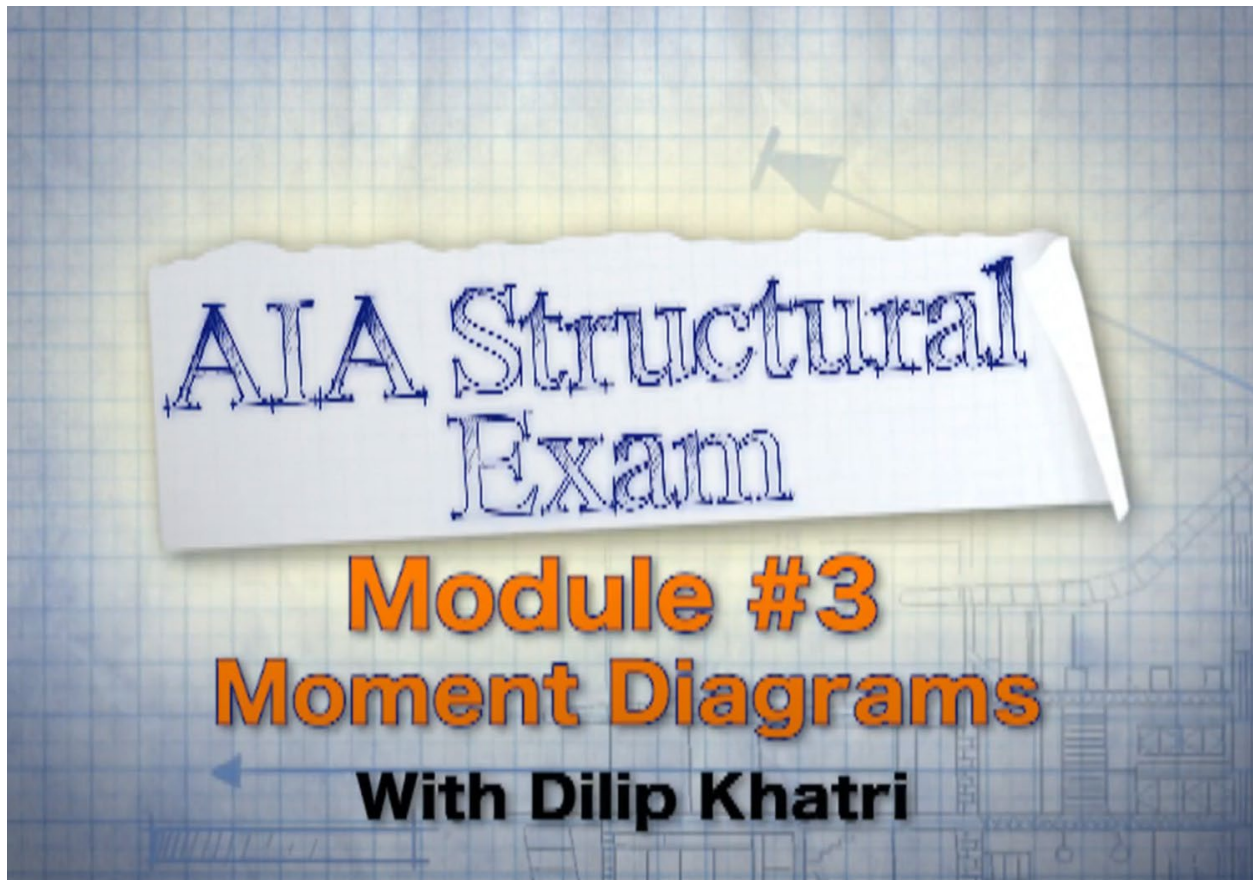
AIA module 2 Master



https://www.youtube.com/watch?v=9bPj_Kzrqxc&t=10s

February 2, 2021

AIA module 3 Moment Diagrams



<https://www.youtube.com/watch?v=ZkRVwn6oKo&t=11s>

February 4, 2021

SB 326 Balcony Law

KHATRI INTERNATIONAL INC.

CALIFORNIA BALCONY LAW

PRESENTED BY: DILIP KHATRI, PHD, SE, PE

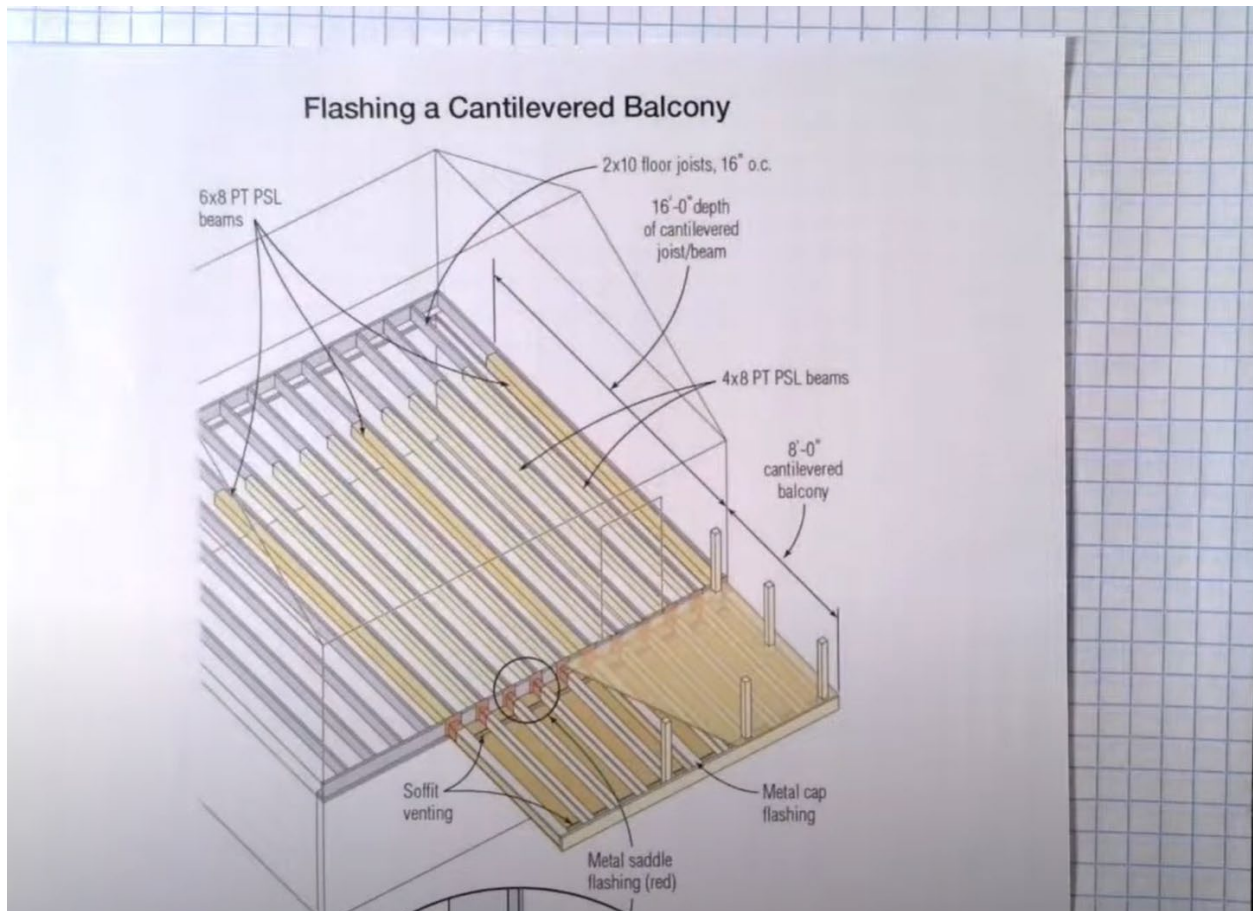
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3579 E. FOOTHILL BLVD., #736, PASADENA, CA 91107**

<https://www.youtube.com/watch?v=xP79KpLQrts&t=13s>

February 22, 2021

Part 2: Notes for Balcony Inspection



<https://www.youtube.com/watch?v=XI4VIOEzvhg&t=5s>

February 23, 2021

Texas Water Loss Evaluation for Wood Structures

WATER DAMAGE TO WOOD STRUCTURES

PRESENTED BY:

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DKHATRI2006@GMAIL.COM

626-351-4830

<https://www.youtube.com/watch?v=nGQrQhJdu6E&t=9s>

February 24, 2021

2021 June 28 Report 1 Champlain Failure by Dr. Khatri



<https://www.youtube.com/watch?v=MkYpzSuWrIk&t=7s>

June 28, 2021

2021 July 2 Report 2 Champlain Tower Collapse



**CHAMPLAIN TOWER COLLAPSE
REPORT #2
REVIEW OF PLANS
STEEL + CONCRETE CORROSION
7/2/2021**

**PRESENTED BY:
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PHD, SE, PE
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INTERNATIONAL
INC.
STRUCTURAL
ENGINEERS
dkhatri@aol.com**

KHATRI INTERNATIONAL INC.

<https://www.youtube.com/watch?v=foxcHCZq25Q&t=5s>

July 4, 2021

2021 July 12 Report 3 Champlain Tower Collapse



**CHAMPLAIN TOWER COLLAPSE
REPORT #3
REVIEW OF PLANS
FOUNDATION PERFORMANCE
7/12/2021**

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ENGINEERS
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<https://www.youtube.com/watch?v=R1VFcguTc9w&t=5s>

July 12, 2021

2021 Aug Fatigue Analysis of Wind Tower Foundations

FATIGUE ANALYSIS OF WTG CONCRETE FOUNDATIONS

DR. DILIP KHATRI, PhD, SE
Principal

KHATRI INTERNATIONAL INC.
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dkhatri@aol.com

<https://www.youtube.com/watch?v=5-q0shFxUfM&t=18s>

August 20, 2021

2021 August 27 Report 4 Champlain Tower Collapse

**CHAMPLAIN TOWER COLLAPSE
REPORT #4
ANALYSIS OF DIFFERENTIAL
SETTLEMENT
FOUNDATION PERFORMANCE
8/27/2021**



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ENGINEERS
dkhatri@aol.com**

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<https://www.youtube.com/watch?v=aXn5V21ejhE&t=12s>

August 27, 2021

2021 Sept something from nothing KD Final 2

SOMETHING FROM NOTHING

A WEBSERIES BY DILIP KHATRI

<https://www.youtube.com/watch?v=sPmzJzUBIU0&t=39s>

September 24, 2021

Introducing New Structural and Architectural Design Lessons



<https://www.youtube.com/watch?v=BdViiFlhK1k&t=4s>

February 3, 2022

Aspire to the Sky | The Wilshire Grand Story

WINNER OF OVER 70
INTERNATIONAL FILM FESTIVAL AWARDS



<https://www.youtube.com/watch?v=LPFcVNI71vU>

February 28, 2022

The Wilshire Grand Center Story of Construction



<https://www.youtube.com/watch?v=LLvlqq7xD0w&t=3s>

March 2, 2022

Interview with Robert DeNichilo



ROBERT DENICHILO

INTERVIEW

**MARCH 8TH 2022
HILTON ORANGE COUNTY/COSTA MESA**

<https://www.youtube.com/watch?v=3w4Y98bpjSY&t=13s>

March 30, 2022

Interview with Angela Adams



ANGELA ADAMS

INTERVIEW

**MARCH 8TH 2022
HILTON ORANGE COUNTY/COSTA MESA**

<https://www.youtube.com/watch?v=p35h193vf7M&t=1s>

March 31, 2022

Interview with Erica Wood



ERICA WOOD

INTERVIEW

**MARCH 8TH 2022
HILTON ORANGE COUNTY/COSTA MESA**

<https://www.youtube.com/watch?v=0YzyR7uGuIM&t=4s>

March 31, 2022

Interview with Michael Kennedy



MICHAEL KENNEDY

INTERVIEW

**MARCH 8TH 2022
HILTON ORANGE COUNTY/COSTA MESA**

<https://www.youtube.com/watch?v=3FexfN3ZRSA&t=5s>

April 1, 2022

Interview with Alain Vina



ALAIN VINA

INTERVIEW

**MARCH 8TH 2022
HILTON ORANGE COUNTY/COSTA MESA**

<https://www.youtube.com/watch?v=5hDtzS4Z1Pc&t=21s>

April 1, 2022

Something From Nothing: Episode 1



SOMETHING FROM NOTHING

<https://www.youtube.com/watch?v=86q1ApXrA4Y&t=7s>

April 4, 2022

SB 326 Balcony Law Presentation – CAI-OC Program at the Hilton Costa Mesa March 8, 2022

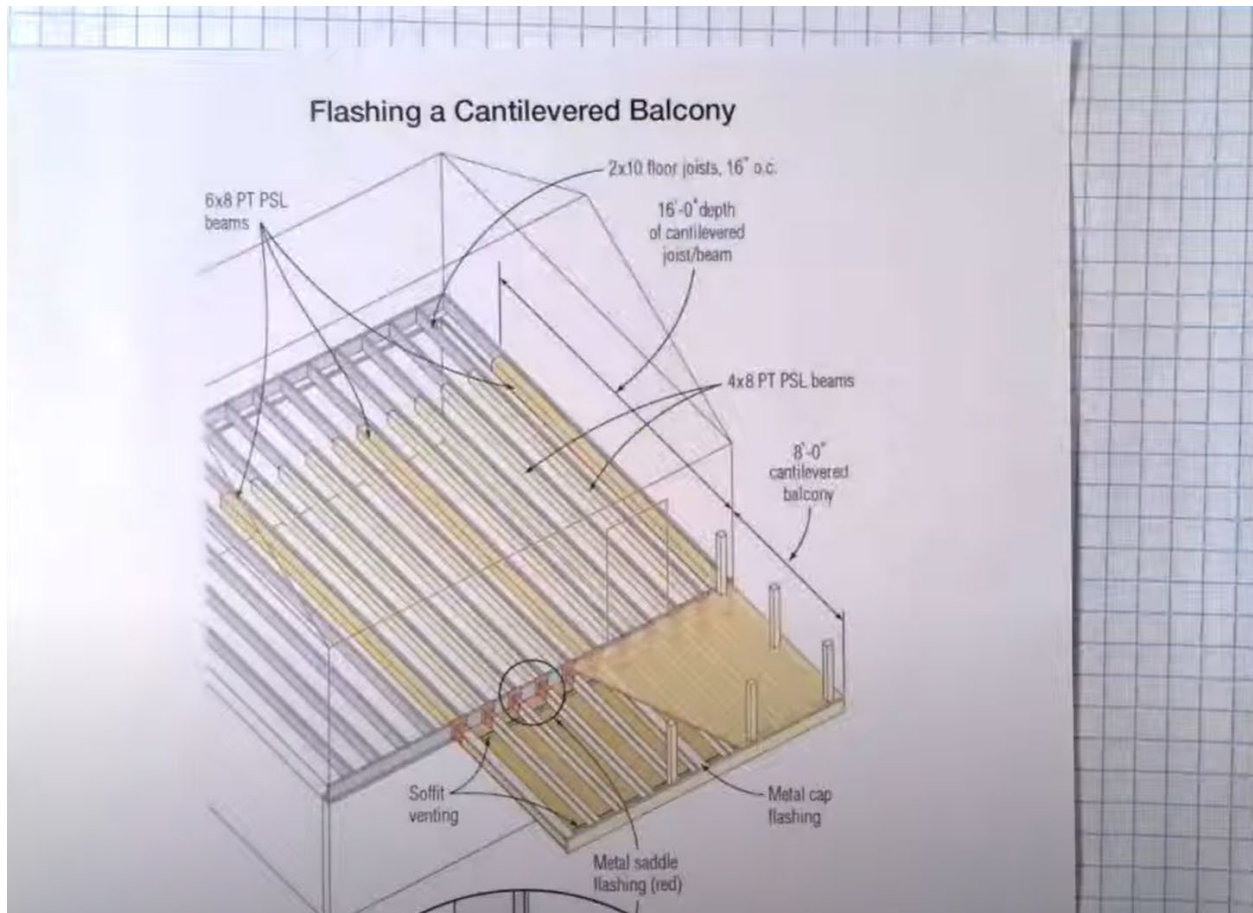


SB 326 Balcony Law Presentation CAI-OC March 3, 2022

<https://www.youtube.com/watch?v=otVvKa-sEEs&t=3s>

April 7, 2022

2021 Feb 19 – 010635 Cantilevered Balcony



<https://www.youtube.com/watch?v=dzcD0Xq4nus&t=7s>

April 8, 2022

Welcome to Structural Stories – Channel Intro

STRUCTURAL STORIES

<https://www.youtube.com/watch?v=HtmJIHfXqw&t=44s>

September 15, 2022

The Wilshire Grand Tech Talk

The Wilshire Grand Center TECH TALK

<https://www.youtube.com/watch?v=9t6XiDzTIKc&t=12s>

January 2, 2023

2019 Interview at Nice Film Festival



<https://www.youtube.com/watch?v=ut9pQfuK-1U&t=7s>

January 2, 2023

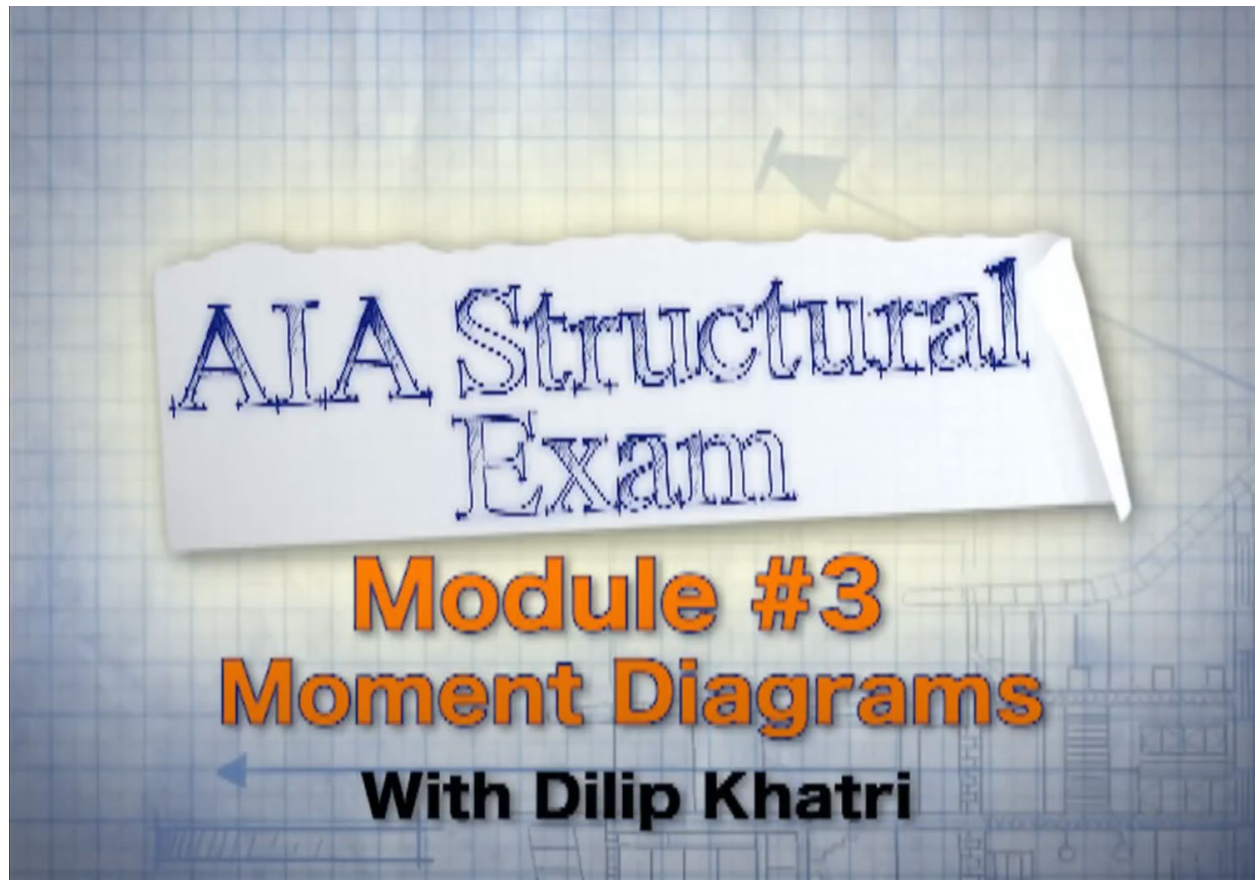
2019 Madrid International Film Festival



<https://www.youtube.com/watch?v=-jOraxFhC7Y&t=6s>

January 2, 2023

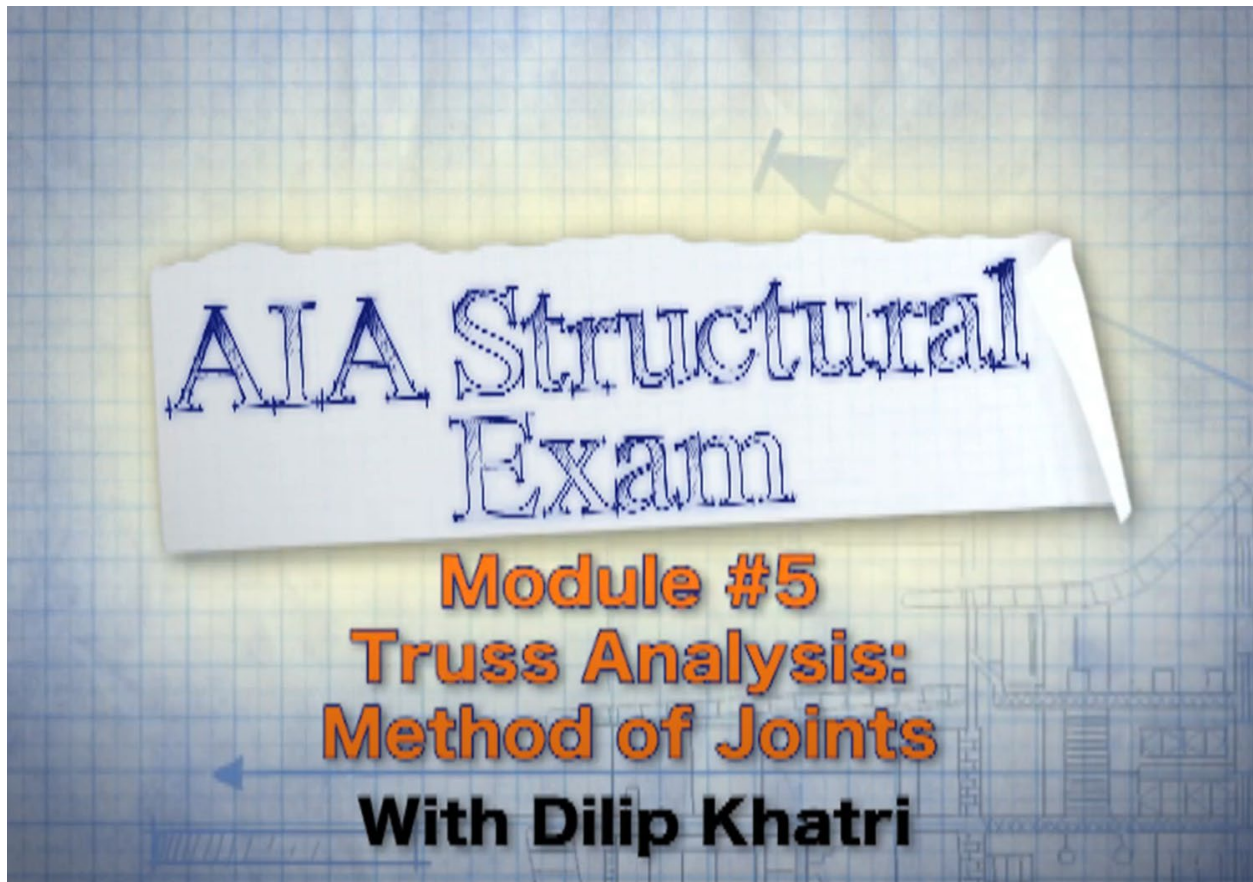
AIA Structural Exam – Module #3 – Moment Diagrams



<https://www.youtube.com/watch?v=tfxgQSAPxn4&t=10s>

January 15, 2023

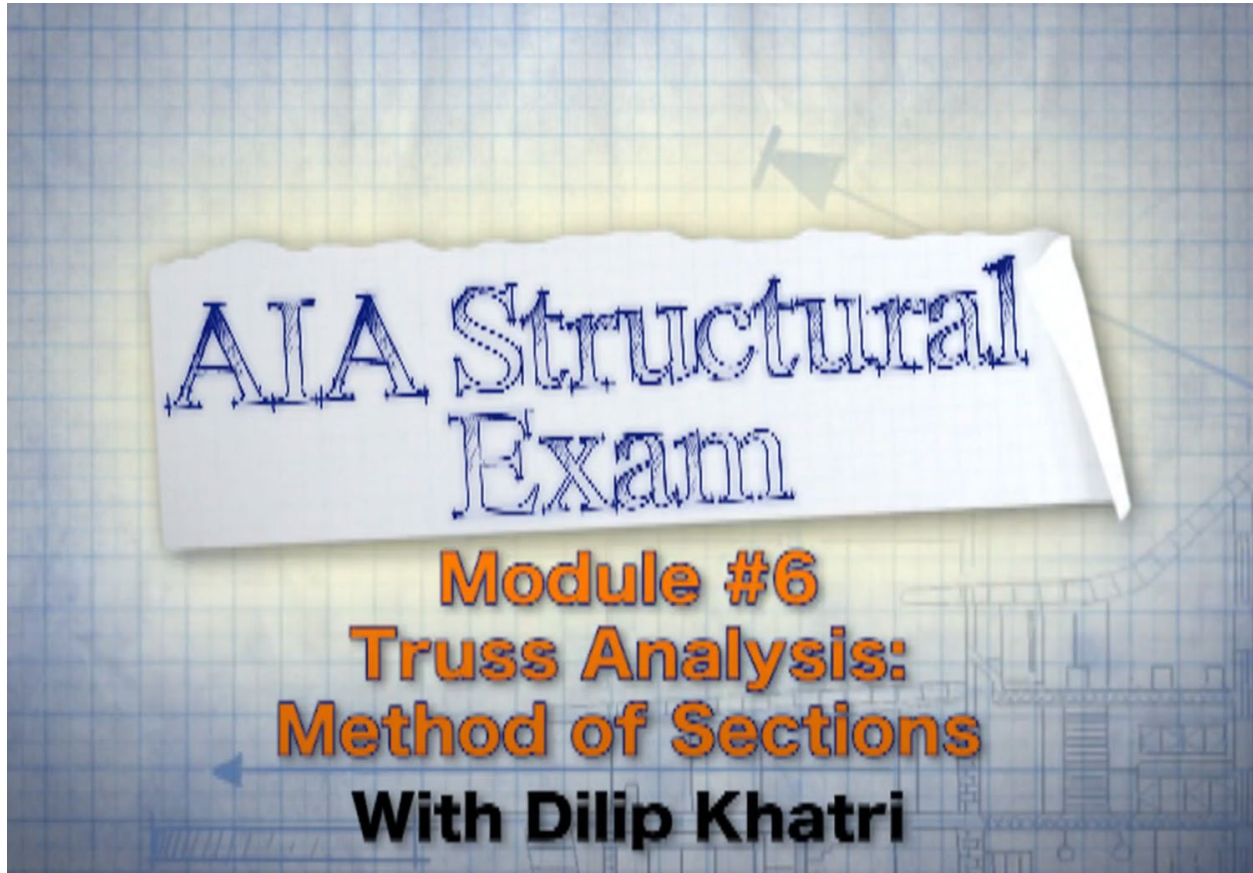
AIA Module 5 Truss Analysis: Method of Joints



<https://www.youtube.com/watch?v=jW5IH7YboRk&t=8s>

January 15, 2023

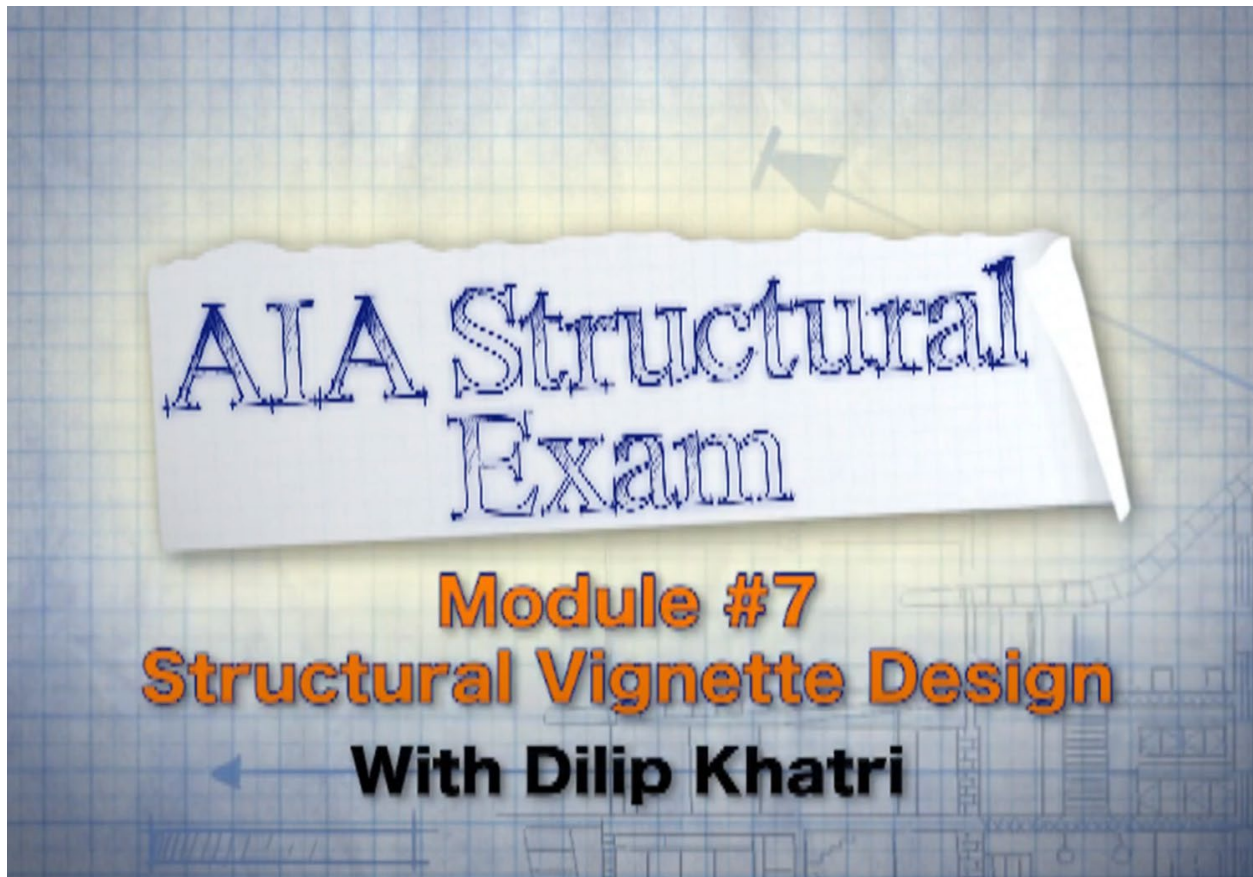
AIA Module 6 Master Dilip Khatri: Truss Analysis Method of Sections



<https://www.youtube.com/watch?v=0WSIKlqmoCU&t=16s>

January 15, 2023

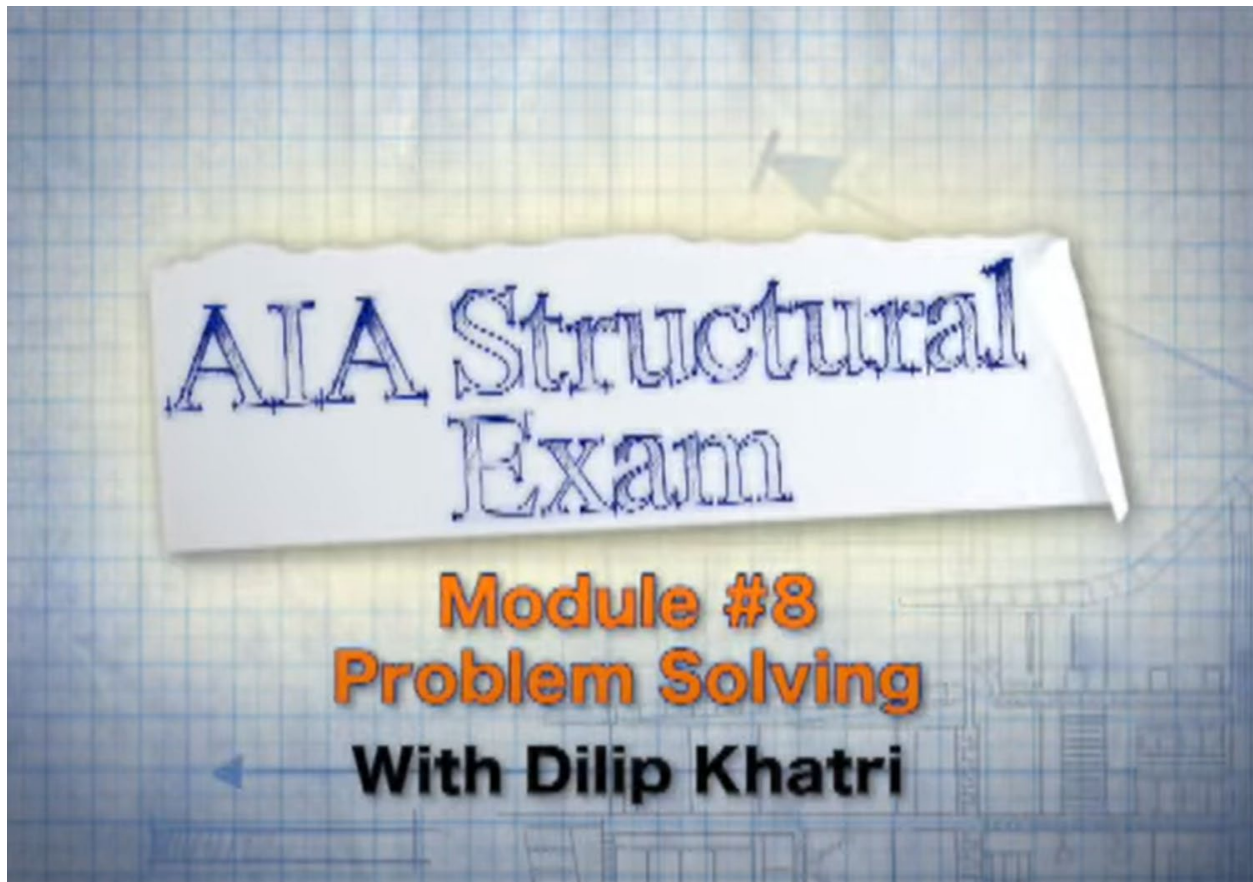
AIA Module 7 Master Dilip Khatri: Structural Vignette Design



https://www.youtube.com/watch?v=qfmTF5MZ3_A&t=3s

January 15, 2023

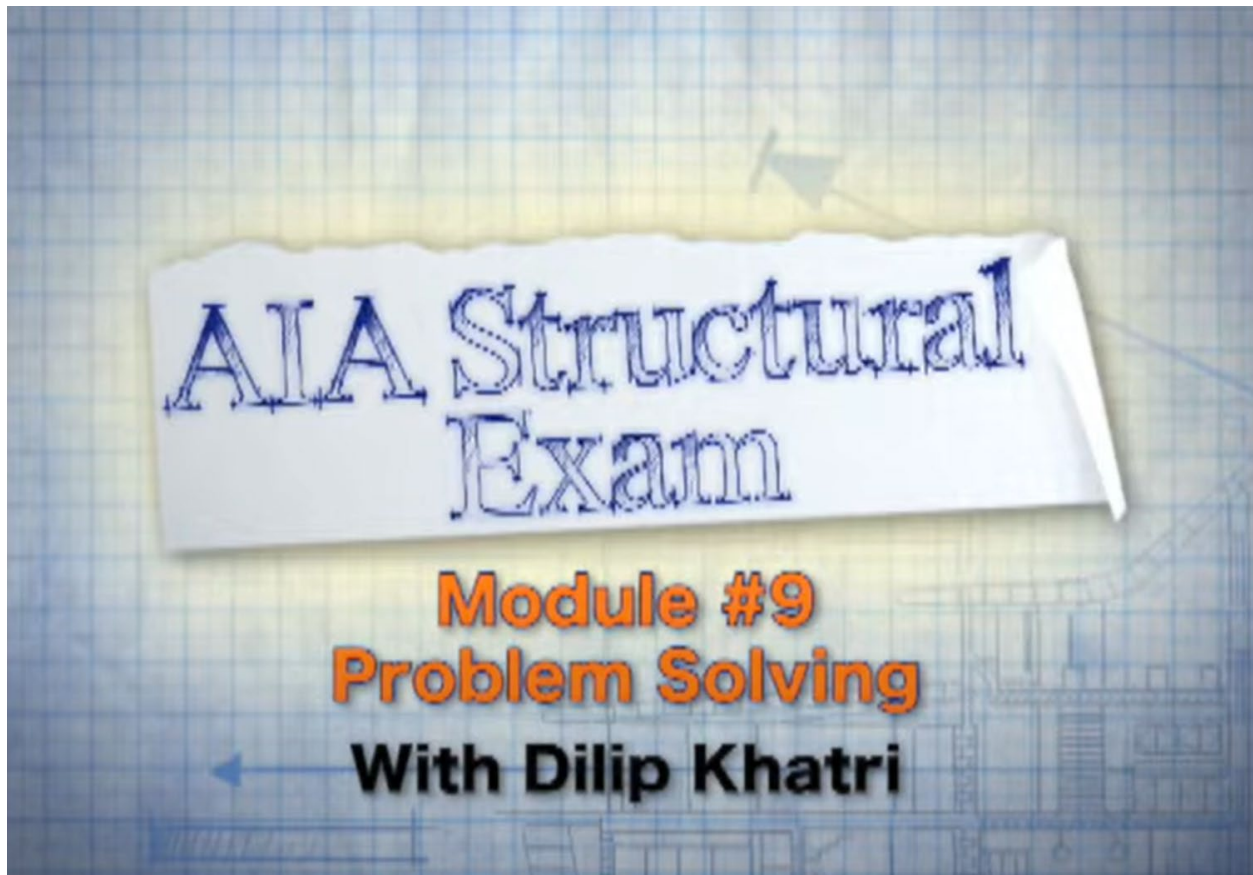
2023 AIA Structural Design #8 Vignette Design



<https://www.youtube.com/watch?v=mtHUj6Okc2Q&t=5s>

January 16, 2023

2023 AIA Module 9 Problem Solving



<https://www.youtube.com/watch?v=iu608m-D03Y&t=5s>

January 16, 2023

Structural Retrofit of Buildings

RETROFITTING OF STRUCTURES

<https://www.youtube.com/watch?v=Pj0LHplzrEs&t=4s>

January 19, 2023

Master Degree in Structural Engineering USA



https://www.youtube.com/watch?v=1-MPb_98jVc&t=5s

January 29, 2023

Aging Infrastructure

CITY-COUNTY ENGINEERS ASSOCIATION

JUNE 2, 2022

AGING INFRASTRUCTURE



DR. DILIP KHATRI, PhD, SE

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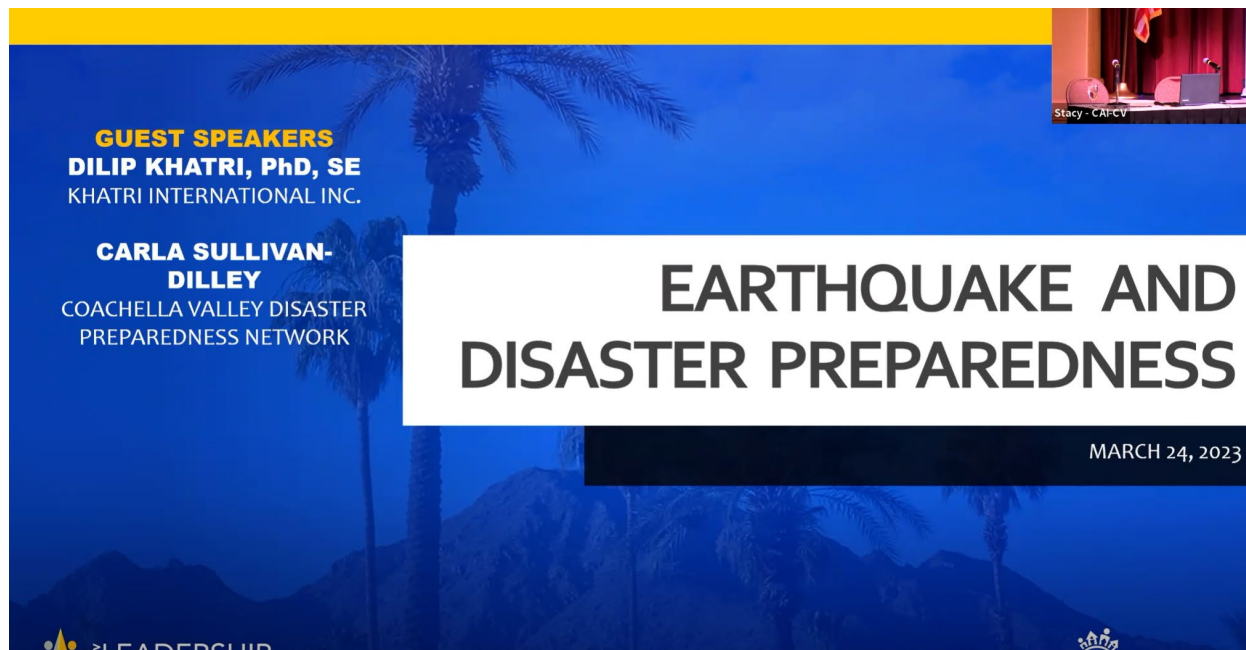
www.khatrinternational.com

dkhatri@aol.com

<https://www.youtube.com/watch?v=Hrt7PIAjxYA&t=170s>

February 21, 2023

Earthquake Presentation for Coachella Valley CAI



The thumbnail features a blue background with a palm tree and mountains. A yellow bar is at the top. On the left, it lists guest speakers: Dilip Khatri, PhD, SE (Khatri International Inc.) and Carla Sullivan-Dilley (Coachella Valley Disaster Preparedness Network). The main title 'EARTHQUAKE AND DISASTER PREPAREDNESS' is in large white letters. The date 'MARCH 24, 2023' is in the bottom right. A small inset shows a speaker at a podium with a 'Stacy - CAPCV' sign. Logos for 'LEADERSHIP' and a crown are at the bottom.

GUEST SPEAKERS
DILIP KHATRI, PhD, SE
KHATRI INTERNATIONAL INC.

CARLA SULLIVAN-DILLEY
COACHELLA VALLEY DISASTER
PREPAREDNESS NETWORK

EARTHQUAKE AND DISASTER PREPAREDNESS

MARCH 24, 2023

LEADERSHIP

<https://www.youtube.com/watch?v=dDZmdfWIBF8&t=569s>

April 5, 2023

Something from Nothing Series Episode 2: Adena Geiger



SOMETHING FROM NOTHING

<https://www.youtube.com/watch?v=Gogd1617BS4&t=6s>

April 29, 2023

Something from Nothing Episode 3: Maria Mohammad, SE



SOMETHING FROM NOTHING

<https://www.youtube.com/watch?v=NA8TGG1TBAU&t=17s>

April 29, 2023

Something from Nothing Episode #4: Daryl Friglliana, PE



SOMETHING FROM NOTHING

<https://www.youtube.com/watch?v=BF9Vz3JWqAY&t=25s>

June 24, 2023

SEAOSC: Webinar Building Settlement and Structural Collapse Analysis



Webinar | Building Settlement and Structural Collapse Analysis

October 11, 2023

<https://www.youtube.com/watch?v=xtnkWmSYwOs&t=30s>

October 22, 2023

Southern Calif Landslide Repair SD

LANDSLIDE REPAIR STRUCTURAL RETROFIT OF BLDGS FOR COMMON INTEREST DEVELOPMENTS & RESIDENTIAL STRUCTURES

PRESENTED BY: DILIP KHATRI, PhD, SE, PE

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<https://www.youtube.com/watch?v=pQKpwEN6SyM&t=10s>

July 2, 2024

Aspire to the Sky: The Wilshire Grand Story



ASPIRE TO THE SKY
THE WILSHIRE GRAND STORY

<https://www.youtube.com/watch?v=FV3cGQjyxkw&t=22s>

November 14, 2024