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The likelihood that a strong earthquake will occur is moderate, but the risk is heightened by New York Citys population density, the scale of its built environment, the interdependencies of its critical infrastructure systems, the age of its infrastructure, and the high proportion of buildings that were built before seismic design provisions were adopted in City building codes in 1995. A mix of building types in NYC. Source: NYC Department of Environmental Protection (DEP) An earthquake is caused by sudden slip on a fault that releases energy in seismic waves. As rocks and the Earths plates are strained by these tremendous geological processes from plate tectonics, energy builds up under the Earths surface. Eventually, accumulated strain deep underground becomes so great that it is abruptly released in an earthquake, which generates seismic waves that cause shaking.U.S. Geological Survey, What Is An Earthquake and What Causes Them to Happen?, U.S. Geological Survey. From the earthquake source, or focus, deep underground, the waves travel away and cause shaking at the Earths surface. An earthquakes epicenter is the point on the earths surface that lies directly above the focus. Seismologists and engineers often measure the shaking that occurs as ground acceleration. The intensity of ground shaking depends on several factors, including the amount of released energy, the depth of the earthquake beneath the Earths surface, the distance from the fault, and the type of underlying soil or bedrock. How intensely a built structure responds to shaking during an earthquake depends on the buildings height, weight, and design, and its coupling to the ground. For example, a building on a concrete pad will have a different response to an earthquake than a building with a deep foundation. An earthquake has the potential to damage and destroy buildings and a citys infrastructure, and take lives. Under certain conditions, earthquakes can trigger landslides and cause soil liquefaction. The latter occurs when shaking and ground vibration during an earthquake cause unconsolidated, water-saturated soils to soften and turn fluid. Ground shaking, landslides, and liquefaction together can damage or destroy buildings, disrupt utilities, trigger fires, and endanger public safety. Aftershocks are part of the earthquakes sequence that follows the largest, initial earthquake shock. Aftershocks are typically less intense than the main shock, and may occur for weeks, months, or years after the initial earthquake event. Earthquake size is classified according to a magnitude scale that can be related to the energy released at the earthquakes source. Seismographs and other scientific tools are used to measure and record data to understand the severity of each tremor in the Earth and the severity of each earthquake event. In the past, earthquake tremors were ranked according to the Richter scale, but in the 1970s, the scientific community began to use the more accurate Moment Magnitude scale. The Moment Magnitude scale measures the size of an earthquake at its source in relation to the size of the fault and the degree to which the fault is displaced. It is a logarithmic scale each point that an earthquakes magnitude increases on the scale represents an energy release that is 32 times larger than the point that precedes it.U.S. Geological Survey, Earthquake Magnitude, Energy Release, and Shaking Intensity, U.S. Geological Survey. Moment Magnitude Scale The 2011 Virginia earthquake, which rattled the ground as far away as New York City, was a magnitude 5.8. By comparison, the 2011 earthquake that damaged the eastern coast of Japan was a magnitude 9.0 and considered catastrophic. The upper limit for earthquake magnitude on the Earth is 10.0. The Modified Mercalli Intensity (MMI) scale is a measurement based upon what has been observed in seismic shaking during earthquakes. The MMI reflects twelve categories of intensity based on peoples reactions, their observations, and building damage during seismic events.U.S. Geological Survey, Earthquake Hazards Program, U.S. Geological Survey. The Modified Mercalli Intensity Scale Note: Abbreviated description of the levels of MMI. Source: USGS On August 10, 1884, New York City experienced its most severe earthquake, which was estimated to have a magnitude of 5.2 on the Richter scale.Bob Groves, N.J. Is Not Immune to Quakes, The Record, Bergen County, March 2, 2001. On the MMI scale, the reported maximum intensities of the 1884 earthquake would correlate to Levels VI to VII. Experts also usequantitativemethods to describe earthquake severity,such as Peak Ground Acceleration (PGA). PGA is an expression of the grounds maximum acceleration as it shakes and moves during an earthquake and can be described by its changing velocity as a function of time. Acceleration is an important way to measure and discuss the intensity of an earthquake, because many seismic building codes incorporate it into guidelines for building construction. Building codes stipulate, for example, the amount of horizontal inertial force (or mass times the acceleration) that buildings should be able to withstand during an earthquake without life-threatening damage. PGA is expressed as a percentage of the force of the Earths gravity (%g). A very strong earthquake, such as 1994s magnitude 6.7 earthquake near Los Angeles, produces PGAs of over 100 %g in the horizontal direction, which is greater than acceleration due to gravity.City of Los Angeles, Remembering the Northridge Earthquake, City of Los Angeles, January 16, 2020. The effect of 100 %g horizontal acceleration is similar to holding a building by its foundation and turning it on its side for a moment. PGA continues to be an important measurement of ground shaking. However, Spectral Acceleration (SA) is the ground-motion measurement unit commonly used today in modern seismic building codes. Compared to PGA, SA is considered to be a better indicator of damage to specific building types and heights. SA reflects how buildings of particular masses, heights, and structural stiffness (and related natural response period) react to being shaken by an earthquake. In a simplified manner, a building is represented by an inverted pendulum of a certain mass on a massless vertical rod that replicates the buildings natural period of vibration and the mechanical damping. A very approximate rule for the natural spectral period Tb (seconds) of a building as a function of the number of stories (n) in the building is as follows: Tb (seconds) = 0.1n. For example, a two-story building tends to have a natural period of about 0.2 seconds (frequency of 5 hertz), whereas a 10-story building tends to have a natural period near Tb=1 second (frequency of 1 hertz). PGA is also used to understand more about the types of earthquake hazards that are likely. The U.S. Geological Survey (USGS), which studies seismic conditions nationally, produces maps that indicate where future earthquakes are most likely to occur, how frequently they might occur, and how hard the ground may shake (PGA).Mark D. Petersen, Morgan P. Moschetti, Peter M. Powers, Charles S. Mueller, Kathleen M. Haller, Arthur D. Frankel, Yuehua Zeng, et al., Documentation for the 2014 Update of the United States National Seismic Hazard Maps (U.S. Geological Survey, August 5, 2014). The National Seismic Hazard Model Map displays the likelihood of damaging earthquake shaking in the United States over the next 100 years. The latest USGS maps, released in 2023, show that there is a 5 to 25 percent chance of a slight or damaging earthquake occurring in the New York City area over a 100-year period. The National Seismic Hazard Model Map, 2023 Source: USGS Strong earthquakes in New York City have not been registered, but moderate-magnitude earthquakes are possible and have occurred (as in 1884). Even if an earthquakes epicenter is far from New York City, the geology underlying the northeast United States can cause some ground shaking to be felt in the city.S. Nikolaou, Local Geology of New York City and Its Effect on Seismic Ground Motions, proceedings from the Fifth International Conference on Case Histories in Geotechnical Engineering, New York, NY, April 1317, 2004. When an earthquake occurs, the older, harder bedrock of the Northeast transmits high-frequency motions that can travel long distances before they subside. For example, tremors from the 2011 earthquake in east-central Virginia and the 2013 earthquake along Canadas Ottawa River were felt by many people in the eastern United States, including in New York City. The 2011 Virginia earthquake caused extensive damage 87 miles away in Washington, DC. If an earthquake occurs beneath New York City, the unique geologic characteristics of the metropolitan area could result in significant effects due to soil amplification. The two main factors contributing to soil amplification here are the sharp contrast between softer soils and very hard bedrock, and the bedrock motions, which could to be relatively short and shake with high frequency. High-frequency shaking is efficiently transmitted through the bedrock of the eastern United States and typically affects short, two- to five-story masonry buildings. If a shallow layer of soft soil (less than 100 feet in depth) sits atop hard bedrock, shaking is amplified but only for a relatively short period of time. By contrast, a high-rise building atop deep soil deposits will shake longer and shake more slowly during an earthquake. Subsurface conditions in New York City, which vary widely across the five boroughs, can affect the degree to which an earthquakes ground motion is amplified. As shown on the map titled Soil Types in New York City, geologic conditions range from solid bedrock at ground surface (green) to artificial fill (purple). Soil Types in New York City Source: Developed by Mueser Rutledge Consulting Engineers, based on the original NYC Folio Map of 1902 For centuries, large areas of New York City have been filled to cover soft sediments and marshes in order to create new space for building development.Michael Kimmelman, When Manhattan Was Mannahatta: A Stroll through the Centuries, New York Times, May 13, 2020. For example, Manhattans present-day Chinatown is on land created by filling in a large pond; the Worlds Fair Park site in Flushing, Queens, was built on an ash dump; and JFK Airport on Brooklyns south shore was built atop a hydraulic sand fill. These areas are similar to the Marina district in San Francisco, which suffered extensive damage in the 1989 Loma Prieta earthquake because of amplification of seismic waves by the soft soils. Historic map of the Chinatown area of New York City Source: Local Geology of New York City and Its Effect on Seismic Ground Motions Between 1700 and 1986, over 400 earthquakes with a magnitude of 2.0 and above have been recorded in New York State. Between 1973 and 2012, New York State had only two damaging earthquakes with a magnitude of 5.0 and above. Historically, larger earthquakes have a longer return period in New York City. That is, they happen much less frequently than smaller earthquakes.Jagtar S. Khinda, New York Citys New Seismic Design Criteria Guidelines for the New Millennium and an Update on the Seismic Retrofit for New York City Bridges, proceedings from International Bridge Conference, Pittsburgh, PA, June 1416, 1999. On August 10, 1884, one of the regions strongest earthquakes happened near New York City somewhere between Brooklyn and Sandy Hook, New Jersey. Based on contemporary reports of its damage, scientists today estimate it to have been a magnitude 5.2 earthquake. Although considered moderate by todays magnitude scales, the shaking from this earthquake event was felt from Virginia to Maine, damaging chimneys and brick buildings in New Jersey and New York City. Considering the amount of building and development along the Hudson and in New York City since 1884, if the same magnitude earthquake occurred today, the amount of damage to people and property would be far greater. The historical earthquakes map shows the distribution of earthquake epicenters throughout the Tri-state area from 1737 to 2014 that were near New York City. Note that this map shows only approximate locations of epicenters for pre-1973 events; also, not every pre-1973 earthquake event is included on the map.U.S. Geological Survey, Historic World Earthquakes, U.S. Geological Survey. NYC Historical Earthquakes Source: NYCEM GIS On April 5, 2024, a magnitude 4.8 earthquake, centered in Tewksbury Township, New Jersey, about 65 km west of New York City. Millions of people in the metropolitan area and anywhere from Virginia to Maine and beyond felt the ground shaking, resulting in the largest number (>180,000) of U.S. Geological Survey (USGS) Did You Feel It? reports of any earthquake. Despite its widespread reach, the earthquake resulted in no significant damage, marking it as a relatively minor seismic event. Although the seismic hazard in New York City is moderate, because of the potential occurrence of a unique set of factors, summarized by the high seismic risk equation, the risk to the area could be high due to the high cost of dealing with the repercussions of any earthquake damage in a congested city environment. High Seismic Risk = Moderate Seismic Hazard x High Density & Monetary Value x Lack of Seismic Design (Before 1995) With approximately 1 million buildings, New York Citys risk is very high, largely due to the lack of seismic codes in older buildings, the dense built environment, and the highly interconnected infrastructure. Most buildings in New York City were built before 1995, when more stringent seismic provisions in the Building Code were adopted; so, many of the most common building types here, such as unreinforced masonry buildings, are particularly vulnerable to seismic events. New York Citys newest commercial and residential buildings are built to modern seismic standards, which minimizes physical risk. Yet, the economic risk remains real estate and new development sprouting across the boroughs is so valuable that the costs associated with repairing damage from an earthquake are extremely high. Any event that interrupts the flow of business, transportation, tourism, or finance in New York City, known as a business interruption, poses the risk of a negative economic impact on domestic and international trading partners. Unlike other natural hazards, earthquakes occur no warning a situation that places the local population at immediate risk. Since New Yorkers experience earthquakes less frequently than other natural hazard events, people might be at higher risk, because they are less likely to be prepared to respond to this type of emergency. Earthquakes present a significant risk to public safety and health. A large-magnitude earthquake may cause significant injuries and casualties, disrupt emergency and medical services, and endanger individuals who depend on these services. Long-term health risks associated with earthquakes include post-traumatic stress disorder and a range of mental health problems such as depression and anxiety. A moderate (magnitude 5.5 to 6) earthquake, which is possible in New York City, could cause significant injuries and casualties. Mortality and injury typically peak within the first 72 hours following an earthquake. In a study of 1,100 fatal earthquakes around the globe, 75 percent of fatalities were caused by collapsing buildings. According to the Federal Emergency Management Agency (FEMA), nonstructural failures account for the vast majority of earthquake damage, causing serious injuries or fatalities and making buildings nonfunctional. Nonstructural components (not part of a buildings structural system) that cause risk include the following: Architectural components, such as cladding, windows, glass, and plaster ceilings. Mechanical, electrical, and plumbing (MEP) components. Furniture, fixtures & equipment (FF&E) and contents, such as heavy picture frames, mirrors over beds, hanging plants, and heavy furniture (bookcases, filing cabinets, and china cabinets).FEMA, Reducing the Risks of Nonstructural Earthquake Damage A Practical Guide, FEMA, December 2012. During an earthquake, these components may slide, swing, or overturn if they are not tightly affixed to the structure of the building. Theaters, libraries, and other large public areas often have plaster ceilings that are highly vulnerable to collapse when an earthquake shakes the building. Nonstructural failures can cause fatalities, injuries, and property loss and also block exit routes during emergencies. In California, and in other seismically active regions of the country, many homeowners understand earthquake risk and take precautions, such as securing shelving to walls, anchoring valuable items, anchoring water heaters, and embarking upon additional mitigation efforts. In eastern U.S. cities, residents rarely take these precautions because they experience so few earthquakes and assume the risk is low. Buildings (six stories and taller) that have rooftop water towers are another risk in New York City. If an earthquake hits, water tanks can be toppled, disrupting water service to residents and potentially injuring pedestrians. Destruction of roads, bridges, and tunnels as the ground shakes during an earthquake would trigger widespread injuries and fatalities. The disruption of and damage to infrastructure and other critical systems often has a cascading set of impacts. Ground shaking during earthquakes could cause damage that generates fires, putting residents at significant risk. The disruption of transportation networks puts anyone who depends on them at risk, and also hinders delivery of emergency and medical services. In an earthquakes aftermath, health risks increase due to the potential for polluted water and diseases spreading throughout the community. The time at which an earthquake occurs also influences its impacts. Historically, if an earthquake occurs on a weekday between 9 a.m. and 5 p.m., mortality rates rise, because people are more likely to be working in a large building and children are likely to be at school. If an earthquake occurs during the night, people are likely to be at home inside with their family members. Damage to buildings after a moderate earthquake could force thousands of New Yorkers into interim housing or require permanent relocation for many people. This poses a challenge regarding where to locate interim housing because the city has limited housing options, and the surrounding region may be affected as well. An earthquake can put New York Citys economy at risk, displacing and disrupting businesses and utilities, and impairing peoples ability to work and generate income. Property owners are at risk of economic loss due to the need for expensive repairs and the loss of rental income. Any downtime in New York Citys operation, as a major global financial center, potentially affects the entire worlds economy. If important national monuments, landmarks, symbols of cultural heritage and arts institutions housing artifacts of great significance are damaged during an earthquake, the psychological and cultural impact from damage to these icons would be felt across the entire nation and perhaps internationally. Although earthquakes in New York City have a moderate probability of occurrence, any potential strong shaking here could prove to be catastrophic due impacts of damage and interruption of services in the unique urban built environment with densely-spaced and aged buildings and infrastructure with complex interdependencies of and layers of lifeline services. New York Citys built environment consists of a unique concentration of commercial and residential high-rise skyscrapers and low-rise buildings that are largely made of unreinforced brick. Each building type has a very different risk profile according to its height, material, location, and foundation. The structural systems of New York Citys high-rise buildings are less vulnerable to earthquake damage than low-rise buildings. Large earthquakes with long-period waves tend to damage tall buildings; however, these categories of earthquake events are less likely to occur in New York City. Large-magnitude earthquakes that occur farther away from New York City, such as in Canada or the Midwest, can create low-frequency (slow-moving) shaking in the city that can affect tall buildings. Buildings built according to the New York City Department of Buildings (DOB) 1995 building code and successive seismic regulations such as the 2008, 2014, and 2022 New York City Building Codes which include a chapter for structural requirements are expected to be capable of mitigating the impacts of an earthquake. The regulations require buildings to be designed, at minimum, to preserve human life if a major earthquake hits and to preserve general occupancy conditions if less severe earthquakes shake the building. Structures in New York must be designed for earthquake loading since 1995, when the first seismic provisions became in effects. Older buildings not designed for earthquake loads are inherently vulnerable should a large earthquake occur. Unreinforced masonry (brick) buildings are most at risk because masonry is unable to absorb tensile forces during an earthquake. Instead of bending or flexing, walls, facades, and interior structures break or crumble. During a strong earthquake, the structural support system of an unreinforced masonry building has an increased risk of collapse. The typical modes of failure are: Failure of the roof-to-wall connection with a resulting collapse. Out-of-plane (when forces are exerted perpendicular to the surface) failure of unreinforced masonry walls. In-plane failure of unreinforced masonry walls, when cracks develop in the plane of the wall.FEMA, Unreinforced Masonry Buildings and Earthquakes: Developing Successful Risk Reduction Programs, FEMA P-774, October 2009. As of 2019, Brooklyn has the largest number of masonry buildings (165,661), followed by Queens (108,694), the Bronx (49,734), Manhattan (29,766), and Staten Island (7,041). Among these are over 100,000 multifamily, unreinforced brick buildings in New York City as a whole, most built between the mid-1800s and 1930s.Dan P. E. Eschenasy, Cases of Failure of Unreinforced Brick Walls Due to Out-of-Plane Loads, Structural Forensics Magazine, May 2011. All are between three and seven stories high. Many New York City neighborhoods consist of rows of attached unreinforced masonry buildings. The buildings rely on one another for stability, so any building that sits at the end of a block or next to a vacant lot is particularly vulnerable during an earthquake event. Masonry loft buildings, which are common in New York City, are vulnerable because they lack interior walls and have higher-than-average ceilings. Because wood is a lighter and more flexible building material, wood frame buildings respond better to earthquakes. In New York Citys fire districts, buildings constructed with wood frames are required to have a masonry veneer (or larger distances between buildings). Most one- to two-family houses in New York City are wood frame construction. For these homes, an earthquake could damage the masonry facade, but the structure could still stand. However, for three- to four-story buildings with load-bearing masonry, the buildings stability could be compromised during an earthquake. Even if an earthquake caused little damage aboveground, damage to a buildings foundation could render it uninhabitable or unusable. A large portion of New York Citys waterfront originated as wetland or wasteland that was filled in, reclaimed, and built up over time. During colonial times, this land was typically created by using fill with poor structural properties. A few decades ago, more controlled fill and construction procedures were applied. New York City has adopted guidelines to protect structures from flooding and has increased its resiliency by recommending that coastal buildings be elevated so that a soft story base permits floodwaters to pass through for example, supporting the first floor on piers. However, during an earthquake, this combination of a soft story base and poor subsurface conditions could shift most of the buildings load to the foundation, concentrating most of the damage in the bottom story. When reinforced masonry buildings begin to come apart in earthquakes, heavy debris can fall on adjacent buildings or onto the exterior where pedestrians are located. The diagram on the left shows the failure of parapets, one of the most common types of unreinforced masonry building damage. This level of damage can occur even in relatively light earthquake shaking. If an earthquake occurs in New York City, there is a risk that its impact will compromise infrastructure such as transportation, utility, electricity, and water/waste water systems.As part of other capital improvements being made here, some of New York Citys existing lifeline assets such as bridges have been partially retrofitted to improve their seismic performance. However, the seismic vulnerability of the citys complex network of interlinked infrastructure remains poorly understood and exists as an area of high concern, even as parts of the infrastructure undergo change, upgrade, and renewal. Some of New York Citys critical infrastructure systems are vulnerable because they have aged and have maintenance and life cycle challenges. During an earthquake event, soil below the ground water could liquefy with its strength reduced or lost. This could result in large-scale ground failure that damages pavements and building foundations and massively disrupts underground utilities. Areas with artificial fill are vulnerable to liquefaction and include the shorelines of Long Island (and around the JFK Airport), the Worlds Fair area in Flushing, Queens, the tip (Battery Park) and Chinatown in Manhattan.A strong seismic event in close proximity to the city could cause structures built atop liquefied soils to sink and settle. Damage to underground infrastructure usually occurs wherever pipes and other utility transmission lines are unable to withstand soil differential movements. Damage to these critical links could trigger secondary impacts that pose even greater risk to the public water contamination, fires, and sudden, powerful explosions. Earthquakes can severely damage the natural environment, destroying trees and disrupting the landscape. Competition for space can push development on formerly marginal lands. With increased urbanization, an earthquake (combined with effects of extreme weather) would also affect the more densely populated areas. What would once be a small localized event will become now a catastrophic event Earthquakes also pose risks that could cause severe harm to the natural environment fires caused by gas pipe explosions, flooding and other disruption caused by broken water pipes, accidental releases of hazardous waste, and devastating landslides. With the increased occurrence of flash floods, hurricanes, extreme rainfalls, an earthquake could be combined with these climate induced hazards which could increase the risk exponentially. As New York Citys substantial stock of seismically vulnerable (pre-seismic code) buildings is gradually replaced with new structures conforming to more robust seismic building code specifications, the percentage of vulnerable buildings will gradually decline. However, this would take a very long time. The dollar value of New York Citys vulnerability would be expected to decline as well; however, if the value and volume of New York Citys built assets increase over time, the economic risk from seismic exposure could still increase. Aging components of New York Citys infrastructure could amplify the structural impacts of earthquakes in the future. Investments, such as improving the seismic performance of existing bridges, should reduce the risks from future earthquakes. Even though earthquakes hit without warning and cannot be prevented, many strategies can be used to reduce the risks associated with them. Risk-mitigation strategies continue to grow more successful as seismologists, geologists, engineers, architects, emergency responders, and other experts innovate new public-safety initiatives in their respective fields. The primary strategies involve more robust seismic building code requirements, enhanced seismic design requirements, increased effort to inspect and maintain critical infrastructure, and retrofitting of buildings. Protecting Buildings: Regulations, Enforcement, Engineering Strategies, and Maintenance The 2023 earthquakes in Turkey and Syria brought renewed attention to the importance of building codes and proper enforcement. In New York City, DOB develops and updates building codes to mitigate risk from earthquake and enforces these codes through extensive administrative measures. The seismic regulation follows the developments and improvements in national seismic standards. Since 1985, FEMA has sponsored earthquake engineering research by the National Earthquake Hazards Reduction Program (NEHRP). Their latest2020 NEHRP Recommended Seismic Provisions: Design Examples, Training Materials, and Design Flow Chartsis the primary source of national seismic design requirements for new buildings and other structures.National Earthquake Hazards Reduction Program, Effect of Soil and Rock Types, Earthquake Coordinators. New York Citys current building code is as stringent as any in the United States, with the likelihood of failure or collapse of a modern, code-compliant structure being the same as that in California. Codes provide general occupancy conditions for less severe earthquakes. Any existing building in New York City that undergoes substantial modification is also required to adhere to these standards. The first seismic provisions in New York Citys Building Code were signed into law in 1995 and took effect in February 1996.NYC Department of Buildings, NYC Codes, City of New York. DOB further addressed the citys structural vulnerability to earthquakes in 2008 and subsequently in 2014 and 2022, when it adopted the International Code Councils (ICC) family of codes as the basis of the New York City Construction Codes. It is important to note that while the NYC Construction Codes adopted the ICC codes, they also amended some portions to be more stringent than the ICC. The 2008, 2014, and 2022 Codes aim to make buildings stronger, more flexible, and more ductile able to absorb energy without breaking in a brittle manner. The Codes have sections on soil types and building foundations. Seismic detailing is required to enable a buildings joints, structural connections, and piping to hold up during an earthquake. Under the 2008, 2014, and 2022 Construction Codes, critical facilities such as firehouses and hospitals are required to be designed to both survive an earthquake and also remain open and functional following one. In 2014, DOB revised the Construction Codes and moved toward a new concept the risk-based approach, following the model of the American Society of Civil Engineers Standard (ACSE) 7-2010 for designing and constructing seismic-resistant structures. In a similar manner, the 2022 Code follows the model of ASCE 7-2016. These enhanced codes require that new buildings in New York City are designed so they are less likely to collapse or sustain significant damage during an earthquake. The revised code also strengthens the design requirements for prevention of soil liquefaction and takes the citys unique geologic conditions into account. Building designs must account for site-specific soil conditions and building foundations and must ensure that joints and structural connections are flexible. Special detailing for electrical and mechanical systems, building contents, and architectural components are also specified. Code committee work is now in progress for the next revision to the Construction Codes. DOB is also working on a draft of the NYC Existing Building Code, which includes a structural chapter intended to address issues related to seismic loads in existing buildings, among other concerns, by referring the user to the NYC Building Code structural requirements. This initiative aims to improve safety or mitigate hazards in buildings constructed before the seismic requirements were enacted. To make sure that buildings are built to code, new construction and major renovations cannot begin until DOB has reviewed plans and issued work permits. Most of the details required by earthquake design are subject to special inspections performed by qualified private engineers who are responsible for reporting findings to DOB. To meet seismic standards, architects and engineers employ several methods to design and engineer the retrofit of older buildings strengthening connections among building elements, increasing the structures flexibility, reducing building mass to minimize impact from seismic forces, and strengthening foundations placed in poor soil to ensure stability. For existing unreinforced masonry buildings, connections between structural elements are strengthened by anchoring walls to the roof and walls to the foundation, thus increasing the structures ability to transfer loads during an earthquake. Another approach is to add steel frames to unreinforced brick walls to increase resistance to out-of-plane forces.Dan P. E. Eschenasy, Cases of Failure of Unreinforced Brick Walls Due to Out-of-Plane Loads. Parapets are often the most damaged element of unreinforced buildings. Seismic risk can be reduced by anchoring parapets with bolt diagonal steel struts and repairing their mortar. Alternatively, unreinforced masonry parapets can be replaced by masonry parapets anchored to the building. Simple, commonsense solutions are often enough to improve the seismic performance of a structure and to reduce the seismic risk. For example, anchoring or bolting furniture to a wall reduces the risk of injuries from falling objects as well as damage to the contents of a building. Anchoring water tanks on buildings that are six or more stories is another method to reduce the risk that the tower would topple over, potentially injuring pedestrians. Anchoring can also prevent the loss of water service to the buildings occupants. Guidelines written to protect coastal buildings from flooding and coastal storms also discuss seismic safety issues, in particular, the vulnerabilities of elevated buildings. To protect buildings with a soft story base, solutions focus on lessening the extra load by adding bracing or shear walls, or enlarging or strengthening the columns and piles. Routine maintenance on all buildings in New York City is essential to minimize the risks associated with earthquakes. This includes keeping roofs secure and in good condition, securing cornices and aluminum panels, repointing mortar regularly (especially on parapets and chimneys), and fixing all cracks. Earthquakes can cause major damage to infrastructure that was not originally designed to withstand earthquake impacts older bridges, tunnels, sewers, water supply systems, and wastewater treatment plants. New York City is acting to mandate that new infrastructure be designed to meet more robust seismic loading requirements, and that older infrastructure be retrofitted to meet those standards. Federal, state, and local government agencies all play roles in setting standards for and overseeing the implementation of seismic safety improvements for infrastructure. Seismic guidelines for infrastructure govern New York Citys actions in retrofitting older bridges, tunnels, and other critical facilities to withstand risks from earthquakes, and designing new infrastructure according to safer standards. After the 1989 Loma Prieta earthquake, which caused extensive damage to several bridges in Northern California, many central and northeastern states began adopting new seismic provisions for highway bridges. In New York, bridge owners hired seismologists to assess the risk of this hazard here. The Federal Highway Administration administers seismic retrofits of bridges through local authorities, under a 1991 inspection and rehabilitation program mandated by Congress. In 1998, the New York City Department of Transportation (DOT) developedseismic criteria guidelines,which it updates as new science and solutions emerge.Federal Highway Administration, Seismic Retrofitting Manual for Highway Structures: Part 1 Bridges (Publication No. FHWA-HRT-06-032), Turner-Fairbank Highway Research Center, U.S. Department of Transportation, January 2006. New York City began seismic retrofitting of critical and essential bridges in 1998. Transportation agencies serving the New York City area either have retrofitted or are in the process of retrofitting the bridges that they manage. Seismic isolation is one of the more common methods of seismic protection in bridges and structures. In New York City, the JFK light rail system uses this method. This approach protects bridges or structures by isolating the earthquake movement from the foundation to the structures. Isolators (rubber and steel bearings) are mounted between the bridge deck and its piers, or between the building and its foundation. Isolators are intended to absorb the earthquakes energy and minimize the energy transferred to the structure. DOT is in the process of retrofitting the Brooklyn Bridge to conform to current seismic performance requirements outlined in the infrastructure codes. Under Contract 7, which began in September 2019 and continued through 2023, DOT worked to improve the load carrying capacity of the arch blocks, strengthen the masonry towers, and focus on repairs of the historic brick and granite components.NYC Department of Transportation, Infrastructure: Brooklyn Bridge, City of New York. This retrofit includes replacing the original timber piles with stronger structural piles and reinforcing the masonry elements of the bridge. Other bridges have been replaced when seismic performance was assessed as inadequate. Seismic assessment of bridges in the New York City area requires evaluating each bridge for performance standards based on whether the bridge is determined to be critical, essential, or other. Retrofitting of older bridges or designs of new bridges should incorporate design elements that fit the level of damage expected from the projected earthquake and allow for repairs required after the event.Weidlinger Associates, New York City Seismic Hazard Study and Its Engineering Applications: Final Report (Weidlinger Associates Prepared for the NYC Department of Transportation, 1998). NYC DOT, which owns and maintains 799 bridges, is in the process of implementing seismic retrofits of all its critical, essential and other bridges.NYC Department of Transportation, 2020 NYC DOT Bridges and Tunnels Annual Condition Report, City of New York. The New York City Department of Environmental Protection (DEP) is currently conducting several projects to enhance seismic protection of the wastewater treatment system. DEP is retrofitting wastewater treatment facilities and methane gas storage systems to withstand earthquakes, because most were designed and built prior to implementation of the current, more stringent seismic standards. To reduce the risks associated with seismic activity to New York Citys sewer system, DEP is inspecting and repairing structural deficiencies in some of the major sewers. DEP is conducting a study to assess the seismic resiliency of our water supply system (water tunnels, piping, clean water pump stations, dams, shafts, and tanks) and to determine the appropriate seismic design standards. Study findings will prioritize areas in the water distribution system requiring retrofits to meet current seismic standards. City Water Tunnel No. 3 (described in theNYC Hazard Environment) is currently designed to strict seismic standards. Applying the Citys seismic guidelines, the Metropolitan Transit Authority (MTA), which is administered by New York State, is currently incorporating seismic requirements into its bridge and tunnel restoration projects within New York City. Collaboration among seismologists, geologists, engineers, architects, politicians, and emergency managers is required to manage earthquake risks. Further research into the potential impacts of earthquakes on New York City will expand knowledge about this hazard and promote greater public awareness. This research may include earthquake impact modeling of New York Citys unique built environment to estimate potential physical and economic losses, incorporating New York Citys large stock of older buildings, soil conditions, and unique geological characteristics. Examples of the research projects follow. In 2023, USGS released a new version of the National Seismic Hazard Model of seismic hazard forecast for the United States from induced and natural earthquakes.U.S. Geological Survey, Short-Term Induced Seismicity Models, U.S. Geological Survey, October 24, 2019. Similarly, the Next Generation of Ground-Motion Attenuation Models was a multidisciplinary research endeavor that concluded in 2008. Involving collaboration between academia, industry, and government, this initiative focused on creating a consensus for new Ground Motion Models (GMMs), hazard assessments, and site responses for the central and eastern North American region. This project marked a significant advancement in our understanding and prediction of ground motions, especially in the western United States. It replaced the earlier models from the 1990s and early 2000s, providing a more robust and reliable estimate of ground motions.Pacific Earthquake Engineering Research Center (PEER), A Roadmap for Next Generation Attenuation Models for Central & Eastern North America (NGA-East) (U.S. Geological Survey, April 2008). The Earthquake Engineering Research Institute established a New York-Northeast chapter to promote awareness of earthquake risk and to offer educational resources on how to reduce this risk at all levels. The organization relies on interdisciplinary expertise, drawing from the fields of engineering, geoscience, architecture, planning, and the social sciences. The Multidisciplinary Center for Earthquake Engineering (MCEER), in collaboration with the Structural Engineering Association of New York, initiated studies to better understand the vulnerabilities of unreinforced masonry buildings in New York City. Working alongside the State University of New York at Buffalo, MCEER completed shake-table tests on prototypes of unreinforced masonry structures. This was a precursor to an extensive program aimed at devising engineered solutions for New York Citys archaic building stock.M. Tantala and G. Nordenson, et al., Earthquake Risks and Mitigation in the New York | New Jersey | Connecticut Region, The New York City Area Consortium for Earthquake Loss Mitigation (NYCEM) Final Summary Report. MCEER-03-SP02. (Multidisciplinary Center for Earthquake Engineering Research, University of Buffalo, 2003). Researchers Simulate Earthquake Shaking New York City Buildings Source: SUNY Buffalo Many New Yorkers are unaware that their community is at risk of danger from earthquakes. Because earthquakes occur unexpectedly, New Yorkers will not have advanced warning that one will strike, so promoting awareness and preparedness among local communities is essential. NYC Emergency Management (NYCEM)sReady New York campaignencourages New Yorkers to be prepared for all types of emergencies, to develop a personal disaster plan, and to stay informed about the entire range of hazards that may affect the City. NYCEMsReady New York Preparing for Emergencies in New York City guide explains what to do when an earthquake strikes and the steps to take immediately after. NYCEMsReady New York Reduce Your Risk Guideincludes long-term strategies for homeowners and residents to reduce the potential damage that an earthquake can cause. Additionally, NYCEMsStrengthening Communities programoffers grants to community networks to build their emergency preparedness plan and support local community resources. The training program focuses on five key areas/deliverables to build an emergency plan specific to each community:creating a needs assessment; designing community maps of the area where services are provided; building a resource directory; preparing a communication strategy; and creating donations and volunteer management plans. NYCEM staff provide training, coaching sessions, and tools that guide participating networks through the program. Earthquakes can inflict psychological harm in addition to physical harm, so it is essential to plan for mental health services as part of any future response and recovery effort. The New York City Department of Health and Mental Hygienes (DOHMH) Mental Health First Aid education program alerts the public to the range of potential mental health issues, how to identify warning signs, how problems are manifested, and the types of commonly available treatments. FEMA and the Northeast States Emergency Consortium organize annual Great Northeast Shakeout drills to encourage organizations, households, and agencies to practice safety during an earthquake. These drills are an opportunity for groups to update their preparedness plans, restock supplies, and secure items in their homes and workplaces to prevent damage and injuries if disaster strikes. A participant in the Great Northeast Shakeout Drill. The primary objective of current building codes is Life Safety based on a Risk Category which addressed a seismic event that will give new construction a uniform collapse risk of 1% in a 50-year horizon. This ensures no loss of life during and immediately after an earthquake, but does not address the time to reoccupy and reuse a building or a lifeline infrastructure. Recovery time is estimated for a typical office building in San Francisco to be 6-12 months for design-level earthquake and ~ 2 years for the maximum earthquake considered in the code. Growing interest in improving resilience and post-event recovery by public and professionals led to the reauthorization of National Earthquake Hazards Reduction Program in 2018, with a Congressional assignment tothe National Institute of Standards and Technology and FEMA to spearhead an effort to identify the needs for improving time for public to re-occupy and re-initiate functions after an earthquake event. Theoretical range of building performance and relative placement of safety-based and recovery-based goals. Source: FEMA, courtesy of R. Hamburger In 2021, the two agencies published the Recommended Options for Improving the Built Environment for Post-Earthquake Reoccupancy and Functional Recovery Time. The concept of Functional Recovery (in addition to Life Safety) is introduced as a post-earthquake performance state in which a building or infrastructure system is maintained or restored, to safely and adequately support basic intended functions of pre-eq use or occupancy of a building, or service level of a lifeline system. The acceptable time to functionally recover after the event may vary for different building uses and lifeline services. The new concept of Functional Recovery is human-centered and requires thinking beyond code in a philosophy that combines technical knowledge with implementation and recovery. Initial studies using decision support FR frameworks that account for risk and losses from damage but also time to return to service, have shown significant increase in the benefit to invest in resilience.NIST-FEMA Special Publication NIST SP-1254/FEMA P-2090, Earthquakes are always a surprise, no amount of seismic monitoring can predict them with any exactitude, but the 4.8 magnitude earthquake that struck the New York metropolitan area on April 5 was more so than usual, as earthquakes of this size are relatively rare in the region. Fortunately, there was no widespread damage and no casualties, other than a jolt to the confidence of its population, but it has nevertheless spawned some crucial questions about the infrastructure of a city that is known for its multitude of some of the tallest buildings on earth.The earthquake prompted inspections of infrastructure and led to some temporary disruptions in transportation as a precaution. It left many residents wondering how the citys buildings would fare under stronger seismic waves.Engineering experts have reassured the population. According to these experts, New York Citys glass towers and luxury steel skyscrapers, which can be over 1,000 feet tall, are actually at much lower risk of sustaining damage or collapsing during an earthquake than the citys older buildings.I have total confidence in high-rise buildings in New York, said Eric Cowley, president of Cowley Engineering.The citys building codes were amended in 1995 to ensure that new construction or any significant upgrades are designed to make buildings earthquake-resistant and minimize the probability of collapse, which is the biggest cause of death during temblors.The more modern seismic codes in this country came after the Northridge and Loma Prieta earthquakes in California, said Chris Cerino, president of the National Council of Structural Engineers Association and senior structural engineer at STV, a structural engineering firm. Those earthquakes happened in 1994 and 1989, respectively.The New York metropolitan area hit by the April 5, 2024 earthquake. Photo: Google MapsCowley said newer buildings are much lighter

California regularly experiences?So 4.8 is not very large. The intensity of shaking relates to the magnitude of the earthquake as well as the distance. A 4.8-magnitude that happens 100 miles away is less severe and theres less damage potentially compared with one that occurs ten miles away. As an earthquake, 4.8 is not that large in terms of damage potential for buildings, but if buildings arent well designed, there could be damage. Also, an aftershock would be an order of magnitude lower than the earthquake. So if 4.8 is the main shock, youd expect 3.8 or less for aftershocks. What do we say to Californians that will make fun of us for overreacting?I dont think its an overreaction, honestly. If an area does not experience earthquakes often, it can be scary. Any shaking can be terrifying. It is honestly news that an earthquake happened in the Northeast. People should be aware that ground shaking in the Northeast can happen and can be damaging. So this one may not have caused damage, but it should create some awareness that the earth can shake in New York. But buildings are designed for earthquakes. What advice would you give New Yorkers for dealing with this in the future?There really is no practical way to get notice of an earthquake happening. Theres no way to detect an earthquake before it actually occurs.I would just say that earthquakes are a reality of the Northeast United States. They dont happen often, theyre not really large. Our buildings and infrastructure are designed for earthquakes. I dont think they should be concerned that an earthquake of this magnitude results in damage. It can happen, but its rare. Being prepared is something people should keep in mind, but I dont think it should be a major concern. Daily news about the politics, business, and technology shaping our world. Vox Media, LLC Terms and Privacy Notice By submitting your email, you agree to our Terms and Privacy Notice and to receive email correspondence from us. When the shaking started at 5:46 a.m., Yasuhisa Itakura, an architect at a big Japanese construction company in Kobe, was sitting at his desk finishing a report he had toiled over all night. His office swayed, but the books stayed on their shelves and nothing fell off his desk. I thought to myself, this earthquake is not that big, Mr. Itakura said. It was, in fact, catastrophic. The Great Hanshin earthquake of January 17, 1995, killed more than 6,000 people in and around the industrial port city. Mr. Itakura had been cushioned from the violence of the earthquake because his three-story office building was sitting on an experimental foundation made from rubber an early version of an engineering technique called base isolation. The technique that protected Mr. Itakuras building is used in roughly 9,000 structures in Japan today, up from just two dozen at the time of the Kobe earthquake. Thousands of other buildings in the country have been fitted with shock-absorbing devices that can greatly reduce damage and prevent collapse. Chile, China, Italy, Mexico, Peru, Turkey and other countries vulnerable to earthquakes have adopted the technologies to varying degrees. But with notable exceptions, including Apples new headquarters in Silicon Valley, the innovations have been used only sparingly in the United States. Seismic safety advocates describe this as a missed opportunity to save billions of dollars in reconstruction costs after the inevitable Big One strikes. Earthquakes are of course natural phenomena. But the amount of damage they cause is a function of decisions made by politicians, engineers and business executives. Japan and the United States, two of the worlds most technologically advanced countries, have the same problem how to protect people and society from earthquakes and yet they have responded in very different ways. Japan, through both government mandates and its engineering culture, builds stronger structures capable of withstanding earthquakes and being used immediately afterward. The United States sets a minimum and less protective standard with the understanding that many buildings will be badly damaged. The two approaches reflect different attitudes toward risk, the role of government and collective social responsibility. Analogous to Americas debate over health insurance, the American philosophy has been to make more resilient buildings an individual choice, not a government mandate. Do we want to be more like Japan and are we willing to pay the price? said Joyce Fuss, president of the Structural Engineers Association of California. A lot of people would say no and maybe some people would say yes. Isolating the Building From Ground Motion Inherent in the American approach to seismic engineering is a risk calculation: Many American engineers operate on the assumption that a building, which might be used for 50 years before it is torn down and replaced with a new one, has a relatively small chance of being hit by a huge earthquake. If you spend the money today and the earthquake happens tomorrow, then congratulations, youve done a good job, said Ron Hamburger, an American structural engineer who is perhaps the leading authority on the building code. But the fact is, truly significant damaging earthquakes will affect a place like San Francisco or Los Angeles maybe once every 100 to 200 years. How lucky do you feel? he added. Apples new headquarters in Silicon Valley was constructed with an acute awareness that the building sits in earthquake country. Jim Wilson/The New York Times Left, Los Angeles City Hall was retrofitted with base isolators. Right, the building housing Sonys office in Tokyo uses base isolation, as well as another seismic technology known as shock absorbing dampers. Left: Trevor Tondro for The New York Times, Right: Kazuhiro Nogi/Agence France-Presse Getty Images Left, Los Angeles City Hall was retrofitted with base isolators. Right, the building housing Sonys office in Tokyo uses base isolation, as well as another seismic technology known as shock absorbing dampers. Left: Trevor Tondro for The New York Times, Right: Kazuhiro Nogi/Agence France-Presse Getty Images In cities like San Francisco, where the median price of a home is well above a million dollars, the notion of making construction costs even more expensive is likely to be unpopular, even if the goal is to preserve the city in the long run. Large earthquakes are around 10 times more common in Japan than in the continental United States, according to Hiroo Kanamori, an emeritus professor of seismology at the California Institute of Technology. But seismic history suggests that California may be due for large earthquakes, which often come in clusters. In Northern California, the last five major earthquakes along the Hayward fault, the jagged crack in the earth that runs through the heavily populated cities of Berkeley and Oakland across the bay from San Francisco, have occurred on average every 140 years. The last one was 151 years ago. (Seismic history has also shown that predicting earthquakes is a fools errand.) [At Risk in a Big Quake: 39 of San Franciscos Top High Rises] The last major earthquake in the contiguous United States, which caused $20 billion of damage to the Los Angeles area, was a quarter of a century ago. The land has been peaceful in America, said Masayoshi Nakashima, president of the International Association for Earthquake Engineering. Young generations in particular are not necessarily familiar with the reality of earthquakes. The debate over whether to build more resilient buildings in the United States has been held largely out of public view, among engineers and other specialists. But at stake is whether places like Silicon Valley, Seattle, Salt Lake City, San Francisco or Los Angeles might be forced to shut down after a direct hit and for how long. [Want to get our daily newsletter California Today by email? Heres the sign-up.] A federal study last year found that a quarter of the buildings in the San Francisco Bay Area would be significantly damaged after a magnitude-7 earthquake, a disaster that would be compounded by the fact that nine out of every 10 commercial buildings and eight out of 10 homes in California are not insured for earthquakes. Cities wont be usable for many months, if not years, said H. Kit Miyamoto, a member of the California Seismic Safety Commission, a government body that advises the State Legislature and the governor on earthquake issues. Throwaway buildings equal a throwaway city. In a severe earthquake, most American buildings are designed to crumple like a car in a head-on collision, dissipating the energy of the earthquake through damage. The goal is to preserve lives, but the building like a car after an accident may be useless. Mr. Hamburger, the structural engineer, estimates that half of all buildings in San Francisco could be deemed unoccupiable immediately after a major earthquake. Some cities like San Francisco are considering rules that would require buildings to be more rigid, similar to those in Japan. There is no such thing as earthquake-proof construction, but experts say American buildings could be much more resilient for little additional cost. A multiyear federal study concluded that fixing buildings after an earthquake costs four times more than building them more strongly in the first place. The United States is losing an estimated $4 billion for every year that it delays a stronger building code for earthquakes, the study calculated. Mr. Miyamoto, who was raised in Japan but now lives in California, said there was increasingly sharp disagreement between Japan and the United States over seismic engineering. The Japanese are completely flabbergasted about how we design out here, he said. American vs. Japanese High-Rise Construction American high-rises are typically built with a concrete core that resists most of the seismic forces of an earthquake. Japanese high-rise construction commonly uses a grid of steel beams and columns that evenly distributes seismic forces across the structure and diagonal dampers that serve as shock absorbers. American high-rises are typically built with a concrete core that resists most of the seismic forces of an earthquake. Japanese high-rise construction commonly uses a grid of steel beams and columns that evenly distributes seismic forces across the structure and diagonal dampers that serve as shock absorbers. American high-rises are typically built with a concrete core that resists most of the seismic forces of an earthquake. Japanese high-rise construction commonly uses a grid of steel beams and columns that evenly distributes seismic forces across the structure and diagonal dampers that serve as shock absorbers. American high-rises are typically built with a concrete core that resists most of the seismic forces of an earthquake. Japanese high-rise construction commonly uses a grid of steel beams and columns that evenly distributes seismic forces across the structure and diagonal dampers that serve as shock absorbers. Protecting tall buildings from earthquakes is among the highest-stakes endeavors for engineers. The collapse of even one skyscraper could have catastrophic effects. Tall buildings are also perhaps the biggest bone of contention between American and Japanese engineers. Most new high-rises in the United States are built around a reinforced concrete core, a technique that Japanese engineers shun because they say it performs unpredictably in an earthquake. Tall buildings in Japan are almost always built with steel. Japan, of course, still has many vulnerabilities, some of which were made clear when the 2011 Tohoku earthquake created a tsunami that breached sea walls, killing an estimated 16,000 people and spreading radiation from a damaged nuclear reactor. The country has many older buildings constructed before major changes to a 1981 building code, and even the countrys seismic innovations are of varying quality and effectiveness, as highlighted by revelations last year that a manufacturer of seismic shock absorbers falsified its performance data. But over all, Japanese engineers say, earthquakes over the past two decades have proved the effectiveness of the countrys stricter regulations and innovations. Kobe and the Tohoku earthquake of 2011 led to a surge in demand for more robust buildings, with consumers willing to pay a premium for the latest technologies. One company has developed inflatable airbags that deploy underneath a wooden home when a large earthquake is detected. Of Japans 9,000 base-isolated structures, 4,300 are multistory buildings, many of them offices, condominiums and government buildings, and 4,700 are houses, according to the Japan Society of Seismic Isolation. Base isolation is advertised on Japanese television and on the Tokyo subway, touting the seismic systems of newly constructed condominiums. Nice Corporation, a Japanese construction company, says a seven-story base-isolated building costs 13 to 15 percent more than a conventional one. Ian Aiken, an engineer who specializes in seismic technologies, says the systems can cost as little as 5 percent more. Many new buildings in Japan are not base isolated, but even conventional ones are generally stronger and stiffer than American ones, according to Mr. Hamburger, the code expert, and other engineers who have worked in both countries. The so-called resilience movement designing buildings to better withstand natural disasters such as earthquakes has gained adherents in the United States in recent years. Canada is also studying higher strength requirements for its buildings. But American advocates say they face a number of obstacles. Evan Reis, a co-founder of the U.S. Resiliency Council, a nonprofit organization, says the biggest impediment is that unlike in Japan, buildings change hands frequently in America and the developers who build them do not see the incentive in making them more robust. Short-term thinking is absolutely the biggest villain, Mr. Reis said. People are willing to roll the dice. [San Franciscos Big Seismic Gamble] Efforts in the California Legislature to strengthen seismic laws faltered last year. A bill that would have mandated that buildings be functional after an earthquake was watered down in committees and then vetoed by the governor at the time, Jerry Brown. Experts say there is little political upside to advocate stronger buildings because the public is largely unaware that buildings are designed to be damaged in a large earthquake. The building is going to take punishment and hopefully allow us to get out alive, said Richard J. McCarthy, the executive director of the California Seismic Safety Commission. The commission began a campaign this year to warn the public that the building code protects them less than they may think. Amarnath Kasalanati, the associate director of the Pacific Earthquake Engineering Research Center at the University of California, Berkeley, says it is paradoxical that more buildings in the United States do not use innovative seismic technologies, since American scientists and engineers were early leaders in the field. Mr. Kasalanati estimates that there are 175 base-isolated buildings in the United States, mostly museums, hospitals and older buildings like the city halls of San Francisco and Los Angeles that were retrofitted with isolators. One American company that helped develop seismic isolation devices has shipped 70 percent of the 20,000 devices it has produced overseas. The base isolators installed in Apples headquarters are two stories underground. Made by Earthquake Protection Systems, a company based in California, the devices isolate the steel frame of the building from the shaking of the ground and foundation during an earthquake. Jim Wilson/The New York Times One notable building in the United States that uses the devices is Apples giant new headquarters in Silicon Valley. Steve Jobs, the Apple co-founder, died before construction began on the building. But when he introduced plans for the circular, glass-sheathed structure, he described it as a little like a spaceship. As seen on a rare tour, the four-story orb, which holds 12,000 people and is about as wide as the Pentagon, is the Rolls-Royce of base-isolated buildings. [Inside Apples Earthquake-Ready Headquarters] The building, which has a concrete foundation that resembles a bathtub, is not attached to the ground if cranes or helicopters existed that were powerful enough, they could lift it up. At the base of the buildings nearly 700 support columns are stainless steel pucks that sit on top of massive steel saucers. When an earthquake causes the ground to shake, the pucks slide across the saucers as much as four feet, slowed by friction. A Sliding Mechanism Controls Building Motion The net effect for occupants is that when the ground jolts back and forth, the building moves significantly less. One of the designers of the building was Jony Ive, the man who was responsible for the look and feel of Apple products such as the iPhone and iPad. A native of Britain, Mr. Ive said he found the threat of earthquakes utterly alarming when he moved to California in the 1990s and was surprised by the Californian nonchalance toward them. Mr. Ive said he and Mr. Jobs never considered using a conventional foundation for the building. We would have seen it as utterly bizarre not to protect our investment, he said.

Earthquake proof buildings usa. Are new buildings earthquake proof. Nyc earthquake. Are buildings earthquake proof. Are buildings in new york earthquake proof.

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