CODE CHECK

Your Key to the Codes

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June 1, 2021

To: City and County of San Francisco Board of Supervisors

Re: Joe Eskenazi articles on seismic retrofits in San Francisco
Letter from structural engineer Randy Collins dated 4/28/21
Letter from Charles Perry dated 4/30/21

The problem of unsafe gas lines is real and may be broader than the instances that were found concurrent with seismic upgrading. The board has been presented with materials that presume we have to choose between safer structures or safe gas piping. Though a tradeoff of one safety issue for another may be temporarily necessary, it need not be permanent. Seismic upgrading and safe gas lines are both achievable. The sequence in which work is performed, and the coordination of responsible parties, should be the only issues at hand.

First off, let's look at the responsibilities of the building department, structural engineers, and contractors. Bear in mind that individual cases could be different, but in general, the scope of a seismic retrofit does not trigger a requirement for upgrading existing conditions that do not conform to current codes. Indeed, a building inspector could be seen to be overstepping their authority if they go beyond the inspection of what is on an approved set of plans and construction documents. Gas lines are a plumbing issue. They are not within the training or expertise of structural engineers. A plumbing permit is not necessary for a seismic upgrade.

Next, look at jurisdiction over those gas lines. In general, gas lines up to the meter are within the purview of PG&E, not the building department. After the meter, they are subject to the California Plumbing Code as enforced by the local building department. The lines in question here are the high-pressure service laterals owned by PG&E. The building department cannot be faulted for knowing to "stay in their own lane" when it comes to gas laterals that are owned by PG&E.

PG&E's guidelines (Green Book 2.3.1 B) state that they do not permit installing gas service laterals under or through structures, buildings, foundations, or decks, or the installation of gas service risers directly into concrete or asphalt paving materials. Obviously, many older buildings predate that policy. The Uniform Plumbing Code (the model for the California Plumbing Code) has prohibited unprotected iron piping from contact with soil or concrete since the 1946 edition, and installation of gas piping below ground beneath a building was prohibited in the 1948 edition.

The California Plumbing Code requires each building to have an exterior gas shutoff valve. One reason is so that first responders can shut off the gas to the building before entering. Typically, this shutoff is at the meter and, on new construction, the meter would be outside the building. My understanding is that PG&E has retrofit some of the properties in question with new (plastic) underground piping and shutoffs in the sidewalk, while others have old iron piping with no shutoff outside the building.

There have been many instances where underground gas leakage on single-family residences and apartments has resulted in tragedy, even without the supervening event of an earthquake. Gas leakage into soils resulted in the migration of the gas through a loosely backfilled trench into a residence in Palo Alto, resulting in an explosion. A similar event in Sacramento resulted in a fatality. In each instance, the warning odorant that is added to natural gas had been filtered by the soils and the gas leaks were not apparent to the occupants. It does not take an open flame to ignite a room or garage filled with an explosive gas mixture. Any spark could do it; even simply starting the car could be sufficient.

Settlement, corrosion, and earthquakes all have the potential to cause gas leaks inside the buildings with older high-pressure gas lines. The owners of these buildings are placed in a difficult position. We might find insurance underwriters refusing to renew coverage unless gas service laterals are also replaced to PG&E standards. If there is a gas-fueled fire, we might find these same insurance companies filing subrogation claims against the engineers and contractors who performed the seismic upgrades. If someone sells the building prior to the fire event, the number of potential defendants rises exponentially.

This problem is an example of aging infrastructure. The problem is not isolated to the buildings undergoing seismic renovation; it is a larger question of how PG&E's distribution system can quickly be brought up to modern standards. The solution must not be limited to simply those properties already identified by the seismic retrofitting program, nor should the owners of those properties be the only ones to bear the financial burden.

San Francisco has suffered several devastating city-wide fires in its history. A means must be found to accelerate PG&E's upgrade program for these gas laterals before they become the cause of the next major fire.

Background: *Douglas Hansen is the senior author of the Code Check series of field guides to building codes, with over 1.3 million copies sold. He has authored numerous other publications and holds several code certifications. He was formerly the senior inspector and plan checker for plumbing, mechanical, and electrical systems at the City of Santa Clara. He has been certified as an expert witness on building codes in Superior Courts in several northern California counties.*

From: Beinart, Amy (BOS)
To: Major, Erica (BOS); Low, Jen (BOS)
Subject: Fwd: Letter from engineer Charles Perry regarding gas lines encased in concrete foundations
Date: Friday, May 7, 2021 3:25:32 PM
Attachments: Gas line photo.png

From: Joe Eskenazi <joe.eskenazi@missionlocal.com>
Sent: Friday, April 30, 2021 2:49 PM
Subject: Letter from engineer Charles Perry regarding gas lines encased in concrete foundations

Hello —

Engineer Charles Perry sent me the following letter. With his permission, I am forwarding it to you.

JE

To whom it might concern:

Randy Collins is correct that the seismic retrofit program made buildings more safe.

Randy Collins is correct regarding the risk of modern buildings with sleeved steel gas conduit that has an internal polyethylene pipe that transmits the gas to the meter.

Where opinions diverge is when dealing with older building: In older buildings, the steel gas pipe is the only pipe, so failure of this pipe will produce a leak; in older buildings, the steel gas pipes are corroded, so they are more likely to fail due to stress cracking of the pitted steel surface as well as loss of cross section. The attached photograph shows a typical gas pipe prior to being wrapped where it passes through a new footing.

In a design earthquake, the ground motion includes horizontal waves with an amplitude

between roughly 1 and 5 inches. This wave passes across a 100 foot building in roughly 0.1 seconds. This means that part of your building is zigging 1 to 5 inches while another part of your building is zagging 1 to 5 inches in the opposite direction (go and look at 1906 photographs and you will see trolley tracks that look like pretzels going up Pacific avenue). This puts bending stress on pipes entering the building.

Might this break a pipe that is 100 years old, rusted, and hard cast in a concrete footing? Yes.

In all buildings, seismic motion is only one possible ground motion. Long term settlement is another source of ground motion. As an example, consider the San Bruno Gas Transmission pipeline failure. The formal investigation was inconclusive and posited the theory that an 11 psi increase in pressure above the existing 375 psi might have contributed to the failure. Understand that this pressure was well below the 400 psi rating and further below the roughly 800 psi failure load (design pressure is roughly half the actual failure pressure).

My own investigation showed that this roughly 30-inch diameter steel pipe broke where it crossed a canyon that had been filled with 30 to 60 feet of soil to create a relatively flat neighborhood. In the roughly 60 years between construction and pipe failure, this fill would have settled several inches. This settlement would have put increased stresses on the pipe. The NTSB determined that one of the pipe welds failed due to increased stress. 400 psi gas discharged from the crack pipe for an extended period of time (several days per witnesses who smelled gas in the neighborhood). Somehow, this gas found an ignition source and an explosion ensued. 8 people were killed. 50+ homes were burned to the ground.

There were other issues to be certain (e.g., the pipe on the north side of the canyon did not align with the pipe on the south side of the canyon; the installer put a dog-leg in the fill to connect the two misaligned pipes; this dog-leg added to the stress in the settling pipe; this dog leg prevented PG&E from running a PIG through the pipe and spotting a deteriorating weld; and PG&E was charged with filing false maintenance records).

The point is: Long-term settlement can cause gas pipes to crack, leak, and start fires.

Differential settlement can also lead to pipe failure — and differential settlement in buildings is common. I bought a 50 year old house on cut and fill. The fill had settled 3 inches across my living room. I am working on an apartment near Washington and Leavenworth (which is an ancient sand dune). One corner of the building has settled more than 3 inches. I worked on several buildings in the Marina: Two had settled between 3 and 6 inches differentially in 100 feet in the prior century. We found a truck bed beneath the foundation of another; liquefaction analysis predicted 22 inches of differential settlement in one building. I did a lateral spreading analysis of a condo complex in Saratoga: 3 of 18 buildings are expected to slide downhill into a creek in a magnitude 6 earthquake due to lateral spreading of a very gradual slope.

I have worked on residences with as much as 6 inches of differential settlement. I inspected buildings on bay fill in Mission Bay and Foster City after the 1989 Loma Prieta earthquake. The ground had consolidated as much as one foot and left these buildings standing on their piers. I did not encounter any failed gas lines, but the opportunity was there.

The most infamous case of differential settlement of the Millennium Tower. It has settled 18 inches. This is a modern building, so claiming that modern high-quality design & construction prevents settlement is nonsense. Imagine a rusted unwrapped unprotected steel pipe being cast

solid where it passes through such a foundation. You could easily anticipate failure.

In every project in which I wish to make any change to the gas service, PG&E requires that they construct a vertical riser OUTSIDE the building and that the pipe enter the building through the framing (which is not rigid). PG&E also requires old steel pipes to be upgraded to the new steel conduit with polyethylene interior pipe.

Why do they require this if they are not concerned about pipes breaking? Answer: PG&E is concerned about pipes breaking. So are the San Francisco Plumbing Inspectors and plan-checkers.

Finally, you do not need to completely break a gas line to create a problem. You only need to create a small crack in a joint or coupling. Although the gas in your furnace, stove, and water heater might be at 0.5 psi (7 inches of water), the gas in the pipe where it enters the foundation is 60 psi. Stick a pin in your bicycle tube and observe the air escaping. Now, imagine that this is natural gas. Now imagine that this natural gas is in an 8" diameter tube that is many miles long. Functionally, the leak is never ending. Now imagine the effect of this accumulating inside a building. I worked on a project in Santa Clara (old memory), where an apartment building was tented for extermination. A gas leak at a meter filled the tent to the lower explosion limit; the gas-air mixture found a pilot light; the apartment building exploded (deflagrated to be precise). The explosion severely damaged the apartment building and surrounding homes.

The challenge with the current situation is determining which buildings had old gas pipes hard cast into concrete. Wrapping pipes is the standard of care in the industry. This protects pipes from damage when ground motion occurs. Where work was done properly, I am not concerned.

The concern arises from the fact that not every contractor knows the standard of care or is being compensated in a manner that allows full consideration of all risks. Many contractors take the position that if something is not on the plans they do not have to do it. How many engineers provided details or instructions to wrap pipe prior to casting concrete? How many engineers located the gas lines prior to design or construction? How many engineers went to the job site to inspect every phase of the work where they could instruct a contractor to wrap unwrapped pipe?

Quantifying this risk is exceptionally difficult. Some 6,000 buildings were flagged for possible retrofit. Nearly 4,000 buildings have been retrofitted. If just 1% of the retrofitted buildings meet the "at-risk-of-failure" criteria, that is 40 buildings at risk of fire or explosion after an earthquake. This would be a disaster. But the number might be 0.1%, then that is 4 buildings. We simply do not know.

This raises the questions of how to address a very real risk that is difficult to quantify. How much of society's resources do we dedicate to this situation? Building owners are already struggling to pay for mandatory seismic retrofits ($200,000 per building average) and fire alarm system upgrades ($20,000 per building average). Adding mandatory natural gas service upgrades ($50,000 per building average) might be the proverbial straw that breaks the camel's back.

As much as I dislike working with PG&E and being subject to their now-completely-risk-

averse policies and mind-numbing delays in doing anything, their goal of upgrading every building's service with a modern lateral that enters the building above-grade from the outside is probably the best approach to solving the current quandary regarding pipes hard cast in footings.

This could be coupled with PG&E's objective of relocating all gas meters to a location where they can be accessed without entering a building; PG&E could allow gas meters to be put inside meter boxes in the sidewalk in front of buildings. This would make the pipe that actually enters the building under the control of the building owner and limit its pressure to roughly 0.5 psi. In situations where meters cannot be relocated economically, PG&E could allow the use of meter closets accessible from a garage / workman's walkway / egress route; PG&E has the authority to do this under their J-15 Standard, but they do not allow it for reasons only they can divine. To control costs and minimize delays, PG&E could allow the relocation of gas lines and meters to be designed, approved, and performed by non-PG&E contractors. As a city-wide process, this work could be planned for completion over the next two decades and factored into PG&E's rate base.

Lest anyone propose the elimination of natural gas in San Francisco and switch to all electric power, this comes with an insurmountable price tag in the near future. Currently, San Francisco consumes 5.6x10^12 Watt-hours of electricity and 6.7x10^ Watt-hours (equivalent) of natural gas annually. Eliminating natural gas as a power source would require every building in San Francisco to get an electric service upgrade to twice its current capacity and reconstruct the entire electric power distribution system in San Francisco.

It would require that San Francisco double its purchase of electric power from sources that operate at night and in the morning when solar & wind power are not available to heat water and homes. You guessed it … these power plants would run on natural gas.

Sincerely,

W. Charles Perry