Built to Last

When our roads and bridges crumble and collapse, we have one kind of problem. When they don't, we have another.

BY ALAN WEISMAN

The fire station where Erin Moore and I have paused in our stroll through downtown Tucson won't fall apart anytime soon. Its bottom half is walled in 18-inch-thick concrete, which surrounds massive I-beams that frame tall, wooden double doors. The steel-clad upper two stories are faced in slabs of pale stone. "Now *that* one," Moore says, nodding approvingly, "will leave a very nice skeleton." A tall, light-haired architect in her early thirties, Moore has wide, alert eyes that absorb copious amounts of information in a glance. Through them she sees architecture in four dimensions, not the usual three.

"I don't see a structure as beautiful unless it has a graceful way to break down built into its future," she says, shading her eyes against the autumnal desert glare. Solid as this fire station is, she can envision how, if its destiny is left to time, the sun will loosen the grout and caulking that secure its facing, sending the stone crashing someday. The big doors will succumb as gravity and moisture undo their hinges, and its floors of concrete, poured over corrugated decking, will crack and flake apart. Slowly but inexorably, the building's base will disintegrate to sand and lime, eventually leaving only a rusting matrix of rebar and steel beams. Finally, that too will corrode, to iron oxide dust. Aesthetically, Moore says, the deterioration of this building will be far more interesting and pleasing than the fate of the tinted-glass-and-steel downtown boxes we've passed, doomed to collapse one day into messy piles.

"We live and build within a cyclical ecosystem, in which things mean as much in death as in life. When we show clients an architectural rendering, it's like when an OB-GYN shows expectant parents an ultrasound image—that's not what their kid will always look like. It's not just how something looks now, but how it *will* look. Architects should think of ourselves as choreographers. What we make will always be interacting with time, weather, chemistry, and with people's touch."

Across the street is a venerable example: one of Tucson's few remaining blocks of flat-roofed adobe houses. Replastered every few years, they last indefinitely; neglected, they melt attractively until all that remains is a pile of reusable window frames. Once, such natural mud constructions defined the entire city. Then railroads arrived, bringing sheet metal that could form low-maintenance pitched roofs. But that was only the beginning. Most of the Tucson of today won't dissolve charmingly back into the earth from which its walls rose. Instead, its legacy will be heaps of aluminum shower-stall parts; sun-cracked, faux-clay vinyl roofing tiles; cement-and-polymer hybrid siding advertised not to weather, but which does anyway as water infiltrates its nail holes; plastic and brass- or chrome-plated debris that once adorned façades and swimming pools; and lumps of polymer glop used to bind these items, that

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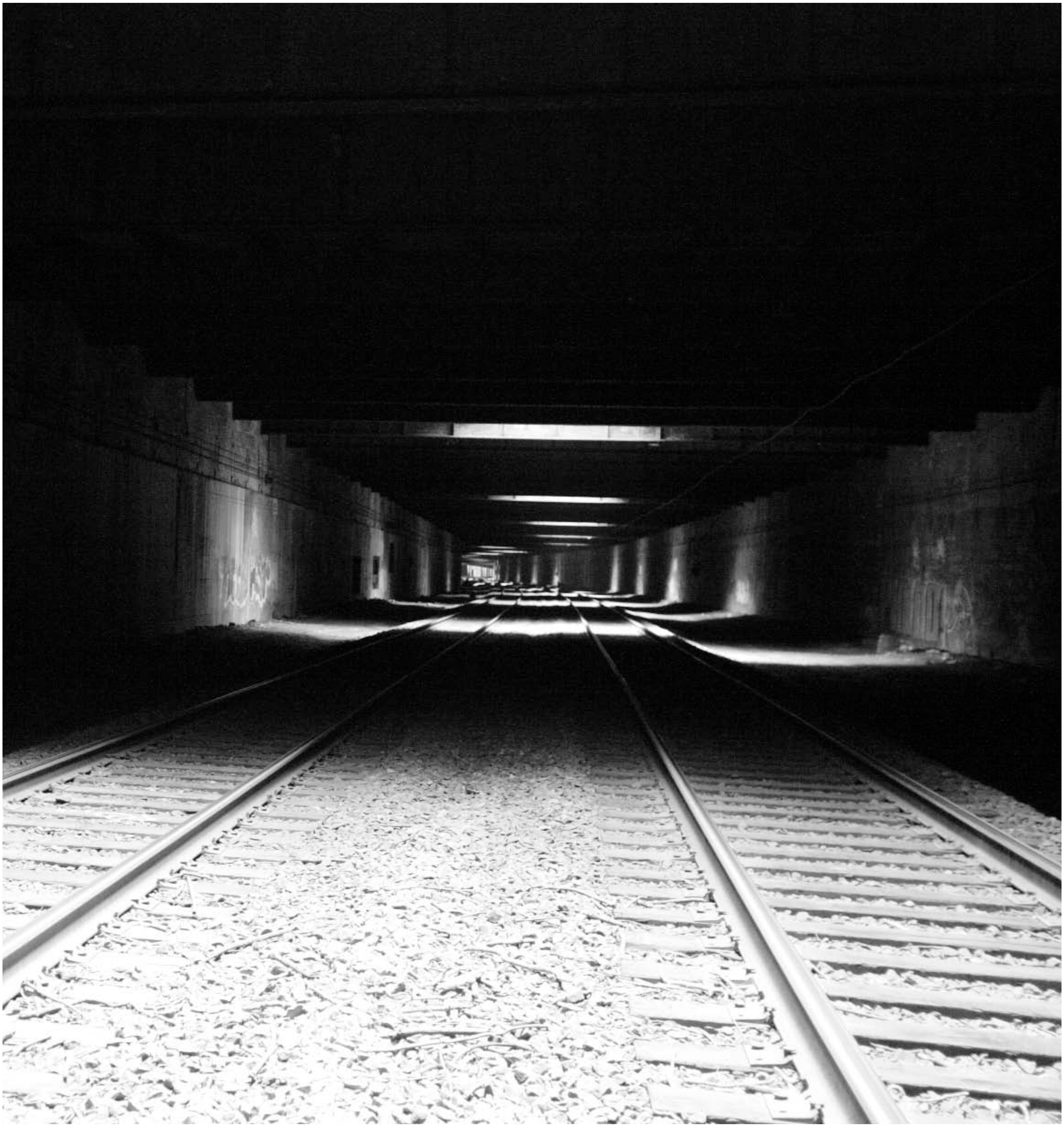
won't break down for thousands of years.

Yet even if our cities were filled with totally biodegradable and recyclable architecture, we would still be faced with clutter that won't disappear in any reasonably human span of time, because every edifice and dwelling is linked by infrastructure intended to be resilient. Unlike buildings, whose durability isn't always a virtue—"You want a McDonald's to be ultrapermanent?" Erin Moore asks students at the University of Arizona, where she teaches—we get into trouble when entropy shreds the connective tissues of our civilization. We want our roads, bridges, tunnels, mass-transit rails, dams, pipelines, sewers, canals, and transmission cables to last. When they don't, the consequences range from irritation and anxiety to panic and disaster. But if we design infrastructure to endure forever, have we only created another kind of problem?

On August 1, 2007, a Minneapolis bridge that forms part of our interstate highway system dropped into the Mississippi River—"without warning," newscasters said repeatedly. Though their shock was genuine, their analysis was mistaken. While I was researching my book *The World Without Us*, a bridge expert named Jerry Del Tufo had explained to me exactly why such events were predictable, if not inevitable.

When trains stopped running in this Manhattan tunnel for a decade, a community of homeless people built shanties in the abandoned cavern.



Del Tufo, a structural engineer with the Port Authority of New York and New Jersey, has at various times been in charge of several bridges linking New York's boroughs. One snowy February afternoon in 2005 he drove me to the Bayonne Bridge, which connects Staten Island to New Jersey. As we gazed up at the Bayonne's colossal underside matrix of steel bracing, Del Tufo explained that New York bridges such as the George Washington and this one, both more than 70 years old, were built before computers were around to calculate the minimum amount of materials budget-crunched contractors could get away with. Back then, cautious engineers simply heaped excess mass onto the bridges they imagined.

CAN WE RISK building something enormously costly that might soon become obsolete?

"These bridges are so overbuilt, traffic's like an ant on an elephant," Del Tufo said. "The GW alone has enough galvanized steel wire in its three-inch suspension cables to wrap the earth four times. We're living off the overcapacity of our forefathers."

By contrast, the Minneapolis bridge, half the age of these robust older spans, was already known to be crumbling before it failed. At the time of its collapse, four of its eight lanes were closed for repairs to the roadway deck and to several weakened steel joints, the extent of their deterioration hidden from public view behind tarpaulins. Although no official cause of the calamity has been identified by the National Transportation Safety Board, the added weight of construction materials and cement trucks to evening rush hour traffic was apparently enough to break the I-35W bridge's back. That only 13 people died was considered miraculous.

A year earlier, just one car was crushed when a three-ton slab of concrete held in place by epoxy became unglued and fell from the ceiling of an enclosed ramp in Boston's recently completed Big Dig, a massive public-works project that rerouted snarled downtown traffic over a new bridge and through two tunnels—one of which is more than three miles long. Thousands who'd traveled the same route that day were stunned by the random good fortune of their near miss.

The dilemma of modern construction is summed up in an anecdote that Wernher von Braun, the scientist who developed the U.S. space program, used to tell about John Glenn, the first American to orbit the earth: "Seconds before liftoff, with Glenn strapped into that rocket we built for him and man's best efforts all focused on that moment, you know what he said to himself? 'My God! I'm sitting on a pile of low bids!' "

And we've been driving over and under them. One obvious remedy is to spend more public funds to shore up our underpinnings. Yet this logic collides with an invisible obstacle—invisible because it lies beyond the horizon, that is, in the future: How can we know what kind of infrastructure will be necessary five or 15 years from now? Can we risk building something enormously costly that might soon become obsolete? And when it eventually does outlive its service, will we be able to afford to dismantle it without leaving huge, indelible gashes in the landscape, and reuse the stuff for which we paid so much to construct it?

Two hundred miles west of Tucson, 300-year-old wagon wheel ruts marking the passage of Jesuit explorer Padre Eusebio Kino are still traceable in the desert caliche, just above the Mexican border. To the north, paralleling Kino's route, the 10-inch-thick, four-lane band of poured concrete ending at San Diego known as Interstate 8 will last far longer. But what if our search for energy-efficient, next-generation transportation were to produce a vehicle—say, a hovercraft—that rendered unnecessary

This granite aqueduct in Segovia, Spain, built without mortar or cement, has endured for 2,000 years, but pollution and age are slowly deteriorating it.

not only energy-gobbling transmissions and friction-prone rubber tires but possibly even roads themselves—and for that matter, tunnels and bridges?

What would we do then with the four million miles of pavement cross-hatching the United States alone? What would China do with its own ever-thickening, mostly brand-new weave of highways, already half the size of ours and spreading fast? Although concrete and asphalt can be recycled, their main application is to build more roads. Either way, reusing or removing implies vast, possibly prohibitive energy expenditures. Even leaving them intact for bicycles would become extravagant once maintenance costs were factored in. Nature would eventually overgrow them—in a few centuries to a few millennia, depending on climate—but until then, they would bear accusing witness to how our century of motorized vehicular addiction scarred formerly sublime land.

Hovercraft may seem an unlikely scenario to us now (though at Chicago's 1893 World's Columbian Exposition, technology exhibits for the next century failed to predict airplanes, television, and personal computers). But another potential innovation that could supersede a significant part of our infrastructural legacy isn't so far-fetched. During the 20th century, we wrapped much of the earth's landmasses in wire: electrical and communications lines that, if the United States' grids alone were strung in a single strand, would reach the moon and back, and nearly back again. Whenever storms or accidents sever their copper, aluminum, or optical-fiber lengths, we lose money and, temporarily, our sanity, as we wait helplessly for repairs to restore power or re-establish contact.

Yet increasingly we communicate wirelessly, with devices that require far fewer cables and antennae. With no small envy, we encourage developing nations to seize the chance to leapfrog our stage of technological advancement, with its unsightly tangle of overhead cables, and beam their telephony, voice and data alike, via radio bands. Although we can't yet substitute pulsing lasers for high-voltage power lines that require 150-foot steel-lattice towers every thousand feet to bear their ponderous weight, we already have technologies that could drastically reduce the sheer mileage of metal we've draped across continents, simply by generating electricity locally—possibly on every rooftop. All that copper and aluminum, if salvaged, might even slake our need to uproot entire mountain ranges and everything that lives on them just to rip more minerals from the ground.

Less easy to dismember, let alone recycle, would be the tons of concrete poured into forms spanning river canyons to create dams. Among the most immense and costly of all human creations, dams are an instant mix of blessings, which in time often become greater liabilities than assets. China's soon-to-be-completed Three Gorges Dam, the world's biggest, is but the latest such structure to provoke predictions that the havoc it wreaks on land, people, and ecology may only be resolved by dismantling it.

It wouldn't be the first. Along North America's coastlines, dams meant to electrify and irrigate so that people and crops might flourish have also clogged arteries through which irreplaceable organisms such as salmon flow. Not only are they commercially precious, but their disappearance causes such cascading losses of life (or livelihood, in the case of fishermen) that dams that obstruct salmon spawning routes lately have been torn down at an expensive clip. Similarly, in the wake of catastrophes such as Hurricane Katrina, the wisdom of channeling rivers through concrete chutes so that cities can occupy their deltas is being reassessed. Once freed, a river heals surprisingly quickly, burying under great loads of silt whatever unsightly scrabble remains after we try to put nature back the way we found it.

NATURE WILL EVENTUALLY inter any infrastructure left standing. Vulnerable assemblages of concrete and steel may be the first to go.

As the massive cost of clearing the way for Boston's Big Dig suggests, should large numbers of roads ever become unwanted, it would simply be too expensive to do much other than bury them. In fact, in urban centers destined to be abandoned (or abandoned already, such as parts of Detroit), that job will probably be left to nature. As sewers become clogged with plastic bags and other debris, deserted streets are colonized by germinating weeds and trees, whose roots crack through the pavement as it disappears beneath leaf litter. Like sewers themselves, the cement and asphalt paths that formerly connected our lives to homes and workplaces will gradually sink out of sight, overlain by a spreading cap of new soil.

Given enough time, nature will also inter any other infrastructure still standing—most likely our oldest, built from large stones hewn directly from the earth, which will long outlast our more economical but far more vulnerable assemblages of concrete and steel. The ghost of a Mayan pyramid builder would be amazed to see his once monumental, seemingly indomitable kingdom swallowed by forests. So would we. ■