Sinking cities: New York, Chicago, Tel Aviv at risk from climate change

A new study showed for the first time that "underground climate change" causes the ground beneath urban areas to move, expand and contract.
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A smartphone receives data from the underground temperature sensors (photo credit: Northwestern University)

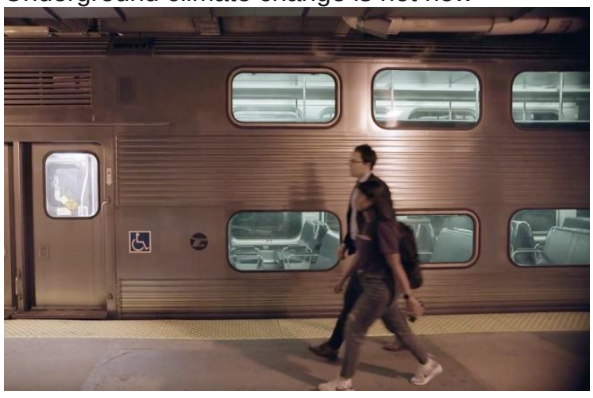
New York and Chicago are sinking, according to two different pieces of research. Local scientists say there is no reason to assume Tel Aviv will be different.

"We can expect to see many, many unhappy surprises," said Tel Aviv University's Prof. Alon Tal.

On Tuesday, a new study by researchers at Northwestern University and published in *Communications Engineering* showed for the first time that "underground climate change" - heating underground - causes the ground beneath urban areas to move, expand and contract. Ground deformation, they said, can cause buildings to crack, tilt or settle, affecting their durability and aesthetics and reducing their general operational performance.

"Underground climate change is a silent hazard," said Northwestern's Alessandro Rotta Loria, who led the study. "The ground is deforming as a result of temperature variations, and no existing civil structure or infrastructure is designed to withstand these variations. Although this phenomenon is not dangerous for people's safety necessarily, it will affect the normal day-to-day operations of foundation systems and civil infrastructure at large."

Underground climate change is not new



Professor Alessandro Rotta Loria and Anjali Naidu Thota, a Ph.D. student in Rotta Loria's lab, walk through a train tunnel beneath the Chicago Loop (credit: Northwestern University)

Underground climate change is not new. Previous research has shown that the shallow subsurface beneath cities warms by 0.1 to 2.5 degrees Celsius per decade, the study explained. This warming has already been linked to ecological issues, such as contaminated groundwater, and health issues, such as asthma and heatstroke. Rotta Loria's team ties it for the first time to infrastructure.

"If you think about basements, parking garages, tunnels and trains, all these facilities continuously emit heat," Rotta Loria said. At the same time, construction materials trap heat derived from human activity and solar radiation during the day and release it at night, with some of it being absorbed in the ground.

To conduct the research, Rotta Loria's team installed a wireless network of more than 150 temperature sensors across the Chicago Loop — both above and below ground. As a control, it put sensors underneath Grant Park, a greenspace located along Lake Michigan. The sensors highlighted that the temperatures under the loop were as much as 10 degrees warmer than below Grant Park.

"We used Chicago as a living laboratory, but underground climate change is common to nearly all dense urban areas worldwide," Rotta Loria, who spoke to The Jerusalem Post, said.

The data was collected over three years. Then, using a proprietary 3D computer model, the Northwestern researchers simulated how ground temperatures evolved from 1951 and predicted how temperatures would change by 2051. Rotta Loria was also able to model how rising temperatures affect different types of ground surfaces, from clay and sand to limestone. Soft and stiff clay contract, he said. Sand and limestone, as well as hard clay, expand.
Rotta Loria's simulations warn that warmer temperatures can cause the ground to expand upward by as much as 12 millimeters. They also can cause the ground to sink downward by as much as 8 millimeters.

"Although this seems subtle and is imperceptible to humans, the variation is more than many building components and foundation systems can handle without compromising their operational requirements," the research summary said.

He said that buildings in the United States are relatively new. However, in places like Europe, buildings are ancient and likely even more susceptible to underground climate change. Rotta Loria added that "buildings made of stone and bricks that resort to past design and construction practices are generally in a very delicate equilibrium with the perturbations associated with the current operations of cities. The thermal perturbations linked to subsurface heat islands can have detrimental impacts on such constructions.

A temperature sensor, placed underground beneath the Chicago Loop (credit: Northwestern University)

"In other words, you don't need to live in Venice to live in a city that is sinking — even if the causes for such phenomena are completely different," he continued.

Rotta Loria recommended applying thermal insulation underground to existing buildings to help mitigate the challenge. He also offered that geothermal technologies could absorb part of the heat that is being wasted otherwise and be reused.

The Northwestern study comes on the heels of a separate report by the US Geological Survey and the University of Rhode Island that showed extensive construction is causing New York City to sink under its weight. The risk of flooding is exacerbated when coupled with rising sea levels due to climate change.

The researchers calculated the mass of all buildings in the city and modeled how much they are sinking by the pressure they exert on the Earth. The results: The city is sinking at around 1 to 2 millimeters a year - and in some areas at double this rate - a year while sea levels rise at around twice the global average as glaciers meet and seawater expands from global warming.

"The combination of tectonic and anthropogenic subsidence, sea level rise, and increasing hurricane intensity imply an accelerating problem along coastal and riverfront areas," the team wrote.

The researchers said that the city's structures weigh 1.68 trillion pounds. While some buildings are anchored on solid bedrock, others are built on sands and clays, which, as the Chicago study explains, can expand, contract and sink both due to natural settling and climate change.
"We have a baseline sinking of about 2 millimeters a year," Tom Parsons, a geophysicist at the US Geological Survey, told *the Post*. "When you look at the weight of the buildings in New York - depending on where they are - you can see about 4.5 to 5 millimeters, especially on soft soils. Then rising sea levels have created another two or more millimeters yearly."

In other words, the city could be sinking in some parts at as much as seven millimeters a year. At this rate, it would still take centuries for New York City to be underground, Parsons said. However, it does raise concerns.

"When we have major storms or hurricanes, these storms push the seawater onto land, and we have already seen a lot of damage and casualties from that," he said.

Repeated seawater contact with building foundations is also not good, as it could corrode steel and destabilize buildings, Parsons said.

Parsons said he hopes the paper will raise awareness that every additional high-rise building constructed on the coast could contribute to flood risk. He added that mitigation strategies should be implemented from laying the cornerstone.

Moreover, he said, existing cities have to start planning.

"Flooding kills people, which is probably the greatest concern," Parsons said.

In Israel, the Ministry of Environmental Protection has raised a red flag about rising sea levels. Using simulation tools, it has shown that cities like Tel Aviv and Haifa could be subjected to extreme flooding, explained Prof. Isaac Meir of Ben-Gurion University's Civil and Environmental Engineering Department.

Gideon Behar, special envoy of climate change and sustainability for the Foreign Ministry, said last month at the OSCE High-Level Conference on Climate Change, "We need a regional plan to prepare for rising sea levels in the Mediterranean. At this point, many countries in the region have no assessment of the extent to which the population will be exposed to the rise, let alone protective mechanisms."

On Monday, the Permanent Mission of Israel to the UN tweeted his statement.

There is also a growing hazard of sinkholes in Israel, primarily driven by the lowering of groundwater levels, noted Tal.

"Israel's performance in climate mitigation is borderline scandalous," Tal told *the Post*. "Israel is a coastal nation and needs to be very concerned about what Tel Aviv will look like in 50 or 100 years.

"Buying on Yarkon Street in Tel Aviv may no longer be a good investment."