Impact of Increased Precipitation on Midwestern Construction

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A comprehensive analysis of the effects of precipitation on the Midwestern construction industry.
Abstract

This magazine presents the current impact of increased precipitation in the Midwest on the construction industry. Mainly, the impact on jobsite safety, changes in design codes, and the resulting increasing insurance rates. The goal of this independent research is to gather a better understanding of the influence of these changes, because only then can one accurately seek to combat their harmful effects. As a vital element of the global economy, the construction industry must be conscious of their changing relationship with the environment around them. Therefore, understanding the affects of climate change, will increase awareness of toxic processes and help to develop more sustainable alternatives.

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Written and edited by Monica Feltman, a Civil Engineering student at the University of Akron. She has worked in the construction industry as a field engineer and construction estimator for over two years. In May of 2018, she received her OSHA 30-hour certification. This paper was written under the supervision of Robert Bunnell, Professor of Practice at The University of Akron.
This paper seeks to begin globally. When discussing the environment and climate change, people often like to speculate on the facts, when they are, however, facts. Therefore, this paper will begin with the basic facts of the plight of climate change.

The world is warming.

Not only is the world warming, but it is warming at a rate faster than anything seen before. According to Charles Downer, from the U.S. Army Engineer Research and Development Center, the average temperature has increased by more than 1.5°F in the time between 1900 - 2010. If you cut that range in half, from 1950 - 2010, the average temperatures are recorded to have increased twice as quickly. And if you were to shorten that range even further to 1980 - 2010, the increase in air temperature escalated three times as quickly. This near exponential increase will soon reach an inelastic level which will permanently damage the earth.

The below graphic depicts the increasing global temperatures over the past century. The temperature has drastically increased in the past 50 years.

Ice is melting.

To be more exact, land ice is melting. When ice that is already floating in the sea melts, it does not affect the sea level. It is the ice trapped in the polar islands, however, that has the potential to drastically raise the sea levels globally. Rising coastlines will affect every continent and the major cities that are located on them. According to the April 2017 issue of the National Geographic Magazine, since 1990, the total sea-level rise of about nine inches has been a major catalyst to the increase in coastal flooding. Hurricane Sandy, for example, caused $68 billion in damage due to flooding and high winds. As sea levels rise, engineers are forced to reevaluate the status of the current and future structures in order to comply with these changes.
3. **Weather is getting worse.**

The water cycle has become highly variable, largely in part due to the increase in humidity. The increasing temperatures from global warming add moisture to the air. This offsets the delicate balance in the water table, resulting in unpredictable bouts of precipitation. That variability intensifies stresses on vegetation which increases the atmospheric pollution. This affects large urban environments more severely. Additionally, the changes in precipitation patterns increase human vulnerability to disease due to infectious disease-carrying insects. The more dangerous or unpredictable the storm, the more severe the damages in terms of cost, structural stability and human life.

4. **It’s a human problem.**

With increasing population growth and production rates, it is not difficult to see the effects humans have on the environments around them. Granted, the earth has natural warming and cooling periods, but the global temperature increases that have been occurring have been nothing short of unnatural. According to the chart from the National Oceanic and Atmospheric Administration, not a single year in the past 40 has the temperature been below the baseline average.

Without swift and severe action, the earth and its human inhabitants will feel the consequences of passivity.
Comments on Climate Trends

Discussions on climate change are riddled with projections and estimates from every scientist and meteorologist down to the concerned neighbor with a rain gauge. However, climate trends are often difficult to express for a variety of reasons. Unlike baseball statistics or population growth, the climate trends offer basic outcomes due to the current state of the climate demanding change. These outcomes are developed into the Special Report on Emission Scenarios, SRES, and are used to include anticipated socioeconomic changes in the climate projection outcomes. The first outcome, A2, produces trends as if the inhabitants of the Earth make no life-long environmental changes, and the current trends on carbon emissions stay the same. The second, B1, and more hopeful, climate trend creates the projections assuming lower emissions are produced, and some semblance of the environment is saved. At such a tipping point in environmental conservation, any long-term futuristic discussion should include the possibility of either outcome to reduce the amount of uncertainty and confusion in the data presented. Additionally, as with every type of data collection, patterns require consistent data from as many long-term sources as possible. When dealing with precipitation over time, the severity of the trend can often be altered based on the representation of the data. For example, taken annually, the average percentage of rainfall will be different taken over 50 years as opposed to a single month. This variability in trends is what makes precipitation more difficult to predict than other parameters like temperature. This also exposes builders/engineers to the damaging consequences of underestimating the severity of the situation.

The Maps show the difference in projected changes of average surface air temperatures from 2071-2099 compared to a hundred years previous (1970-1999). Graphic Source 10
The damages of climate change will affect every aspect of human life, but this paper attempts to focus mainly on the impacts of precipitation in the Midwestern United States and its effects on the construction industry. This refined focus will allow the data presented to be more specific and detailed as it relates directly to its readers.

The Midwest, the nation’s breadbasket, the home of the plains, whatever it is called the Midwest is home. Home to over sixty-one million people. With eight of the fifty most populous United States cities located in the twelve Midwestern states, a major part of the nation’s GDP comes from this region. According to Downer, nineteen percent of the nation’s total GDP, or $2.6 trillion comes from the Midwest. This intensity is where the purpose of these articles is derived; to bring awareness to the construction workers and managers in this region of the consequences of the increased precipitation.

Many of the climate issues that come from the Midwest are due to the large range of seasonal air temperatures that the region experiences. This creates a higher energy demand for heating in the winter and cooling in the summer. According to the US Energy Information Administration (EIA), the average winter consumption of natural gas in the winter of 2014-2015 was $636 per resident but $731 for midwestern residents. Over the past decade, the consumption rates for the Midwest have well surpassed all national averages. The high reliance on fossil fuels for heating in the region increases the production of greenhouse gasses, perpetuating the cycle of global warming.
Historic Precipitation

Of all the researched climate projections, nearly every reputable resource suggests an increase in heavy rainfall. From May 2018 to April 2019, for the first time in the 120 years of record-keeping, the Lower 48 states had average precipitation of over 36 inches (36.2 inches). In 2019 alone, most locations in the Midwest, specifically, have seen totals within the top ten wettest years. Meaning the annual precipitation for 2019 was among the highest across most of the Midwestern cities. This increase in precipitation is not something new, the Midwest precipitation has been increasing for a while. Since 1895, the annual precipitation in the Midwest has increased by 2.5 to 5.5 inches in some places which equates to a 5-15% increase. That level of increase, for example, is as if the average June temperature in Ohio hypothetically surged from 79°F to 91°F. However, when it comes to precipitation, these drastic increases appear to go largely unnoticed. Additionally, of the decades recorded, the 1930s have been the driest on record, largely impart due to the Dust Bowl. The wettest decades on record have been the most recent three. John Walsh from the University of Alaska Fairbanks, explains that, overall, the locations that are typically dry will get drier and the wet locations will get wetter leading to more dangerous extreme weather.

The photos to the right/bottom, depict the improvements of doppler radar throughout history. Radar improvements have allowed meteorologists to precisely record the weather events as they occur. Meaning, the forecasted climate trends are more reliable now than ever before. As the understanding of the atmosphere improves, so does the meteorologists’ ability to predict the severity of weather events more accurately, which in turn, can save numerous lives in preventative warnings. With flooding and levee overflow being a major cause of the damages experienced by the Midwest, from major rivers like the Mississippi and Missouri. Being able to properly alert the public in an appropriate amount of time will allow residents to evacuate the danger zone.

A1: 57 S Band Radar (50s, 60s, 70s)
B2: 74 C Band Radar (70s, 80s and early 90s)
C3: WSR 88 D S Band Doppler Radar (mid 90s though today)
It is widely known that all precipitation drains to larger bodies of water and eventually to the ocean. So, when a region like the Midwest is hit with excessive precipitation, all the additional water must go somewhere. One option is to flow into the Great Lakes. In fact, Summit Lake located just three miles from The University of Akron in Ohio is the continental divide where water north flows into Lake Erie and water south flows to the Ohio River. As a result of the increasing precipitation, the Great Lakes have been experiencing near-record high water levels. Linda Lam, a writer for the Weather Channel, explains that there is an increased potential of severe coastal impacts such as lakeshore flooding and shoreline erosion. With an eroding coastline, the cities located on the coast can be impacted by losing real estate along the shore, structural stability in the coastal buildings, and possibly tourism in major cities like Chicago. In an article for the *Times Online*, Rita Alton, a Manistee, Michigan homeowner describes how the eroding coastline has created a clifftop eight feet from her front deck. This problem has been exacerbated by the little shoreline-ice cover. The ice normally provides a buffer against the pounding waves. The Great Lakes total winter ice-coverage has decreased by 63% since the 1970s. As ground temperatures rise and land ice melts, the coastlines along the Great Lakes will continue to rise and erode surrounding beaches. With more than 20% of the global total of freshwater, the largest single supply, and home to many aquatic species, the Great Lakes cannot afford to be altered in any way. According to Michigan State University climatologist, Jeff Andresen, any change to the Great Lakes will influence the friction surface drag, which will alter the heat and moisture content in the air. An unnatural heat or moisture content in the air leads to highly variable weather patterns, furthering the cycle of precipitation related problems.}

"It’s never been like this, the destruction is just incredible." - Rita Alton (Lake Michigan resident)

In 2019, Lake Michigan experienced the largest increase in mean lake levels with 3.25” recorded above average.
When discussing an increase in precipitation, the numbers recorded for total rainfall are not increasing due to a gradual increase in precipitation, but rather, the increase in the number and intensity of heavy rainfall days. Meaning, the ten wettest days recorded per year account for as much as forty percent of the total precipitation in that given year. Furthermore, the number of twenty-four-hour duration, one-in-five-year storms has increased four percent per decade since the beginning of the twentieth century.

When scientists describe something as a one-in-five-year storm or a hundred-year storm, it does not mean that caliber of event occurs every hundred years, it instead refers to the statistical probability of that event happening in a given year. So, a one-in-five-year storm has a 20% probability of occurring in a given year. These storms, in turn, have an increasing frequency by the decade.

Even more, the frequency of two-day rainfall is up 30%. Two-day storms increase the risk of flooding due to pre-saturated ground conditions. The intensification of the heaviest rainfall days combined with the increasing duration of the storm event produces more rainfall than most Midwestern cities are designed to handle.

Map (above) shows the percentage increase in the amount of precipitation falling in “very heavy” events from 1958 to 2012. Further proving the inconsistency of the precipitation increases, but the severity of the impact on the Midwest.

According to Professor Emeritus Miguel A. Medina, Jr. from Duke University, “essentially no.” He continues to provide the following reasons why:

1.) The antecedent moisture conditions on the ground surface. Meaning how much moisture was already in the ground and how much surface runoff the land can handle.

2.) Topographic conditions such as size, shape, and slope of the drainage area.

3.) The drainage area’s geographic location in relation to the path of the storm.

4.) The duration of the storm compared to the size of the watershed. For example, streams of shorter drainage areas will increase in streamflow before streams of longer drainage areas.

The factors contributing to the ability of a geographic location to handle a storm of significant duration make the long-term effects difficult to predict.
Flooding

When discussing the flooding on an averaged, national level, the numbers are far from alarming. However, that is a result of the trend magnitudes for increasing (Midwest) and decreasing (Southwest) floods canceling each other out. This provides further proof of the connection between flooding and increased precipitation. In places where the spring soil moisture is above average, such as the Midwest, the soils are unable to absorb the necessary amount of rainfall which causes additional flooding. These types of floods are referred to as “flash floods”; a leading cause of death among weather events. A major problem presented by the presence of flash floods is widespread sewage contamination. This occurs in places where the municipality uses a combined sewer, in which the treated water and the stormwater run through the same system. When high-intensity rainfall causes flooding, the sewers will overflow out into the streets and contaminate the surrounding areas.

Another major cause of the flooding is the rapid expansion of urban areas. The increased impervious pavements, like sidewalks, rooftops, and roadways, reduce the water infiltration in those areas. This increases surface runoff, which worsens the effect of high-intensity rainfall. In 2008 alone, flooding caused 24 deaths and $15 billion in losses in the Midwest. With the possibility of sewer contamination and increasing metropolitan construction occurring, the demand for new, updated infrastructure that protects human health in terms of water quality must be satisfied. As these flooding conditions worsen, current infrastructures such as levees, canals, and reservoirs may prove to be severely undersized.

CEDAR RAPID FLOOD

During what was considered a one in five-hundred-year storm, the Cedar River in Cedar Rapids, Iowa reached a historic level of 31.12 feet. The waters then expanded to cover 10 square miles (14% of the city). With that extensive coverage, it was estimated that 10,000 residents were displaced, luckily no flood-related deaths occurred as a result. The impact of the damages from the flooding placed the Cedar Rapids Flood as the six largest FEMA disaster in history with $6 billion in property damage and $848 million in public aid overall. In Iowa that month, it had rained every day and then on June 12th, five additional inches of rainfall became too much for the river to handle. The water had nowhere to go. It was predicted that a major cause of the flooding was due to the large agricultural fields that cover most of Iowa. These fields act similarly to the impervious pavement, in the sense that they allow water to flow more quickly to the waterways. The reduction in drainage time more rapidly increases the water level of the river which cannot handle the new input flow. As a result of the flooding in 2008 and its precarious location near the Mississippi River, the state of Iowa has developed an extensive flood protection plan to defend against future disasters and reduce the possible environmental damages.
When thinking about precipitation, snowfall is not likely to be the first thing that comes to mind. In reality, snow can be a very important form of precipitation to analyze.

Increasing Frequency

According to the NOAA, the frequency of extreme snowstorms in the Midwest has increased over the last century. A major cause of this is the increasing surface temperatures in the Atlantic Ocean, which again, puts additional moisture into the air. Reductions in the Arctic Sea ice create wind patterns that influence the development of intense winter storms in the eastern half of the United States. In a sense, the warming surface temperatures are disturbing the temperature balance of typically colder geographic locations. This is due to slower-moving systems of high-pressure patterns traveling over the North Atlantic. In simplest terms, storms occur when warm, moist air rises rapidly into the atmosphere, condenses and cools, then falls back to the ground in some form of precipitation. In many instances, however, the moisture to form the necessary evaporation comes from air masses moving through the area. Storms then occur at the boundaries between different air masses. In this way, the Midwest becomes the perfect theater for the meeting of the two pressure systems (cool, dry north and moist, warm south). If either of those competing pressure systems is altered, the effects of the changes can become unpredictable and more severe.

El Nino vs. La Nina

El Nino and La Nina are not specific storms that will hit a region during a set time of year. Rather, they are changes in the flow of the weather patterns, similar to construction changing the traffic patterns. During El Nino, Pacific winds are weaker, and the ocean is warm which increases dryness. During La Nina, the Pacific winds are stronger, and the Pacific ocean is cool which increasing precipitation where waters remain warm. When El Nino is present, snowstorms are twice as likely to occur in areas east of the Rocky Mountains based on data from the top one hundred snowstorms. Emphasis should be placed on the fact that the El Nino effect is a matter of probability not surety. With many factors influencing an increase in winter storms, it is important to note that El Nino may not be the sole cause of the additional storms. It would be beneficial, however, for outdoor occupations to be aware of the El Nino years that may affect their professions.

Winter Rain

Just as dangerous as winter snow is winter rain. The warmer temperatures surrounding the Great Lakes are creating an early onset of spring melt. This increases the duration of the rainy season. The snow is melting earlier in the year which results in more of the annual precipitation being rain instead of snow. When an area experiences an increase in the amount of winter rain, it pre-saturates the ground making spring floods more likely. Winter and spring precipitation will experience a more significant increase than at any other time of year at around ten to twenty percent increase.
Snowfall Trends

When looking at the snowfall trends over recent decades, the statistics are leaning towards extremes. In the northern states, the snowfall is increasing due to their location downwind of Lake Superior and Lake Michigan. The milder wintertime temperatures and the warmer waters causing less ice coverage on the Great Lakes is a probable cause of these increases. To the south, the trends are showing a reduction in the amount of annual snowfall likely for the same reasons.

Without lake effect snow to supplement the melting snow, the southern Midwest states are experiencing less and less snow coverage. Recent observations made by scientists at Michigan State University would confirm that the mild winter temperatures melt the snow more quickly despite more snow falling. This means that the warmer temperatures are not mitigating the risk of winter weather. The storms are still occurring, with ever-increasing frequency, the ground is simply melting the snow faster than normal. This means the aspects that make winter storms dangerous like decreased visibility and slippery road conditions are still at play and are still occurring at an ever-increasing rate.

Offutt Airforce Base in Nebraska — Photo Source 11

Bomb Cyclone

March 17, 2019:
Jason Samenow, a reporter from The Washington Post, reviews the National Oceanic and Atmospheric Administration’s March climate report:

“Flooding from the cyclone inundated ‘millions of acres of agriculture, numerous cities, and towns and cause[d] widespread damage to roads, bridges, levees, and dams’.”

The total economic damage from the historic storm is estimated at over $4 billion. With much of the suffering occurring in the Midwest due to blizzard conditions. When storms hit a widespread area like the “Bomb Cyclone” did, it makes it almost impossible for industries to be unaffected, whether its dangerous road conditions preventing employees from getting to work, or actual structural damages. In Nebraska, much of the losses came from ice slabs destroying crops and sub-zero temperatures damaging livestock. Nonetheless, when the weather impacts various industries, major preventable losses can occur.
Soon enough, the effects of the changes in climate will penetrate every aspect of human life. Without alteration, the construction industry will be impacted in many damaging ways. What is largely accepted as the oldest profession in the world, may no longer be able to operate in a safe or effective way. The following will attempt to explain the impacts the climate, especially the increase in precipitation in the Midwest has had on the construction industry.
Construction management is about delivering a project. It involves controlling time, cost, quality, and safety, and acting in a socially, politically, and environmentally acceptable manner.

“Construction management is about delivering a project. It involves controlling time, cost, quality, and safety, and acting in a socially, politically, and environmentally acceptable manner. “

-Construction Management Fundamentals, Second Edition
Quick Facts

about the Construction Industry

1. In the United States, the construction industry is worth $1.29 trillion with over 75% of spending occurring in the private sector. Many economists believe that these numbers will continue to rise in the upcoming years based on the amount of backlog currently in place.

2. In 2017, roughly 7.9 million people are employed in the US under construction related jobs. When the recession of 2008 hit, many workers were laid off, however, many companies are currently looking to replace their lost workers. In 2019, 11.3 million people were employed by the construction industry.

3. Concrete is the most used material in construction. This is congruent with the increased use of cast-in-place reinforced concrete in large commercial structures. Concrete is made using a mixture of cement, coarse and fine aggregate, and water.

4. In 2019, according to the Bureau of Labor Statistics, only 10.3% of the construction workforce is female. Of the entire construction workforce, 12% racially identify as minorities. Most government projects set goals or require the use of DBE, or Disadvantage Business Enterprise. This ensures that companies with minority owners have an equal opportunity during the competitive bidding process.

5. According to the Occupational Safety and Health Administration, OSHA, worker deaths in the United States, on average have been greatly reduced. In 1970 the average was 38 worker deaths a DAY, but in 2017 it was down to only 14 deaths a day. A major cause for this is an increased emphasis on workplace safety and training. On many jobsites, the construction companies require employees to obtain either an OSHA 30 HR or OSHA 10 HR safety certification.
Construction is a high-hazard industry, with many tasks that put workers in danger. As a leader in workplace fatalities, with 21% of all workplace deaths in the US from construction activities, the construction sector must emphasize safety to their workers. When jobsite conditions are not ideal, the risk of injury or death drastically increases, making weather a large adversary to the safety of workers. According to the Bureau of Labor Statistics, the construction industry faced 965 jobsite deaths in 2017. Although workplace safety is an increasingly prominent issue and the number of jobsite injuries is decreasing, many of the fatalities are still preventable. Of the most frequently cited OSHA violations, the “Fatal Four” account for 64% of all fatalities. It is estimated that 631 worker’s lives could be saved per year if these hazards were eliminated.

Although it is difficult to identify the exact catalyst for each of these types of accidents, it is highly possible that the weather could have added to the dangers. Falls are the most prevalent of all types of workplace fatalities and these are largely the result of the lack of fall protection. However, even with the proper use of harnesses, injury can still occur. When precipitation is occurring over multiple days, workers may be hard-pressed to find a stable dry surface, and with looming deadlines often the workers must continue working through these conditions. Ironworkers, for example, must balance like gymnasts atop tall beams performing welds and tightening bolts. Even with the proper safety equipment, the risk of slipping and falling off a slick beam is great. The next of the fatal four, “struck by objects”, can also be caused by adverse weather. Any exceptionally windy day can easily blow debris throughout the jobsite and struck an unsuspecting worker. Like the adage of a penny killing someone when dropped off the top of the Empire State building, but much larger, and much more dangerous objects can be blown around above workers. Of the fatal four, Electrocution, is perhaps the most preventable. It does not take a genius to know that water and electricity do not mix well together. A powerful conductor, ponding water from increased precipitation can pose a lethal threat to electricians working both outside on electrical poles and inside unfinished buildings where water often leaks through unfinished roof systems. Finally, caught in between fatalities are often the unfortunate cause of cave-in excavations; a result of unstable soil. Unnaturally high moisture content can be a direct cause of unstable soil conditions. As weather conditions continue to turn towards the more extreme it will be the responsibility of the project managers and foreman to ensure that good safety practices are performed by every single worker on site.

**Slip Injury** — With increasing precipitation, comes increased ponding of water. The coating of moisture over all surfaces, especially the unfinished ones on a construction site, poses a big threat to workers walking through the site. Injuries from slipping can be as simple as bruising or as serious as something fatal.

**SUNBURN** — Skin cancer is the most common type of cancer in the US (1 million people diagnosed/year). Prolonged exposure to UVA and UVB is the primary cause of skin cancer. One form of protection comes in the form of clothing. Wide-brimmed hard-hats, long-sleeved shirts, and tinted safety glasses are a great way to block radiation from reaching the skin. When possible, take cover under the shade, especially during peak sun hours (10:00 am-4:00 pm).

As always, remember to wear sunscreen.

**Mosquitoes** — hot, humid air combined with an increase in ponding water provides insects with the perfect breeding grounds. Over the past 50 years, mosquito-borne dengue fever has increased by 30–fold.
Heat Exposure — as temperatures continue to rise, workers will be increasingly exposed to heat-related dangers. When someone suffers from heat exhaustion, their symptoms include dizziness, fatigue, and headache which can make it dangerous to operate heavy machinery. Heatstroke occurs when one’s body temperature reaches 104 degrees; this can be life-threatening as the body can no longer regulate its temperature.

Ticks — as job schedule constraints and other weather conditions force more work to hours from dawn to dusk, workers are more exposed to disease-carrying insects. Ticks, for example, are large transporters of Lyme disease.

Cold Rain = Hypothermia — often referred to as trench foot, caused by prolonged exposure to wet and wintery conditions. According to OSHA, wet feet lose heat 25 times faster than dry feet, and symptoms of trench foot can occur in temperatures as high as 60°F. If left untreated, frostbite may occur which is caused by the freezing of skin and tissue. If the body’s temperature drops below 95°F hypothermia occurs which can cause confusion, slowed heart rate, unconsciousness, and possibly death.

Respiratory Disease — according to National Geographic Magazine, “more heat can mean longer allergy seasons,” and “more rain increases mold and indoor air pollutants.” Together these can greatly agitate workers who suffer from upper respiratory problems.

Low Visibility — when the moisture content in the air increases so does the likelihood of fog. A major part of the construction industry includes transporting material to and from jobsites. When roadside conditions are too foggy to traverse, truck drivers must choose to potentially delay the project or drive through the fog.

Graphics source: http://clipart-library.com/
HAIL
Severe hail is defined by precipitation at a size of 3/4” diameter. At this size, the hail can shatter windows and damage any exposed material or persons. Four Midwestern states (MO, IL, IA, and IN) ranked in the top ten states with the highest frequency of hail catastrophes of over $1 million in damage during the period of 1949 - 2006. In a construction application, this means that unfinished single-ply roofs can be dented and must be replaced if damaged. Some hail damage is covered by Builder’s Risk Insurance; however, it is the authority of an insurance inspector to decide if the damage is enough to designate an entirely new roof. If not, the owners and project manager determine if the liability of a potentially failing roof system is worth the cost of replacement. If the roof does need to be replaced, it has the potential for profit loss due to loss of contingency or at the least an increase in insurance rates. This kind of damage can, however, be reduced if proper caution is taken to keep a clean and orderly jobsite.

AIR QUALITY
More than 20 million people in the Midwest experience air quality that fails to meet national air quality standards. These poor conditions are then amplified by higher temperatures and increasing moisture content. Everyday construction workers are exposed to particles in the air that range from dust and concrete fumes to asbestos and chemicals that are exposed to the air. With these long-term exposures on top of unclean and humid natural air, the risk for serious respiratory problems greatly increases.

(left) An air handling unit (AHU) is hoisted on top of the roof of a building on gloomy morning. (right) Coworkers look on at a roofing system on a jobsite tour. When weather conditions are pleasant it makes the job that much more productive and enjoyable.

Photos taken by M. Feltman
The frequency of major heat waves in the Midwest has increased over the last six decades. These temperatures are only projected to increase with increasing summer humidity. During a heatwave, mortality increases 4%, a dangerous statistic for an aging construction labor force. In addition to the risks that extreme temperatures pose, extremely hot or cold temperatures increase in workers’ compensation claims. To combat this, owners may choose to change out workers more frequently or create shorter shifts creating a larger labor demand. In extreme cases, the work may be performed on off-hours to avoid heat exposure, but labor rates at those hours are 1.5 to 2 times greater. Additionally, the extra shuffling around of workers leads to slowdowns throughout the jobsite. Making these jobsite conditions no longer simply dangerous but also costly.
Mud can be a construction worker’s biggest enemy. A jobsite saturated with mud from substantial rainfall will hinder the access to the site for all building trades. On sites that do not have paved roads, equipment—because it is so heavy—may not be suitable to traverse through the mud. Therefore, work will stop until the road has properly dried or road stabilization can be constructed. Much of the construction of gas or oil pipelines depends on being able to transport heavy equipment over unpaved roads. Although some versions of off-road equipment do exist, they may either be too expensive or unavailable in certain situations.

Mud can also delay grading and earthwork activities. When there is an increase in groundwater, contractors are forced to make provisions for dewatering before continuing the excavation and trenching activities. It is like digging a trench but the trench fills with water, that water must be removed before the trench can be continued to be dug. Then once the excavation has been complete, saturated soils may again prove to be a problem when establishing a firm foundation. It would be unwise to build a structure on saturated soil, and additional drainage systems can be costly.
In addition to large commercial buildings, residential construction can also be affected by increasing precipitation. Many residential buildings are constructed using a process called wood-framed construction. This means that timber is used for the beams and trusses instead of steel or concrete. Timber, however, is far more susceptible to damage from precipitation than steel or concrete. If left uncovered, the wood left out on a jobsite can become saturated. If this happens, the boards are almost guaranteed to mold. On top of the molding, those beams may also warp or expand, rendering them useless and increasing overall material costs.

Another rain-related problem would be poor adhesion of paint. Excess humidity due to increased precipitation can cause poor adhesion of paint or wallpaper, discoloration, or at the least delay curing times. Commercial construction combats this issue by requiring a building inspector to test the humidity levels inside the building once the exterior walls have been closed. If the standard is not met, the contractors will have to run industrial fans in the building until the humidity can be reduced. Unfortunately, residential construction does not have to meet as strict standards, which can lead to major problems for homeowners after construction has been completed.
Building codes establish the foundation on which all construction projects are designed and interconnected. Building codes provide residents with the satisfaction that the structure is of sound design. For hundreds of years, these codes have evolved to better meet the needs of the people. Unfortunately, the United States’ willingness to change these building codes seems to come only after disaster. One such example would be the Chicago fire of 1871 which inspired the implementation of fire safety practices.

Unlike insurance companies, many of the design books lack the current information to make sound decisions. What might take weeks for an insurance company to raise their premiums could take years for the governing bodies of design to gather and deliberate on the necessity of change. This means millions of structures can build using outdated information before the proper changes can be made. On their government website, the City of Yorkville, Illinois, shares the International Building Codes, which defines the basic standards that all buildings must be constructed. They also publish an article with the significant code changes that their residents may need to be aware of, however, those code changes only come every three to four years. The last edition of the International Building Code was released in 2018. Due to the challenges of changing the codes, only one or two small additions, clarifications, or modifications were made to each chapter. With the weather patterns throughout the Midwest becoming more severe by the month, it becomes worrisome to be forced into waiting at least three years for more stringent standards.
Water infrastructure for flood control is based on historical patterns of precipitation and streamflow. Based on the evidence produced from a variety of reputable sources, these historical patterns no longer appear to be appropriate guides for the design criteria which engineers are using to develop their designs. However, since bridge piers or dams are built to last for half a century, the design made today should be concerned with the forecasted data, not historical data.

Wind is a product the off-balance of temperatures and the increasing levels of precipitation. On jobsites, it can be extremely dangerous. With increased wind, hard hats may be swept away exposing workers. Unsupported masonry walls may collapse. Unfinished or unbraced roof structures may undergo uplift and remove the entire structure if the winds are strong enough. With increasing heavy winds, if design code changes are not modified, many workers may be left exposed to the harmful effects. If the design code regulations are not reevaluated soon, the structures being built and designed will be under-reinforced and unsuitable for the weather they will be facing in the future.

“IMPROVING OUR CURRENT BUILDING CODES WILL REQUIRE A CHANGE IN THE WAY HOMEOWNERS, YOUNG PEOPLE, AND GOVERNMENT REGULATORS THINK ABOUT CONSTRUCTION.”
With disaster comes design changes. Often it is after a major natural or manmade disaster happens that the design codes change. Those failures reveal the weakness in the standards and allow engineers to develop ways to improve. With every new design code change, countless lives are saved, but at some point, engineers must start to be proactive in their revisions. Waiting until the next natural disaster comes at a hefty price.

The main criterion of a construction contractor is to perform the desired task in the most cost-efficient way. In construction many tasks are repetitive, therefore the more efficient the process, the more repetitions can occur, and more money can be made. However, older building codes will often waste excessive amounts of energy. A costly consequence in a money-driven industry. Additionally, as society moves towards conservation, energy-efficient building codes are becoming increasingly popular. Energy-efficient regulations have benefits that extend further than just environmental waste reduction. When energy-efficient outlets are installed, it gives residents more authority over utility costs. When air quality is more heavily monitored, public health improves. Even a more regulated vapor barrier on window systems will help reduce heating and cooling costs in an ever-changing climate like the Midwest.

As design codes improve, their impact will also have a longer-lasting effect for generations into the future. Every time a design code change is made, it only applies to the buildings constructed from that point on. Existing structures that become uncompliant with the new modifications are not required to be torn down and rebuilt. Therefore, what is built currently will have to stand the test of time. When those changes are made for the better, later generations will reap the benefits of the increasingly safe designs.
When discussing the building code cons, it is not to say that having restrictions for the purpose of safety is harmful, but rather that there are innate disadvantages to having specific rules that everyone must follow.

In the current construction climate, the cost is the main driving factor that will determine the success of the project. Therefore, the designs are often built to the bare minimum that the standards will allow, in order to drive costs down for owners. Additional building reinforcements might be nice, but nothing comes for free. No professional engineer would knowingly defy building code for the sake of making a few dollars, mostly because the consequences of the unethical action are far too high. When the only focus of the design is to make sure the building is “legally safe” there is not much room or incentive to go above the required quality of safety.

In order to produce safer buildings, more stringent building practices must be put into action. The increasing complexity of the safety guidelines makes building operations more difficult for unskilled labor to complete with compliance. Updated codes now shift certain tasks from unskilled labor to semi-skilled or requiring supervision to complete the construction process. Thus, resulting in one of the largest problems currently facing the construction industry; a lack of skilled labor. In August 2019, over seven million construction jobs went unfilled. While more teens are choosing to go to college instead of joining the labor force, companies are struggling to hire workers. Additionally, on some jobsites, especially residential construction, little or no formal training is required. Meaning any worker, regardless of their level of training may be working and installing material intended to meet a certain code.
In construction, a weather delay is defined by the stop-work or impairment of work due to an unexpected weather event. Ohio snow in January is not a plausible cause for a weather delay on an event such as pouring asphalt since the snow is a foreseeable event and asphalt cannot be easily poured at freezing temperatures. If a contractor is behind schedule due to his or her own cause, but it just so happened to rain that day, it does not qualify as a weather delay. Since Midwestern temperatures are inherently unpredictable it is often a common practice to work in extra workdays into the project schedule. These additional days in the schedule can account for all kinds of unforeseeable delays in addition to weather-related delays. For example, if a concrete contractor knows it will take four days to complete a pour, schedule permitting, they might bid the work as a five day tasks to reduce the possibility of not meeting the deadline. This tactic is often used when the owner does not originally provide a set number of weather days. Since it is difficult to define the unpredictability of weather, many owners will abstain from defining a set amount of weather days and delegate those decisions to be made in the contractor’s bid.

To evaluate and accept a project delay as a weather delay, the owner and contractor together need to establish the baseline weather. This is becoming increasingly more difficult since the change in what is considered to be the baseline has changed so drastically over the past decades. Additionally, this may be a point of contention if the original contract does not specifically establish what they consider to be the baseline. The concerned parties need to determine if the weather event in question was a direct result of the weather and if so, how did it cause the delay?

- Did Chicago have freezing temperatures in September which caused the delay of the asphalt paving?

- Did flooding in Kansas produce so much water on the jobsite that project time was spent dewatering the site before construction could continue?

- Did seven days of afternoon summer rain prevent the masons from laying brick?

Overall, contractors and their clients must have a good line of communication to avoid petty weather disputes. If relationships are poor, the dispute over the acceptance of weather delays can be longer than the actual delay itself. The best way to avoid those conflicts would be to determine those baselines and allowances during the contract and negotiation phase.
Some construction activities are more reliant on the weather than others. One example of a construction activity that is highly dependent on the current weather conditions is any type of earthmoving or excavating activities. The more saturated the soil conditions, the more difficult it is to move the earth in the desired way. Think of raking wet leaves as opposed to dry ones. The table above is from an article for the American Society of Civil Engineers, developed by Khaled El-Rayes and Osama Moselhi, both professors of civil engineering. Throughout their report, they discuss that the impact of the rainfall depends on: “(1) the amount of rainfall and (2) the timing of the rainfall”. According to their findings, it only takes one inch (25 mm = 1 in) over the course of five hours in the morning to shut down the project for the day and be saturated enough the following day to prevent work from continuing. However, half of an inch of rain starting in the afternoon over the same five hour timespan will only impact that day’s work, with no additional days lost. The professors go on to reiterate that the drying conditions of the soil depend on hours of sunshine, wind speed, temperature, soil type, and the current drainage systems. Therefore, the variability of these conditions makes the table above more of a guideline than a rulebook. Such variability also makes it difficult for project managers to accurately determine the schedule for potential delays. Even if the soil and drainage conditions are known before the schedule is made, which is not always the case, it is nearly impossible to determine the severity or timing of weather events months or years in advance.

<table>
<thead>
<tr>
<th>Rule (1)</th>
<th>Amount (mm)</th>
<th>Daily hours (3)</th>
<th>Daily period (4)</th>
<th>Current day (5)</th>
<th>Following days (6)</th>
<th>Total working days lost (7)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>13–25</td>
<td>5</td>
<td>Morning</td>
<td>Full day</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>13–25</td>
<td>5</td>
<td>Afternoon</td>
<td>Full day</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>13–25</td>
<td>10</td>
<td>Morning + afternoon</td>
<td>Full day</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>13–25</td>
<td>14</td>
<td>Overnight</td>
<td>Full day</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>6–13</td>
<td>5</td>
<td>Morning</td>
<td>Full day</td>
<td>0</td>
<td>0.5</td>
</tr>
<tr>
<td>6</td>
<td>6–13</td>
<td>5</td>
<td>Afternoon</td>
<td>Full day</td>
<td>0</td>
<td>0.5</td>
</tr>
<tr>
<td>7</td>
<td>6–13</td>
<td>10</td>
<td>Morning + afternoon</td>
<td>Full day</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>8</td>
<td>6–13</td>
<td>14</td>
<td>Overnight</td>
<td>Full day</td>
<td>0</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Weather Delay Scenarios for Earthmoving Operations Based on Average Drying Conditions — Table from Source 29
When project managers are developing a schedule, an important thing that they consider is the critical path. The critical path is a sequence of activities or sequential steps that, when taken over the entire project, add up to the longest duration. Essentially, the critical path determines the shortest completion time for that project. The construction industry relies heavily on developing an accurate critical path to determine when the client can expect the project to be completed. Throughout the course of the project, items that fall on the critical path may be the most affected by weather-related delays. Even a slight delay on a critical item can have serious consequences.

One way that the construction management team improves the accuracy of a schedule is to input historic durations into scheduling software. Once entered, the software can determine the critical path. On projects that span multiple years, the software is able to quickly produce a schedule that would take a project engineer many weeks to deliver.
Based on the design of the contract, approved delays may or may not be compensable. Typically, unforeseeable delays are excusable but not always compensable. If a concrete contractor has a crew out in the field pouring slabs and it begins to thunder and lightning in the afternoon, the work for the day must stop. The foreman may then choose to send his workers home early for the day. The hours that the equipment goes unused is not compensable. If the contractor is renting that equipment by the hour, a change order for those wasted hours will likely be denied. The laborers that are pouring the concrete slabs might be paid hourly and would not get paid if they were sent home. Occasionally, if the jobsite schedule allows, the contractor may be doing work both inside and outside. In this case, a weather delay such as a thunderstorm would allow the foreman to move his or her crew to a different location on the jobsite. This tactic is used to mitigate time lost on a job and maintain the schedule as best as possible. However, if that concrete pour is a part of the critical path, the delay will push the completion date and force the contractor to make up that time in another task.

On a project, missing several days due to weather related delays can result in missing the acceptable construction season entirely. Essentially, if the project is scheduled to have significant asphalt pours, like road repairs, the acceptable period to pour asphalt is generally between Easter and Thanksgiving. If weather conditions prevent crews from completing their pours before the asphalt suppliers shut down their yearly production, the contractors must wait until the spring before they can return to pouring asphalt. That pushes the subsequent tasks in the schedule back until the spring as well which greatly postpones the project completion date.

The estimated cost of weather-related delays in the U.S. alone is nearing $4 billion annually. When compared to other major industries, the construction industry already has one of the lowest profit margins. With competitive bidding forcing contractors to reduce their share of overhead/profit, slight variations or unexpected conditions can make a profitable project unprofitable.

(right) concrete workers pour a retaining wall in early April. The saturated ground near the bottom of the formwork will require dewatering before the completion of the retaining wall.

Photo taken by M. Feltman
Like all goods-producing industries, the construction sector is fueled and operated by money. Without money from clients for the products produced, contractors cannot pay for labor, materials, or insurances. In total, the construction industry is responsible for over $10 trillion (10,000,000,000,000) in global spending annually. In the United States alone, the construction industry spends 1 trillion dollars annually. To put that number in comprehensible terms; go back in time a billion seconds – it is 1989, go back a trillion seconds in time it is around 30,000 B.C. Now imagine that ten times over. That is the amount of money that the construction industry sees annually. That is an incomprehensible amount of money and it is only growing. This could be because the vast majority of large construction projects (over $1 million) go over budget. According to the consulting firm McKinsey, those large projects going over budget take an additional 20% longer than expected. It would be only natural to speculate on the causes of those delays.

From the graph above, the U.S. Census depicts the data from the construction spending over the last decade. After the recession in 2008, many industries suffered. The construction industry, however, lags in its recession due to the projects that are currently in progress when the recession hits. The construction that is already in progress will typically finish despite there being a recession in other parts of the economy.
When natural disasters strike, the damages are well recorded. Insurance companies can adjust to the changing climate by raising their premiums. But if the property owners refuse to succumb to the rising prices, who pays for the future damages? This leaves the government vulnerable to being forced to pick up the bill to prevent chaos in the face of disaster. In many situations, however, there are steps taken to prevent that sort of exposure. Often before construction may begin, the companies must enter into several contractual agreements on what to do in the face of disaster.

The first type of contractual assurance that the owner and contractor will agree on is the bid bond. This is issued as part of a bidding process by the Contractor to the Owner. This guarantees that the winning bidder will undertake the contract under the terms that they bid. Meaning the contractor who won the job cannot refuse the project after a proposed bid has been sent or charge more money without proper cause for a change order. The next type of bond comes after the desired contractor has been selected. The performance bond is issued to the benefit of the Owner and guarantees that the Contractor will complete the contract. This agreement prevents the Contractor from leaving the project before the work is completed, which helps the Owner manage the risk of unfinished work. Conversely, payment bonds are issued to the benefit of Subcontractors and suppliers. These bonds guarantee that Contractors will be paid for the materials and labor that is provided. This helps the Contractor manage the risk of not getting paid for the completed work. Additionally, maintenance bonds also known as warranty bonds are used for defective workmanship or faulty material. Contractual agreements are crucial in the owner/subcontractor relationship, they develop trust throughout the project and bring integrity to the construction profession.

The main difference between these bonds and other insurance policies is that “while the contractor is the one who purchases the bond, the bond is designed to protect the general public” 34. Together these agreements help establish the plan of action for potential construction disasters. Being prepared with an emergency plan will be the best way to combat potential issues throughout the lifetime of the project. At a time when emergencies appear to become more common, strict attention to detail in the procurement process will help to reduce liquidated damages in the future.
Once the contractors have successfully entered into their contractual agreements and dealt with the proper methods of procurement, it is time to decide what types of insurance are needed. Companies of a caliber such as Progressive, Travelers, and Nationwide are often chosen to financially support the contracts throughout the construction process. There are, however, many kinds of construction insurance; the following paragraphs hope to explain the different types of insurances and give insight into how the increasingly disastrous weather may affect them.

The first type of construction insurance is known as builder’s risk. This type of insurance covers the building materials, foundations, and temporary structures that are used on a construction site. Additionally, it will cover the trees and plants that have been installed by the contractor. Generally, builder’s risk insurance can provide coverage on a diverse spectrum of construction from small residential remodeling to large commercial infrastructures depending on the quotes provided by the respective insurance company. Michael Stromberg, a writer from Construction Coverage Expert Reviews & Guides, explains that even the most standard forms of builder’s risk insurance will cover damages from fire, weather, and vandalism. He also explains that damages from earthquakes and flooding are not covered unless a “premium coverage” option is chosen. As explained numerous times before, damages from flooding are among the costliest and are becoming increasingly more common. 

When flooding disaster strikes construction projects that do not have specific flood insurance, those contractors, due to their contractual agreements, would be forced to pay for the damages incurred. In a worst-case scenario, the profit losses can be enough to put a contractor out of business – unless that premium coverage is purchased. However, that brings up the question of what if a contractor cannot afford the premium coverage, or does not have the financial credit to purchase such policies? Thus, the insurances, for a shady contractor, become a gamble on their necessity, only further perpetuating the resulting damages.

Gregory R. Meeder and James P. Chivilo, writers from the Commercial Law Firm Holland & Knight, bring up another problem with builder’s risk insurance. Unlike other formalized insurance policies, builder’s risk is not a standardized process. Meaning individual insurance companies develop specific nuances and potential gaps in coverage. They go on to explain that most insurance companies do not provide coverage for "soft costs" such as scheduling delays. As previously discussed, it may be difficult to argue or quantify these types of losses and therefore, insurance companies choose to exclude them completely.

Understanding these constraints from insurance companies, force knowledgeable and perhaps desperate contractors to raise costs in other ways. This might include raising their material costs or unit prices to cover the insurance gaps in preparation for potential disaster. All it takes is a couple of pennies here, a few dollars there to fill those income gaps over the course of the project. This lack of transparency ruins the working relationship with the owner and tarnishes the reputation of the profession. According to Meeder and Chivilo, the best defense against major project losses is proper preparation of risk claims and a team of industry professionals with claim experiences.
Another type of construction insurance is known as General Liability Insurance (GL). This brand of insurance protects contractors in the case of third-party property damage or bodily harm during the project timeline. These policies cover what is deemed “unnecessary risk” such as faulty workmanship or job-related injury. In many construction contracts, some form of general liability insurance is required.

Weather-related losses are limited when it comes to general liability insurance. For example, high winds create a projectile piece of debris that destroys a bakery's storefront destroying all cakes on display and leaving shattered glass everywhere. General Liability does not cover those damages, it would only cover losses in a scenario where the bakery’s employees damage someone else’s property.

While this type of insurance is important to carry throughout the course of a project, it does little to cover the increasing severity of the real weather liabilities facing construction project.

Workers' compensation insurance is another form of coverage, while it extends to many industries, it is crucial to the practices of the construction industry. Workers' compensation insurance covers the costs after incidents incurred on the job such as medical bills, missed wages or funeral costs. As described throughout the safety portion of this paper, the construction industry is prone to workplace injury and becoming more vulnerable as the weather becomes more severe.

With these facts in mind, it is not difficult for insurance companies covering contractor’s workers’ compensation insurance to increase their premiums. When contractors depend so heavily on this coverage to reassure workers of their compensation in case of emergency, they become completely submissive to the prices determined by the insurance companies.
Insurance Costs

Unfortunately, there is not a straightforward, standardized cost for these insurance policies. Which makes it difficult to analyze the weather’s impact on their cost on a wide generalized basis. Many factors like credit history, business size and location can determine an insurance company’s coverage price. Yet, many contractors choose to keep their specific company insurance rates private as to keep a competitive advantage against similar contractors. Below is a chart proved by Stromberg, depicting the approximate annual costs of the varying types of insurance premiums.

<table>
<thead>
<tr>
<th>Insurance Type</th>
<th>Average Annual Premium</th>
<th>Required?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Builders Risk</td>
<td>1-5% of project cost</td>
<td>Usually</td>
</tr>
<tr>
<td>Commercial General Liability</td>
<td>$500-$1,500</td>
<td>Usually</td>
</tr>
<tr>
<td>Workers' Compensation</td>
<td>$5,000-$8,000 per employee</td>
<td>Usually</td>
</tr>
<tr>
<td>Surety Bonds</td>
<td>$100 - $10,000</td>
<td>Sometimes</td>
</tr>
</tbody>
</table>

These values are based on national averages and could be significantly different for a specific contractor in a dangerous/high-risk situation. In general, the bigger the project or the higher the risk, the higher the cost of insurance.

Overall, insurance policies are a necessity when it comes to a construction project contract. It is crucial to pay strict attention to the contract language provided in these quotes as to not leave gaps in coverage, especially when it comes to the increasing severity of weather-related damages.
According to senior editor, Elana Ashanti Jefferson of the NU Property Casualty Insurance Professionals Blog, insurance prices in the construction sector are rising 10 – 15% annually. This increase is largely due to increases in General Liability insurance from recent hurricanes.

It is no surprise that the aging workforce in the construction industry has a significant impact on insurance prices. With a lack of younger, skilled laborers who are better able to withstand the new dangers of exposure, insurance prices will inevitably continue to rise. As mentioned before, slips, trips, falls, and strains are the most common types of injury on the jobsite. Scott Grieco, a president at The Hanover Insurance Group says, “studies have shown that new [and unskilled] workers are more than three times as likely to be injured on a job.” While environmental factors are increasing the jobsite dangers for even the most experienced workers, those who are lacking in skills must be diligent in their onsite training.

According to insure.com, of the $340 billion in natural disaster damage in 2017, only $138 billion was paid by insurances on those worldwide losses.
Further proof of increasing precipitation levels comes from the rising levels of the Great Lakes. In 2019, the lakes reached unprecedented levels putting coastal cities at risk.

Increasing global temperatures lead to increased humidity. This disturbs the balance of in the water cycle and creates unpredictable bouts of precipitation.

The construction industry spends over ten trillion dollars annually. That number only continues to rise.

The time lost due to rain delays depends on many factors such as soil and drainage conditions, the amount of rainfall, and the timing of the weather event.

Much of the Midwestern climate issues come from the broad range of seasonal air temperatures experienced.

Flooding continues to be one of the costliest disasters in the Midwest and the severity is only increasing. Largely due to flash flooding that occurs from pre-saturated soils.

Updated building codes are released every three to four years. This pace, unfortunately, lags the current climate changes, creating a potential for under-designed structures.

Insurance prices for construction projects are increasing due to more dangerous weather exposures and an aging workforce.

Increased precipitation and ponding of water create slip hazards on unfinished surfaces. This puts workers at higher risk for slips, trips, or falls—a leading cause of workplace fatalities.

Weather delays continue to be a major scheduling issue for construction managers. Missing more than thirty days due to weather delays can result in missing the building season entirely and push deadlines years.
Final Thoughts...

It is no secret, now, that the climate in the Midwest has undergone profound changes in recent years, but identifying those changes is simply not enough. To maintain the necessary sustainability in our civil society, those in charge of building and preserving our infrastructure must be aware of the impact of the environment around them. In 2011, alone, 11 of the 14 US weather-related disasters with damages more than $1 billion affected the Midwest. Understanding the impact of these climate changes and the dangers they present will help construction managers and engineers develop policies and solutions that work towards reducing weather-related consequences.

Since much of the construction process takes place outside, an increase of slick surfaces can considerably increase the number of recordable injuries. An increase in recordable injuries has the potential to significantly delay project deadlines resulting in severe liquidated damages. When insurance companies start to become aware of environmental changes occurring and causing severe damages to project sites, policies begin to change. With an increased risk of injuries and liquidated damages comes higher insurance premiums. This causes the price of the project to be inflated and what was once in an owner’s budget is now unattainable. However, in most forms of engineering design, historical data is used to determine the maximum loads needed for design. Currently, those rain/snow loads are quickly becoming outdated because of these rapid fluctuations. Structures that once seemed indestructible are now becoming rubble in the wake of these storms.

Moving forward, engineers and construction managers must be responsible for their designs and construction practices. It is the ethical responsibility to deliver a product that will withstand the given design-life, using sustainable practices and a safe jobsite. Despite the potential for cost increases, engineers must work with their clients to create a budget and schedule that accommodates the ever-changing conditions.

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Frame from video: https://www.youtube.com/watch?v=vVI67_s6pfF

Page 18-19 graphics found on http://clipart-library.com/