The Routledge Handbook on Infrastructure Designs:
Global Views from Architectural History

Edited by Joseph Heathcott

CONTENTS

INFRASTRUCTURE DESIGNS

Dreaming and Building Worlds

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Infrastructure emerges from deep within our dreams. It takes form through designed artifacts that in turn give rise to new dreams. It is at once an object and an ideal, a technique and a fable, a prosthesis and a prophecy. It reflects a continual quest for the facilities of movement and exchange, sociality and togetherness, power and control. Infrastructure is simultaneously an affect of the fervent human desire for connection and a reflection of our failures to forge such connections on the basis of equality and justice. It is, to paraphrase philosopher Michel Serres, the flawed angel that heralds the unevenly connected world.

This book considers infrastructure across a wide variety of forms, locations, and temporalities. The extraordinary group of authors gathered here provides not only new knowledge of specific infrastructure artifacts, such as the Valens aqueduct, the Hong Kong waterfront, and the Pan-American highway. They also provide new ways of conceptualizing, studying, and understanding infrastructure as a worlding process. Their chapters connect disparate regions, explore themes across broad spans of time, examine questions of linkage and scale, investigate materiality and affect, and trace the interrelation of aesthetics, technology, and power. Some focus on singular infrastructural elements, others on whole systems or interrelated networks; together, they provide a rich and multiform account of how we build and connect the world.

Beneath and Between

The term *infrastructure* is an ambiguous and drifting signifier. This ambiguity has led to several key challenges for scholars of the built environment. The first challenge has to do with the ambit of the word itself. Nineteenth-century French engineers coined the term to refer to the substrate of support for rail lines—the structure beneath the structure.[1] The term spread through transatlantic and colonizing networks, particularly among civil engineers engaged in road building and water projects, as well as military officers concerned with defense works and territorial control. Gradually it came to refer not only to structures below, but also between—physical networks connecting one node or place to another in a system. Today, we regard infrastructure as both visible and invisible, below and between, material and immaterial. It is no longer just the packed gravel substrate under the train tracks, it is also the train tracks themselves, and it is the switches, signals, chronometers, sheds, rotundas, terminals, and operational standards that comprise the system of rail transit, and it is the bodies, social relations, and visions of the world remade by high velocity travel.[2]

Another challenge has to do with the application of the term. Even as the concept of infrastructure expanded to include more artifacts, it also came to be used retrospectively to account for structures built

long before the advent of the term. Thus, the term is freighted with assumptions built into the modern Enlightenment project in which it was born—assumptions such as progress through technology and the superiority of scientific reason over other knowledge forms. Scholars have too often read these assumptions backward into accounts of infrastructure in ways that justify Eurocentric notions of civilization, development, and empire. The expansion of European and U.S. hegemony over the last five centuries has been embedded in and accompanied by self-justifying narratives that view power as the inevitable outcome of technological superiority. Even as this so-called modern world became fractured by successive world wars, faith in progress and the embrace of the "technological sublime" survived and spread globally.[3] And while the term infrastructure has been applied retrospectively, it has also become a standard element in projections of the future. U.S. Presidential advisor and economist Walter Rostow's "stages of growth" encapsulates this vision of a world "modernized" and "improved" through the adoption of Western technology and infrastructure.[4]

Finally, researchers must contend with the reality that while the term refers to connecting affordances, those very affordances often become resonant places in their own right, thickened with significance and leavened over time through countless repeated uses.[5] The oldest known bridge in the world at Argolis was constructed by a Bronze Age Mycenaean Greek community to span a stream and carry chariots along the highway connecting Tiryns and Epidauros. It remains in use today, its irregular corbel arch settled comfortably into the Peloponnesian landscape. The two cities that it connected and helped to grow, however, lay in deposition, long since abandoned. But the bridge stands as a beloved local site and tourist attraction. Similarly, the Galata Bridge (now in its fifth iteration, see Figure 0.1)

Figure 0.1   Strolling and fishing on the Galata Bridge in Istanbul. Galata Bridge is a prime example of infrastructure both as a connector of places and a place in its own right.

Source: Photograph by Joseph Heathcott.

facilitates the flow of people and vehicles across the Golden Horn, connecting Sultanahmet and Beyoğlu. But the bridge itself is a lively destination, a platform for strolling, fishing, and taking in the breeze off the Bosporus.

Despite these challenges, or perhaps because of them, the term has opened up felicitous ways of describing the designed and built world. While it may be overdoing it to declare an "infrastructure turn" in scholarship, infrastructure nevertheless presents a critically important field for investigation as a key affordance in the production of both space and mobility over time.[6] A focus on infrastructure allows us to attend to the details of complex socio-technical systems and built environments—the connectors, the interstitial networks, the nodes that amplify, compress, and switch the flows. And not just material objects, but the invisible pathways, lines of force, and radiant fields that they produce, and the varied relations that emerge through the interconnected web of locations, practices, and things. By centering infrastructure we open ourselves to new stories, new ways of looking at the world.

Design Stories

The core purpose of this volume is to tell new stories about the design of infrastructure. And we tell these stories from an intellectual space animated but not confined by architectural history. What can the perspective of architectural history provide in the way of deeper understandings of infrastructure design? What might a sustained study of infrastructure contribute to architectural history, and how might architectural history provide us with new insights and ways of apprehending infrastructure? To answer these questions, we have to think through what we mean by architectural history as an intellectual project and design as a human endeavor.

In this volume, we take a broad view of design as a neurocognitive capacity shared by all humans. Engagement in design tasks activates particular neuropathways associated with ideation, trial and error learning, task set configuration, and visual-spatial information processing.[7] Through design, we amplify our ability to connect our imagination with action in the world in order to transform that world to suit a desired outcome. In this sense, design is related but not reducible to "problem-solving," a closed loop activity where the variables in a situation are known, as when we find a rock and use it to break open a nut. Rather, design is an open process characterized by an ability to identify and discern between changing variables, as when we hold the same rock and see something different in our mind's eye embedded within the it—the arrowhead, the axe blade, the adornment. In practice, it is a form of abductive reasoning based on iteration, prototyping, and movement between general and specific propositions. It is an inherently futuring cognitive affordance. Like language or perception, design may be more or less advanced from one individual to the next, more or less facilitated by neurophysiology, but every person has the capacity to design.[8]

Given that design is a fundamental human capacity, architecture, as the design of built form, is a practice broadly shared within and across cultures. In popular lexicon, architecture is often used to refer to unique, geospatially fixed buildings designed by professionally credentialed architects—the grand edifice, the monument, the iconographic structure. Likewise, definitions of architecture by architects tend to re-enforce their status as creative geniuses responsible for transcendent works of art. As Jay Pritzker famously declared, "architecture is intended to transcend the simple need for shelter and security by becoming an expression of artistry."[9] Such a definition implies that shelter and security are "simple needs," rather than immensely complex and creative human endeavors, and that the development of human habitat is devoid of artistry unless it involves the work of an architect. While great monuments and edifices certainly count as expressions of architecture, architecture itself is not reducible to such objects; rather, it instantiates through generative practices of form making, temporal marking, and aesthetic expression grounded in human social relations. These practices unfold along continuum from professional to untrained, fixed to mobile, unique to repetitive, integral to modular and permanent to momentary. Architecture emerges from and reflects constant negotiation among people over the

production of space, the terms of exchange, the vectors of mobility, and the making of lived worlds.[10] The task of architectural history is to account for these negotiations over time, and the artifacts, spatial forms, and social relations that they engender.

Nevertheless, as Stephen Parcell has ably demonstrated, while architecture changes over time, so do our definitions of what constitutes architecture.[11] In the mid–nineteenth century a powerful discourse took hold around the notion that the locus of authority to design inheres in the credentialed professional. This conceptualization of design as specialized knowledge acquired through the rigors of training parallels the broader emergence of institutional and discursive practices that codified expertise in fields from medicine to public health, social welfare, education, civil engineering, and planning. The professions gained organizational strength as gatekeepers in the production of scarcity around knowledge, and as managers of the complexity of a rapidly urbanizing and industrializing society.[12] As such, they not only served the interests of powerful state and market actors, but also their own interests as a middling class, with narratives constructed to justify their existence. And indeed, who does not want to traverse a bridge designed by an engineer, or send their children to learn from a qualified teacher?

The question for architectural historians, then, is how do we tell stories about the history of the designed and built world in ways that do not read backward through or reify nineteenth-century notions of design as the delivery of progress and modernity by the credentialed professional? After all, no singular act of genius created the canals of Suzhou or Xochimilco (Figure 0.2), the rail networks of

Figure 0.2 Xochimilco in Mexico City, a listed World Heritage site, comprises a remnant of the Aztec *chinampas*, a unique form of land reclamation with an infrastructure of canals and irrigation channels still in use today.

Source: Photograph by Joseph Heathcott.

colonial India or the Soviet trans-Siberian east, the Mughal port of Surat or vast expanses of modular warehouses surrounding airports across the globe. These infrastructures take form through processes that are highly contingent, spatially and temporally uneven, and seldom predictable. They might have a leader to guide their development, as Mimar Sinan oversaw the creation of the Kırkçeşme water system or as Robert Moses envisioned the transformation of New York City for the automobile age. But most often the design of infrastructure is a multi-authorial process, the result of countless actors toiling in obscurity with varied capacities and skills: carpenters, masons, wheelwrights, founders, haulers, accountants, bureaucrats, laborers. Thus, infrastructure elements might unfold through a directing plan, or they might reflect the work of many hands. They might rise up in great nervous eruptions of energy and investment, or take form gradually across manifold instances of trial and error, addition and subtraction, accretion and obsolescence.

In all cases, our histories of infrastructure design have to be delinked from discourses that frame technological affordances as the inevitable result of the march of civilization. Reading infrastructure back through the lens of modernity and progress reinforces the developmentalist logics that have been central both to nation-building projects as well as to European and U.S. hegemony.[13] Nineteenth-century chroniclers of national growth and development often used infrastructure as a proxy for measuring success in the expansion of settlement, the control over territory, the movement of people and goods, and the formation of citizen-subjects. Infrastructure, like so many other facets of technology, is tightly wound into circular and self-justifying narratives from which it can be difficult to escape. Essays in this volume counter these narratives by reminding us that infrastructure emerges out of processes that are temporally ad-hoc and contingent, spatially rough and uneven, rather than a smooth or continuous flow of things.

Instead of describing an inexorable arc of progress, then, infrastructure ramifies in manifold ways: when the Spanish conquerors drained the lakes of the Valley of Mexico in the seventeenth and eighteenth centuries, they created new land for rapid construction of urban fabric; but in the process, they destroyed the lacustrine habitat so carefully engineered by the Aztecs over several centuries (refer to Figure 0.2), which has led to unending problems of flooding, subsidence, and increased risk from earthquakes.[14] The emergence of discourses on sanitation and hygiene in the nineteenth century led to crucial improvements in water and waste management. However, it also led middle-class reformers from Brazil to India to the U.S. to associate Black, migrant, and poor populations with filth and disease burdensome to the body politic, in turn justifying efforts of isolation or removal.[15] The extension of the Tennessee Valley Authority electric grid provided more access for more people in one region, but at the same time the uneven enrollment and "last mile" challenges lead to a reorganization, rather than elimination, of socio-spatial inequalities.[16] Communities in the South Bronx rose up in opposition to the construction of the Cross Bronx Expressway. The new road destroyed intact urban neighborhoods, but greatly improved the flow of traffic into and out of the city—that is, until it didn't. Like so many expressways, its status as a common pool rival good led not only to frequent traffic gridlock, but also to a public health crisis: an alarming increase in asthma rates among children in the South Bronx.[17] Infrastructure never submits to a simple account.

Infrastructure in an Expanded Field

In order to tell new stories about the design of infrastructure over time, the authors in this volume consider infrastructure beyond its object state into an expanded field. After all, infrastructure unfolds in excess of itself, congeries of always-incomplete social relations, human desires, material resonances, and stories that simultaneously focus and amplify, compress and expand the world. The Silk Road, for example, never existed as one coherent artifact; instead, it comes to us as a compression of many stories that we have forged into a singular narrative. It was at once a collection of spatial and architectural forms that emerged, accumulated, and faded over time—routes, markers, caravanserai, fortifications, ports, custom houses, water wells—and at the same time a space of world-making across geography

Figure 0.3   Caravanserai-i-Shah at Qazvin, Persia (Iran), from Eugène Flandin, *Voyage en Perse* (Paris: Gide et Baudry, 1851). The caravanserai were crucial features of overland trade routes through Central Asia, as well as elements in Orientalist constructions of the world.

Source: Courtesy of Wikimedia Commons.

and culture (Figure 0.3). The nilometers of ancient Egypt not only enabled the practical exercise of recording the annual flood, they provided data for the calculation of hydrological cycles that under-girded the mysteries of priestly power. The U.S. Interstate is both a slab of asphalt with supremely engineered fault tolerances, and a space for projecting freedom, mobility, and American power. And while it ramifies spatially, it is never experienced in totality by any one person, but rather in fragments, ideated through countless maps and atlases. Every airport terminal is a more or less humdrum feature of long-distance travel, and at the same time a tightly wound nodal point in the networked shrinkage of the globe. But we do not know that network as a whole; we know the check-in counter, the security cordon, the departure gate. Wires and switches dumbly send us electricity, but also envelop us in the hypnotic spell of the technological sublime.

The present volume examines infrastructure within an expanded field. This expanded field includes not only the immediate artifacts of infrastructure—the dams, bridges, water pipes, fiber optic cables—but also the materials of which they are composed, the processes that produce them, the labor that animates them, the human affects that they reflect and engender, the landscapes and ecologies that they transform, and the stories within which they are enmeshed. These stories are not only about the construction of structures and systems, but also about the desires behind these constructions, the forms of life that they make possible, and the path dependencies that organize their emergence into the world. Rather than view infrastructure as a taken-for-granted element of modernity, this volume approaches infrastructure through Bruno Latour's assertion that modernity is itself a multiform narrative. Infrastructure, then, constitutes a historically contingent element in the construction and dissemin-ation not of modernity, but of the *story of modernity*—that contradictory knot of dreams, aspirations, and values that shape how we narrate the world.[18]

Moreover, the chapters in this volume explore the political, economic, and social alignments through which infrastructure unfolds. As Fran Tonkiss demonstrates, infrastructure has developed within a wide range of political economies over time, with greatly varied systems of production, use, maintenance, dissembly, and reconstruction.[19] These include absolutist states such as Pharaonic Egypt and contemporary North Korea; localized tributary and reciprocal forms as in Medieval Europe and Dravidian India; extractive imperial systems of Mughals, Ottomans, and British; laissez-faire economies such as those found in Latin America in the long nineteenth century; command socialist governments such as the Soviet Union and China; monarchic regimes with immense sovereign wealth funds, such as Bahrain and the Emirates; and the constitutional liberal democracies of contemporary Europe and North America, characterized by corporate rent-seeking and mixed public/private investment. It also includes emerging transnational forms, as in the decades following World War II, when infrastructure development in Global South countries relied increasingly on World Bank loans for privatized construction subject to the imposition of austerity measures and the lowering of trade barriers.[20]

Infrastructure always reflects, often re-enforces, and sometimes transforms these political alignments. Moreover, once created, infrastructure networks and systems often generate outcomes that are difficult to control over the long term. The great network of Roman roads enabled the movement of garrisons to far-flung precincts of the empire, but also facilitated the movement of dangerous rival ideas such as Christianity as well as existential threats from warring armies from the north. Native American trails became colonial market roads, which became turnpikes and highways, which expanded settler colonial habitat and projected the terrain of empire into continental space through bloody paroxysms of violence against Native American people. When we examine infrastructure in an expanded field, we see not only the objects themselves, the path dependencies they follow, and the newly forged networks they create, but also the political, social, and ecological ramifications of these entangled systems.[21]

Take communication infrastructure, for example. The root level of communication is the singular event punctuated by visual or auditory exchange where a signal encoded with meaning is transmitted from one person and received by another who decodes or interprets that meaning. This is the province of the knowing look, the verbal repartee, the hand sign, the semaphore flag. Every form of communication that exceeds this spatial co-presence is based on signal relay. Chasqui runners on the great Inca road network carried messages between settlements along mountain spines, creeks, and stony trails. The towers of the Great Wall of China served as relay beacons, employing serial fires to warn of enemy attack. Kikuyu villages in East Africa used drum combinations and rhythmic compositions to send nuanced messages from one village to the next through a chain of settlements. The overland stagecoaches of North America carried newspapers, mail, and passengers in twenty-mile segments across mountains, rivers, and plains, until the transcontinental railroad cast them into obsolescence.

The advent of the telegraph did not obviate the relay principal, but it did speed up transmission considerably. While messages sent through the first transatlantic cables in the mid-nineteenth century took hours to transmit, that was still far more rapid than the month required for sending a message on a sailing ship. By the end of the nineteenth century, a thicket of transatlantic cable meant that news could travel from New York to London to Paris in a matter of minutes. With the 1911 completion of the last leg of the "All Red Line" between Brisbane and the booster station at Tabuaeran Island in the mid-Pacific, a message could flow around the world through 28,000 miles of cable in 16.5 minutes. To underscore the line's status as a consummate British imperial project, operators boasted that it would require 42 cuts to overcome the redundancies built into the system.[22] Indeed, by the twentieth century, routes of communication had emerged as central features in the expansion of colonial power across the globe (Figure 0.4).

The compression of signals into electrical impulses created a new system of communication based on ancient principles. But the infrastructure that made such a system possible far exceeded the wires

Figure 0.4   Hammond Map of colonies and lines of communication and travel, ca. 1930. This map indexes infrastructure as a feature of high imperialism.

Source: Courtesy of the British Studies Institute, University of Toronto Libraries.

through which the signals traveled, or the poles that held those wires aloft, or the cables that carried them along the ocean bed. The copper and steel had to mined, refined, and extruded through a series of industrial processes. The vast "negative spaces" left behind—the yawning pits in the ground—were just as much a part of the infrastructure. Gutta purcha, the latex substance used for wire insulation, had to be tapped from a Malaysian evergreen; as with so many economically catalytic plants, it was enveloped in a web of botanical imperialism, monopolized by the British through their control over plantation agriculture, coercive labor recruitment, and the export platform.[23] All of these materials had to be sourced, aggregated, shipped, disaggregated, shipped again, collected and installed. Tall straight timbers felled by the thousands formed the overland vertebrae, while ships lay spool after spool of finished cable, complete with end-coupling devices, across vast bodies of water. An ensemble of equipment such as transmitters, receivers, and eventually printers filled telegraph offices around the world. And of course, human labor animated the entire system.

Today our seemingly instantaneous forms of communication continue to operate on relays, now through modulated carrier waves travelling at nearly the speed of light. The armature of the system takes shape around the unfathomable web of fiber optic cables, diodes, semiconductors, amplifiers, routers, satellite arrays, and sprawling server facilities with massive cooling equipment and electricity demands. All of this allows for the rapid transmission, retrieval, processing, storage, switching, and control of the binary signals that comprise data. Manufacturers funnel millions of tons of materials into the system, including selenium, tin, arsenic, indium, gallium, zinc, and silicon, laid down on boron–doped substrates or extruded into elegant glass strands.[24] As with telegraphy and telephony, our current system of fiber-optic and satellite communication is animated by armies of engineers, chemists, technicians, contractors, installers, street crews, and sales personnel.

All of these communicative practices are at once constitutive of infrastructure, and at the same time more than infrastructure. Infrastructure in an expanded field is always an assemblage of materials and ideologies, but these assemblages create wholes greater than the sum of its parts. Infrastructure is the space between things, but it is also those things remade by their very connection to infrastructure. It is the telephone wire and the water pipe, but it is also the body remade through entangled relations with socio-technical systems that augment, extend, and transform the human—the prosthesis, the cyborg.[25] It is the drum, the fire tower, the cable, the geosynchronous orbital satellite, but it is also the kinship network, the conception of territory, the longing for connection, the sublimity of transcending gravity. Infrastructure is never apart from the swirling eddies of desires, visions, and meanings through which it takes form. It is never innocent or neutral, but always/already entangled in social, political, and economic processes across space and time. However fixed to landscape, it is never fixed in its meaning. Infrastructure builds worlds that far exceed it.

New Vantages

Reading infrastructure in an expanded field brings to the fore many features of its design over time. If we perhaps push the boundaries of what counts as infrastructure a bit far at times, it is a small price to pay for the intellectual ground we gain. Not everything is infrastructure, of course; but few features of the contemporary world remain outside or untouched by the spaces of flows constituted through infrastructure. Thus, the authors in this volume take a broad and inclusive view of infrastructure as the entangled ensembles of nodes, networks, and processes that facilitate the movement of people, ideas, and things from one place to another. Such a framework, in turn, provides new avenues of approach, new vantages from which to recast the stories we tell about the design of infrastructure. I will review five of these vantages and their implications here.

Infrastructure beyond the Teleological Narratives that Constrain It

Far from a uniform and straightforward expansion over time, infrastructure projects tend to be unleashed in nervous eruptions at key historical moments, often as exercises in war, nation-building, or imperial control. At other times they accrue slowly, even imperceptibly, as separate projects knitted together over time, like the Indian Ocean trade network of the thirteenth century. At other times infrastructure erodes or disappears, like so many Mayan temples and processional streets entwined by jungle, or the Late Dynastic Port of Thonis slowly eroding below the azure waters of the Mediterranean. Such contingent and uneven histories remove infrastructure from its overdetermined role as a herald of progress, rung on the ladder of development, or step in the march of improvement. Moreover, infrastructure from one era can be repurposed for another, as with the recent trend of converting decommissioned train lines into linear parks. Despite these temporal complexities, we tend to collapse our accounts of infrastructure into a suite of tropes and narrative conventions that recruit roads, bridges, utility networks, and communication lines into unilinear stories of progress (Figure 0.5). Such stories, in turn, become justification for further infrastructure building.

Infrastructure as a System that both Reveals and Conceals Itself

Infrastructure tends to obscure the forces of its own production as well as the materials that flow through it. Immense expenditures of capital and labor shape networked materialities and spaces of flows, even while those expenditures recede into the overdetermined symbolism of the forms themselves. If we are fortunate, infrastructure brings water and gas to our homes, but those substances have been dramatically transformed from their source origins, and our relationship to them is attenuated by distance and the black box of technology.[26] Meanwhile, dams, docks, pipes, rail lines, and other artifacts seldom reveal their political and economic affordances. When we cross the

Figure 0.5   Cover of the *Municipal Journal and Engineer* Vol. 17, No. 6, 1904. The *MJ&E* was the leading periodical for planners, civil engineers, and city officials in the U.S. during the late nineteenth and early twentieth centuries.

Source: Courtesy of the Library of the University of Michigan.

Akashi Kaikyō Bridge to Kobe, we are mesmerized by its exquisite span, but we do not see the mass dampers that stabilize the bridge's resonance frequencies against strong winds, or the political, environmental, and contracting controversies that have plagued the bridge since its inception. The beautifully designed Bangalore-Mysore cloverleaf interchange obscures the legislative appropriations, land acquisitions, construction contracts, and hard labor that made such a piece of kit possible. Moreover, these infrastructures become such routine features of life that they tend to disappear or sublimate into our unconscious, only to be revealed in moments of crisis, as when the Tangshan Earthquake of 1976 destroyed many of the streets needed for rescue access, or when the blackout of 2003 blanketed the Northeastern United States and Southeastern Canada in darkness.

Infrastructure as Fragmentary and Uneven

This approach reflects what Stephen Graham and Simon Marvin have so aptly described as the "splintering" quality of infrastructure.[27] In their formulation, infrastructure is an always incomplete, spatially uneven set of bundling and unbundling processes that forge the distribution of flows, the forms and limits of territories, and the conditions of inclusion and exclusion. While the sheer extensivity

10

of infrastructure lends it an air of totality and smoothness, close observation and local experience always reveal it to be rough, anisomporphic, and discontinuous. Even as it connects, it disconnects; as it assembles, it dissembles; as it brings some people together, it keeps others apart. At the same time, the contingent and incomplete nature of infrastructure opens up a great variety of uses and tactics among marginalized and disempowered people. In his now classic essay "People as Infrastructure," AbdouMaliq Simone forwards the crucial insight that subaltern groups compensate for the lack of physical infrastructure by establishing embodied routines, substituting labor for capital, and forming "interconnected socialities."[28] And as Swati Chattopadhyay demonstrates, Indian rickshaw drivers, vendors, hawkers, even children playing cricket in the streets have "appropriated and gnawed" at infrastructure to generate linkages, exchange, and tactics of engagement that "are not just unnoticed by the state, but beneath its register."[29]

Infrastructure as Nested in and Connecting across Scale

Following from the notion of infrastructure as fragmented and multiform, this approach allows us to trace its connections across scale. Sometimes infrastructure networks squeeze into the tight precincts of cities and urbanized regions, bundled in overlapping spatial envelopes of collective consumption. Streetcar tracks run atop roadways, which are bracketed by telephone and electric poles. Sewers provide tubing for the extension of wires, fiber optic cables, and other filaments of communication. Dammed and channeled waterways provide navigable routes for shipping, drainage of waste and industrial runoff, and hydroelectric power. Intermodal linkages between networks amplify their respective capacities and provide opportunities for architectural production, as with the grain silos of Buffalo, New York that afford efficient transfer between barges on the Erie Canal and freight train lines. In other cases, infrastructure spreads across space and territory to cover entire regions of the world. Long roads, transcontinental train lines, oceanic shipping lanes, canalized rivers all produce territories far in excess of their physical dimensions. Meanwhile, the globe is enmeshed in planetary surveillance technologies, locational grids, satellite networks, sensors arrays, microwaves, and all manner of manifold overlapping invisible systems. But we experience these globally dispersed technologies in moments and increments, through haptic contact with cell phones, computer and television screens, and dashboard GPS.[30]

Infrastructure as Deeply Implicated in Spatial Inequality and Violence

Infrastructure has always been a factor in the exertion of violence in the world, sometimes in ways that are highly visible, and at other times occulted and obscure. The European network of rail lines and terminals that signified the continent's modernity also served the deportation, movement, and murder of Jewish people during the Shoah. Haussmann's grand boulevards were as much about beauty and order as they were avenues for Second Empire military mobilization against an unruly populace. Chicago's Dan Ryan Expressway facilitated the north-south flow of traffic through a growing city, while re-enforcing the barrier against Black people's westward movement into White neighborhoods. French colonial officials planned *cordons sanitaires* in cities from Casablanca to Saigon in order to establish zones of separation between "native" and European populations (Figure 0.6). The extents and limits of piped water, electricity, transit, and other affordances are major factors in the production of socio-spatial inequalities. At the same time, as Fran Tonkiss reminds us, infrastructure produces forms of citizenship and belonging not dependent on official documents or membership in an electoral roll. "The pipe that runs below my building and connects to the sewer main," she notes, "is a line of civic membership activated far more frequently than my intermittent trips to the voting booth."[31] Such physical networks bind people into polities in ways that are often unpredictable, unintended, even invisible.

In sum, the examination of infrastructure designs in an expanded field presents a range of possibilities for new ways of understanding our interactions with the built world. This is more than simply adding

Figure 0.6   Aerial view of the Place de France, Casablanca, ca. 1920. French colonial officials constructed the space as part of the *cordon sanitaire* separating the walled old city from the *ville nouvelle*.

Source: Photograph courtesy of the Alamy Banque d'Images.

typologies and artifacts to the roster of infrastructure, though that alone would be a valuable outcome. Rather, it opens up a view of infrastructure as an ever-changing assemblage of socio-technical objects, networks, and processes mutually constituted and continuously iterated through spatial imaginaries and material flows. It also opens up considerations of affect, of what infrastructure makes possible in our emotional, spiritual, and material lives. The drone of the subway and the heat of the packed subway car after work. The *eruv*, comprising fishing line connected to lampposts and telephone poles and elevated train tracks, enclosing the Jewish faithful in a protected wall wherein they can perform tasks otherwise forbidden on Sabbath. The stunning views of mountains, valleys, and streams from the Tribhuvan Highway between Chitwan and Katmandu. The dark water of a canal in Xochimilco, gently rippling with the movement of a canoe paddle. The bridge where we last saw a friend, the street corner where we fell in love.

Structure of the Volume

This book considers infrastructure across a wide variety of forms, locations, and temporalities. The authors take us to disparate world regions, explore themes across broad spans of time, examine questions of linkage and scale, investigate infrastructure as phenomenon and affect, and trace the interrelation of aesthetics, technology, and power. Some focus on singular infrastructural elements, others on whole systems or interrelated networks; together, they provide a rich and multiform account of how we build and connect the world. The chapters themselves are organized into eight sections. The first four sections emphasize broad thematic approaches, while the second four sections emphasize typological approaches. This is by no means meant to be a discrete division; indeed, each chapter in the thematic sections deals with specific types and examples of infrastructure, and each

chapter in the typological section illuminates critical themes in infrastructure design. Moreover, chapters interrelate across the divisions into which they have been placed, some tied together by geography, others by time period, still others through a focus on political, economic, or cultural dimensions of infrastructure. In all cases, authors bring highly developed conceptual frameworks and thoroughly empirical studies to the table.

The first section investigates material forms, compositions, and installments of infrastructure. Braden Lee Scott's chapter takes us to Imperial Rome, where successive rulers sought to legitimize their power through the quarrying, transport, and installation of Egyptian stone. Carmelina Martinez considers the work of eighteenth-century French architect Claude-Nicolas Ledoux, who regarded the creation of infrastructure around salt production as an opportunity to propose ideal relations between architecture, technology, and nature. Robby Fivez and Monika Motylińska bring us to twentieth-century cement production in Sub-Saharan Africa, using a novel genealogical approach to trace the ruptures and continuities in infrastructure building between colonial and post-independence Nigeria, Tanzania, and the Republic of Congo. Finally, Stefano Corbo's chapter presents an intriguing architectural inversion, where excavated, hidden, and concealed spaces comprise the "underworld" of infrastructure under late capitalism.

In the second section, authors consider infrastructure in terms of embodied subjects in formation. Hannah Ahblad opens a view onto how Pashtun women have adopted and used communication infrastructure in Afghanistan in order to construct gendered spaces for expression and exchange, particularly in the post-Soviet period. In the context of drought-stricken Northeast Brazil in the early twentieth century, Laura Belik traces the spatial containment of migrant families, which in turn facilitated their recruitment into a regime of coerced labor for infrastructure projects. And Reem Sardina, Sherif Elfiki, and Ahmed El Antably present a novel account of Cairene cemeteries as an infrastructure both for the transportation of souls to the beyond and the habitation of squatters in a city rapidly running out of space for the living.

Visions of the natural world and its relationship to infrastructure form the basis of chapters in section three. Marie Pirard examines the transformation of the Eau d'Heure Valley in Belgium, where for fifty years planners, architects, and engineers constructed a series of dams and reservoirs that resulted in the formation of a hybrid "machine in the garden" landscape. Margaret Vickery's chapter provides a critical evaluation of contemporary Danish approaches to infrastructure design, where architects and engineers seek to incorporate such elements as wastewater treatment and power generation plants into spaces for recreation, education, and play. And Catherine Seavitt Nordenson traces the long durée of the expansion of infrastructure into the Amazon as a project of resource exploitation and territorial control, from early colonial mapping efforts to the rise of the environmental conservation movement in the 1970.

The fourth section presents chapters that frame infrastructure in terms of the spaces of flows. Fatma Sarıkaya Işık and Pelin Yoncacı Arslan show how artists and cartographers from the fifteenth through the eighteenth centuries came to include and render the great bridge of the Valens Aqueduct—a classic space of flows—in their representations of the Ottoman capital. Menno Hubregtse takes on the airport terminal, arguing that since its inception in the early twentieth century it has constituted a highly charged site in terms of its design and technical organization, its growing importance in the self-image of nations, and its more recent role as a site of protest by various social movements. And Huda Tayob follows the flows of people and goods through the space of "Somali Malls," ordinary office blocks modified to perform vital nodes of cultural and economic exchange for the migrant communities of Cape Town.

With section five we shift the organizational emphasis from conceptual rubrics to genres and types of infrastructure. The authors in section five examine infrastructure as imbricated in urban form and city making. Sibel Bozdoğan's chapter explores the long drawn out effort to construct the first bridge over the Bosporus as part of a broader story about changing political alignments, governmental priorities, and dreams of mobility and expansion. Sued Ferreira da Silva tells a new story of

Brasilia that takes us beyond the standard focus on the Modernist city itself, but as the catalyst for the development of a national road network to link the new capital and transform the "wilderness" landscape. Mejrema Zatrić examines emerging ideas of mobility in the context of interwar Belgium and post-war Yugoslavia, where architects and planners reconceptualized cities as "circulation machines" tied in to broader infrastructure systems that could unite territories into political and economic wholes. Peter Chomowicz takes us to Doha, where successive Qatari Emirs have used road building, electrification, and other infrastructure projects as a way to legitimize their rule both at home and internationally.

In the sixth section, authors examine the specific qualities of roads and highways as a type of infrastructure replete with multiple significations and meanings. Robin Williams reveals a growing international exchange in the nineteenth and twentieth centuries among designers, planners, and engineers with regard to street paving methods—debates that were as much about optimal technologies as they were about the political economies of resources. Romina Canna provides a new look at the development of the U.S. interstate highway system, arguing that the aims shifted from the production of an abstract grid laid over national territory to a network explicitly linking together cities, culminating in the construction of urban expressways. And Dicle Taskin explores long-distance travel on the Pan-American Highway in the 1930s and 1940s, arguing that the road reflected and catalyzed dreams of hemispheric cooperation and freedom of mobility.

Section seven considers the construction of fields of power in the flow of resources, technologies, and political control. Luca Csepely-Knorr and Laura Coucill examine the rapid expansion of power production and transmission in postwar Britain, and the search among the varied design disciplines for an aesthetic language suitable to such a large-scale nation-building project. Dalal Musaed Alsayer provides novel insight into the Cold War era efforts by the United States to expand political, economic, and cultural influence in Hashemite Kingdom of Jordan through the extension of large-scale water damning and distribution projects. Keeping with the theme of U.S. Cold War power brokering, José Vela Castillo's chapter takes a close look at the development and use of aerial photography and cartography in the expansion of American military infrastructure in Spain during the 1950s.

Finally, the eighth section of the volume explores water and the infrastructure surrounding it as a major feature of human life across space and time. Luis Gordo Peláez takes us to late eighteenth-century Guanajuato and the long struggles by local officials, residents, and landowners to exert control over the flood prone river in this mountainous landscape. Charlie Qiuli Xue and Cong Sun delve into the great Hong Kong estuary to examine the history of land reclamation efforts from the colonial era to the present, with a focus on the architectural expressions, land use variations, and place-making endeavors that characterize these hard-won urban spaces. And in the final chapter of the volume, Vandana Baweja brings us into the cinematic realm with a close study the 1975 Hindi film *Deewaar* (*The Wall*), tracing its representation of docks, avenues, industrial zones, and other infrastructure spaces of the Mumbai Waterfront.

All told, the authors gathered into this volume cover a broad swath of time periods, geographies, scalar registers, materialities, political and economic forms, and human social relations in the study of infrastructure design. Moreover, while they are all experts on their topics, they come to the volume from varied locations, fields, and career stages, from doctoral students to emerging field leaders to seasoned senior scholars. This variation provides an invaluable range of perspectives in the composition of the chapters. At the same time, the work presented here reveals an emerging consensus around infrastructure design as more than an aesthetic or technical pursuit, important as these are, encompassing in addition matters of territorial expansion, power and control, accommodation and resistance, cultural meaning and modes of human togetherness. Most importantly, the authors introduce us to an incredibly wide range of opportunities, and a suite of novel and engaging approaches, for rethinking infrastructure design as a foundational feature in the dreaming and building of worlds.

Notes

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