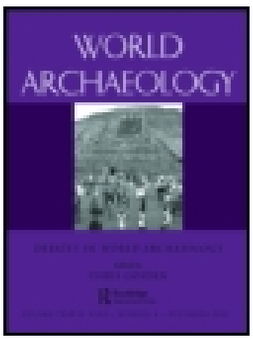

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Urban infrastructure as materialized consensus

Monica L. Smith

Abstract

Infrastructure that shapes and facilitates daily life, such as pathways, conduits and boundary walls, constitutes one of the most dynamic forms of architecture in both ancient and modern cities. Although infrastructure is conceived and designed with particular goals and capacities, its temporal and spatial scale means that it is a constant work in progress that engages numerous agents: civic authorities design and implement infrastructure; designated agencies maintain and repair infrastructure; and ordinary people utilize, modify, ignore or destroy it. Infrastructure can be thus analyzed as a materialization of ongoing communication, in which there are often conflicts among different constituents to achieve consensus. The linguistic concepts of expert language and turn-taking are utilized to assess three brief case studies: historical New Orleans; a multipurpose micro-park in Vienna, Austria; and the archaeological city of Sisupalgarh, India.

Keywords

Infrastructure; communication; performance; identity; consensus; turn-taking.

Introduction

The built environment is a manifestation of agency through which people communicate with one another and modify their surroundings for aesthetic and practical effects. Evidence for humans' investment in the built environment started in the Upper Paleolithic period 40,000 years ago, when people embellished natural caves with pictographs and carvings (Pike et al. 2012). Free-standing architecture was first represented by mammoth-bone houses at Mezhirich in Ukraine 18,000 years ago (Soffer 1985), and the first ritual architecture is documented at the site of Göbekli Tepe in Turkey 11,000 years ago (Dietrich et al. 2012). The meaning of architecture has been thoroughly explored by scholars who have assessed the importance of "home" as a place of family, emotion and identity (e.g. Bryson 2010; Moore 2012), monumental architecture as a focus for community labor investment and social power

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(Bradley 1998; Kolb 1994; Tilley 2004), and the connections and interstices of constructions formalized through 'empty' spaces and pathways (Inomata and Coben 2006; M.L. Smith 2008; Snead, Erickson and Darling 2009).

When people established the first cities starting *c*. 6,000 years ago, they integrated domestic and monumental architecture into neighborhoods physically connected through infrastructure. Although archaeologists sometimes use the word 'infrastructure' to mean any centrally sponsored construction, this article focuses on infrastructure as the manifestation of multi-user physical networks. In contemporary social science and engineering parlance, infrastructure denotes landscape-scale connectivities consisting of elements more extensive than one household can construct, maintain and use by itself, such as roads, pipelines, fences, retaining walls, bridges and terraces (Edwards 2003; Larkin 2013). Infrastructure is designed to fulfill a physical function by serving as a conduit for water or waste, providing protection against the elements and enabling unrelated individuals to access and acquire needed goods and services. Urban centers are precisely the places where infrastructure was first needed and manifested as population densities increased to levels never seen in village or town contexts, resulting in a materialized locus for analyzing social juxtapositions and the consensus-making process.

Scholars of contemporary urbanism are increasingly highlighting infrastructure as a way to understand culture, power and social change from both top-down and bottom-up perspectives (e.g. Anand 2015; Chu 2014; Edwards 2003; Graham 2010; Larkin 2013; Nolte and Yacobi 2015; Star 1999). Infrastructure provides a compelling focus of analysis because of the inherent contradictions and slippage between planning and enactment: infrastructure is highly planned and an intentional focus of investment yet is meant to function as though it were invisible; it is essential and elemental, yet often fails to function to its full capacity. Like monumental architecture, infrastructure provides the opportunity for expressions of performance and branding by a sponsoring civic authority. Like dwellings, infrastructure is used on a daily basis by individuals and household groups who are the end-users of supply and the starting-point of the waste stream. Like uninscribed spaces, the meaning, purpose and responsibility for infrastructure – particularly its maintenance – can result in contentious dialogue.

Even in modern industrial nations with sufficient capital for investment, infrastructure is never an exact match to all of a city's needs: at any given moment, infrastructure is either too large or too small for its intended population, too new or too degraded to be comfortable, too technologically ambitious or too obsolete to be maintained, too dated or too futuristic to be stylish; too thinly allocated to be effective or too concentrated in wealthy or ethnic enclaves to be equitable. From initial design stages during which different visions are expressed, through construction phases regularly extended by cost and time overruns, to use phases marked by continual needs for maintenance and upgrade, infrastructure provides both hope and disappointment. Infrastructure, like ritual, thus has 'gradations of imperfection' (Schieffelin 2007, 16) but nonetheless is often sufficiently functional to carry out some of its intended purpose.

In ancient cities just as in modern ones, infrastructure was the focal point for multiple constituencies that included sponsors, builders and users in an ongoing dialogue that can be read in material remains. Archaeologists frequently have only the fragmentary indications of those interactions (and that too in a condition in which site-formation processes have dramatically affected the evidence for the original conversations; cf. Schiffer 1987). In addition, maintenance, repair and other modifications have changed initial constructions to new forms, such that it is something of an epistemic challenge to identify which stage of infrastructure

would have been experienced by people at which precise moment. Archaeologists however increasingly feel the need to address the lived experiences of people as dynamic rather than static, particularly in urban environments (cf. Christophersen 2015; Harris 2014; M.E. Smith 2010; M.E. Smith et al. 2015; M.L. Smith 2010). The advent of cities provided new and accelerated processes of production, consumption and social interaction; framed by infrastructure's possibilities and constraints, individuals of all social classes created an urban ethos through daily practices of material engagement.

Our understanding of early urban systems may best be served by reference to cities in today's developing nations, where infrastructure projects are frequently beset by a lack of consistent revenue, accompanied by false starts and the inability to repair and maintain systems. Ancient governments similarly had limited amounts of capital for urban infrastructure and development, meaning that there was probably a very selective investment in the most dramatic and visible multipurpose and symbolic infrastructure (such as boundary walls), while systems that fulfilled quotidian needs of transport, water provisioning, waste removal and food supply were filled in by entrepreneurial bricolage, outsourcing, and public/private partnerships, as they are in many cities in the developing world today (e.g. Droney 2014; Kjellén and McGranahan 2006; Lusambili 2007; Silver 2014). Ancient cities were likely to have had many constructions that were technically 'unfinished' yet were sufficiently functional to be put into use (see, e.g., Evans 1982 on Roman aqueducts; Marriner and Morehange 2007 on historical ports in the Mediterranean; Dehejia and Rockwell 2011 on temple architecture in India).

Infrastructure as performance

The built environment provides an opportunity for symbol-making and the demonstration of power (DeMarrais, Castillo and Earle 1996; Inomata and Coben 2006; A.T. Smith 2003). Archaeological analyses of social interactions related to the urban built environment usually focus on households, large-scale monumental constructions and special-purpose venues, but infrastructure provides a promising focal point for understanding multiple expressions of authority and agency. As Edwards (2003) has noted, infrastructure often is an incremental accumulation, with structures and features utilized by multiple generations. Infrastructure is rarely refurbished by the same people who built it, so the meaning of infrastructure for both leaders and ordinary inhabitants is subject to renegotiation in every generation. Infrastructure also becomes implicated in the realm of memory and symbolism through embellishment by sponsoring authorities (often in the form of dedicatory plaques and formal opening ceremonies). More people use infrastructure than build, maintain or repair it, meaning that there is a transfer of intent from the initiators of construction through those who contribute physical labor to the end-users who develop their own memories of events.

The notion of 'performance' is witnessed in the construction phases of monumental public works, but also is applicable to the repair and maintenance phases which provide opportunities for repeated visible actions. Maintenance is essential in achieving the projected use-life of infrastructure, whether a bridge, tunnel, roadway, water line or energy conduit (Graham 2010; Sohail, Cavill and Cotton 2005, 40). There are different types of maintenance, ranging from routine actions understood to be a part of regular functioning (e.g. cleaning out canals) to minor and major repairs, refurbishments, upgrades and replacement. In addition to requiring

communication about the actual work to be done, maintenance provides opportunities for participants to reminiscence about the infrastructure's history and importance, to accept the concept of 'sunk costs' incurred through upkeep and to engage in contemplations of future value and use. Discussions about maintenance can be more complex than the discussion of initial infrastructure design and placement, as the relationship of labor and resource expenditure to effectiveness is not always obvious. Often, maintenance appears not to 'do' anything and actually interrupts the use of facilities, resulting in reluctance to perform maintenance (Hastak and Baim 2001, 69).

While the initial design of infrastructure is generally agreed to be the duty of a central authority, the incremental phenomenon of maintenance is a matter of negotiation between the providers and the end-users of infrastructure. Not surprisingly, each group views others as holding primary responsibility: civic officials assume community participation in operation and maintenance, while communities themselves view builders as responsible for continued inputs through maintenance and repair (Anand 2015; Sohail, Cavill and Cotton 2005). These oppositions provide opportunities for consensus-making, however. When maintenance is performed by central agencies, there is an opportunity to maintain a presence at relatively low cost given that simple activities can make a visible show of central or collective authority (a modern example is cleaning crews whose uniforms bear the name of a sponsoring city authority or business improvement district). Ancient municipal workers might have had similar insignia or markers of validation while engaging in the routine cleaning, maintenance and repair of facilities such as public spaces, roads, drains and boundary walls.

Infrastructure as materialized dialogue

The earliest cities were crisscrossed by infrastructure: streets, canals, water conduits, retaining walls, terraces and other physical constructions designed to serve multiple households. As a component of the built environment, infrastructure also constrained uses of adjacent spaces, such as the public streets and canals that bounded individual parcels of land in Mesopotamia (Baker 2014, 178) and Mesoamerica (Arroyo et al. n.d.). Studies of modern cities illustrate the multiple points of contention revealed in the design, construction, use, maintenance, repair and replacement of infrastructure. Urban dwellers often disagree about the appropriate use of space (cf. Colombijn 1994; Sassen 2004; Streicker 1997) and its symbolic contents (e.g. Konzen 2013; Mitchell and Staeheli 2005). Conflicts occur in the planning stage (e.g. Albert and Gaillard 2012), during construction (Plows, Wall, and Doherty 2004) and after installation when central authorities' intent is co-opted by those who use the infrastructure for other than its stated purpose (Colombijn 1994; Lusambili 2007; Ola and Adewale 2014). Acts of maintenance, repair and replacement also can be opportunities for obstruction and conflict (Chu 2014), in which individually initiated makeshift arrangements often fill in the gaps between officially sanctioned acts of construction and maintenance (Silver 2014).

Infrastructure's capacity to encode meaning, power relationships and consensus constitutes a material manifestation of language processing and dialogue. These factors led Emanuel Schegloff (2006, 70) to make an explicit analogy between talk as a human infrastructure and roads and railways as a physical infrastructure. As scholars of language have emphasized,

humans engage in communication in order to achieve some result (Goodwin and Goodwin 1987, 2; Schegloff 2006, 70–1, 81–2). Similarly, infrastructure is developed to *do* something, and the something that it does is the materialized result of continued dialogue between designers, builders and end-users. Two distinct linguistic elements can be ascertained in the process of achieving consensus among multiple constituents: expert language and the phenomenon of turn-taking.

The language of planning and design can be characterized as 'expert language', which is cognizant of system complexity yet counter-intuitively includes provisions for imprecision (cf. Yang et al. 2003, 708). Expert language is utilized by engineers and architects who evaluate the landscapes in which infrastructure is to be built, the suitability of construction methods and the notion of risk as a component of design, installation and use (Hastak and Baim 2001; Leijten 2009; White 2010). Each of the spatial, temporal and scalar aspects of infrastructure involve uncertainties, some of which are known in advance and some of which emerge during construction and use. Expert language, often laden with symbolic imagery, is also utilized as an expression of political power by civic and community leaders who initiate and underwrite planning (e.g. Bäckstrand and Lövbrand 2006; Chu 2014; Mustafa 2005). Because infrastructure is intended to be used by large numbers of people for practical purposes, the phenomenon of 'expert' language quickly expands beyond civic leaders and engineers to include the entire panoply of end-users who generate their own expressions of expertise and social power in the course of infrastructure emplacement and operation (e.g. Anand 2015).

Infrastructure as a materialized dialogue can be analyzed through the linguistic model of 'turn-taking', during which interlocutors build upon and react to others' statements (Ford 2013; Sacks, Schegloff and Jefferson 1974; Schegloff 2006). Researchers focused on receiver-based communication (Sacks, Schegloff and Jefferson 1974; Schegloff 2006; Schiffer and Miller 1999) emphasize that the listener is not a passive absorber of dialogue but an essential participant in conversation. A 'turn-taking' model emphasizes recipients as active agents who, in their responses, redirect and modify the subject of communication such that information flow is not unidirectional but shared and shaped through the process of interaction. Turn-taking also encompasses conversational 'repair' that results in small calibrations of phrasing, pauses and qualifiers to keep the conversation moving (Sacks, Schegloff and Jefferson 1974, 724; Schegloff 2006, 77–8). In contrast to performances as scripted, linear and unidirectional events, conversation is a recursive and fluid engagement. The conversations that are materialized through infrastructure as a daily component of urban life are thus more comprehensive and dynamic than the performances exhibited through static monumental architecture and staged public display.

Because infrastructure is acted upon by physical processes of energy and material transfer, it too becomes an agent in the conversation. Construction materials, interrupted traffic flows and stockpiled supplies provide pregnant signals of intent even if they lie unused for years, while infrastructure in use can contribute problems and opportunities unforeseen by designers and end-users. As John Robb (2015) has discussed, artifact design often contains implicit instructions to the end-user. Instructions and anticipations are certainly encoded into infrastructure because infrastructure is shaped and emplaced precisely to achieve a physical objective such as facilitating or obstructing flows of water, goods or people. However, challenges of communication among the parties who envision, install, maintain and use infrastructure are exacerbated by

the unpredictability of performance, such that 'failures' have become a revelatory focal point of analysis in infrastructure studies (Anand 2015; Graham 2010).

Infrastructure in macrocosm: water and the historic city of New Orleans

The city of New Orleans presents a case of large-scale infrastructure marked by expert language and turn-taking. Built at the mouth of the Mississippi River and adjacent to the large water body of Lake Pontchartrain, the city of New Orleans relies on infrastructure not only to provide water for urban use but to keep water *out* of the city through levees and other artificial embankments. The failure of increasingly complex, interconnected water systems was most recently manifested at the time of Hurricane Katrina in 2005 when the city's levees broke resulting in over 1,500 deaths and $40–50 billion in damages (Kates et al. 2006). The disaster also precipitated long-term changes in the city's character when thousands of residents permanently migrated leaving a gap of occupation that brought in new inhabitants including a large influx of Spanish-speaking migrants (Blue and Drever 2011).

Craig E. Colten's (2005) masterful analysis addresses the ways in which the catastrophic failure of levees at the time of Hurricane Katrina was not merely the result of recent structural weaknesses but emanated from more than two centuries of management efforts that implicated the city of New Orleans, the state of Louisiana and the federal government of the United States. Starting in the early eighteenth century, the residents and managers of New Orleans engaged in three types of water management simultaneously: the provision of fresh water for human consumption; the use of a sewage system for the removal of waste water; and the containment and canalization of river and lake water away from built-up areas of the city. Between 1791 and 1817, eight major floods affected New Orleans, interspersed with cycles of local canalization, swamp-draining and levee-building that were eventually superseded by a federal Mississippi River Commission project of navigation and flood control in 1879 (Colten 2005, 23, 31). More than a century later, the continually reconfigured patchwork of pumps, levees and canals was overwhelmed by Katrina, although the resulting disaster was, from the long-term perspective, merely one in a very long series of failures reflecting the spatial, temporal and scalar effects of infrastructure in the city (Fig. 1).

The process of managing the topographic challenges of New Orleans over the past three centuries has been accompanied by an ongoing dialogue about appropriate procedures and investments. Expert knowledge was dispensed by engineers who debated the relative merits of levees vs. swamp clearings (including vigorous debate in the 1860s about whether the presence of trees in swamps and along city fringes was inherently unhealthy; Colten 2005, 36). Local inhabitants responded on the basis of historical and personal experience. Initial government actions took the form of the United New Orleans Plan, aimed not only to address physical repairs but also to address historical social inequalities; its development, implementation and nomenclature have been modified many times over in the course of interactions among federal, local, community and neighborhood groups (Olshansky and Johnson 2010). Both the dialogue and the physical infrastructure remain 'unfinished' as people continue to debate emplacement, maintenance, replacement and repair relative to the ongoing mitigation of Katrina's effects and the need to avoid future catastrophes.

Figure 1 New Orleans infrastructure (clockwise from top left): defunct power station; high-capacity canal; pumping station; pipe awaiting placement. Photographs by author.

Infrastructure in microcosm: Grete-Rehor Park, Vienna

Grete-Rehor Park in central Vienna provides an example of the dialogue sustained by civic authorities and community members on a neighborhood scale, in the form of a small and otherwise unremarkable triangular piece of land measuring 0.3 hectares between streets. Amenities provided by the city include paved pathways, park benches, a water source, a bicycle rack and trash bins (Fig. 2). The perimeter is the physical locale for the placement of street signs for the surrounding roadway and tramway, augmented by a number of quasi-hidden elements of 'bundled infrastructure' in the form of signal boxes and conduit junctions for water, electricity and traffic control. Mutually agreed upon codes of behavior are symbolized in this very small space that is managed almost as an afterthought by civic authorities who make a minimal investment in maintenance while the community acknowledges the park's presence by using the space for recreation, leisure and information.

The park space also is the locale of symbolic activity in the form of a statue of the nineteenth-century writer Ludwig Anzengruber that is now obscured by bushes and invisible except to those who pass directly in front of it on one of the parklet's five pathways. Park benches are graced with the city motto 'Wien ist anders' ('Vienna is different'). Private enterprise is evident on advertising signs posted on lamp-posts and two functioning telephone booths. The park is also a place for dialogue with non-governmental agencies through a charity donation box juxtaposed with numerous special-purpose bins for recyclables and ordinary trash. The encoding

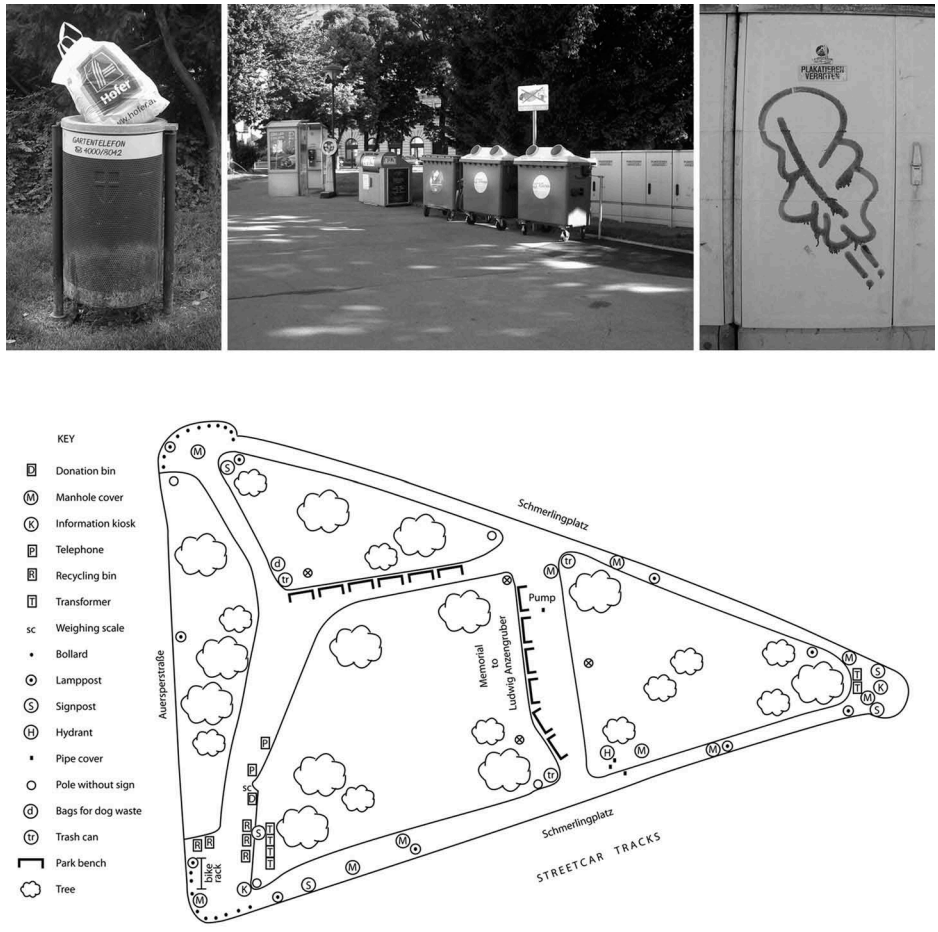

Figure 2 Grete-Rehor Park, Vienna (clockwise from top left): overflowing trash can; bundled infrastructure of telephone booth, scale, donation box, recycling bins and transformers; graffiti; map of infrastructure locations within the park. Photographs and map by author.

of waste receptacles appears to have been orchestrated according to shared understandings about the disposition of unwanted items. But not all materialized behavior is in accordance with mutual expectations: signal boxes have been defaced by graffiti, public trash bins are the repositories of unsanctioned household waste and park benches are subject to vandalism.

During regular civic-funded episodes of maintenance, uniformed workers are tasked with routine activities such as righting park benches and emptying the visibly overflowing trash cans. Communication between end-users and civic authorities about appropriate public behavior is thus materialized in turn-taking activities: individuals place discards into trash cans, and maintenance workers transfer the trash to a municipal waste truck. This communication contains imperfections that may in future warrant conversational 'repair' given the hint of unfinished objectives, such as the posts without any signs indicative of either future intent or past activities that have now become obsolete. The monument to Anzengruber illustrates that he was once

well-known enough to be identified only by his last name on a plaque, a presentation at odds with the statue's current physical obscurity.

Infrastructure in antiquity: the ancient city of Sisupalgarh

The archaeological site of Sisupalgarh, located in eastern India, is an urban settlement whose initial occupation dates to the mid-first millennium BCE and continued for nearly a thousand years (Lal 1949; Mohanty and Smith 2008; Smith and Mohanty n.d.). The site's formal encircling rampart encompasses an area 1.1 square kilometers in size within which are monumental constructions (formal gateways, a central monolithic pillar structure, reservoirs and long avenues). Ordinary residential structures are found both inside and outside the rampart perimeter (Fig. 3).

As in the examples of New Orleans and Vienna, Sisupalgarh contains the material evidence of linguistic interactions in its infrastructure. Expert language and the top-down intentionality of

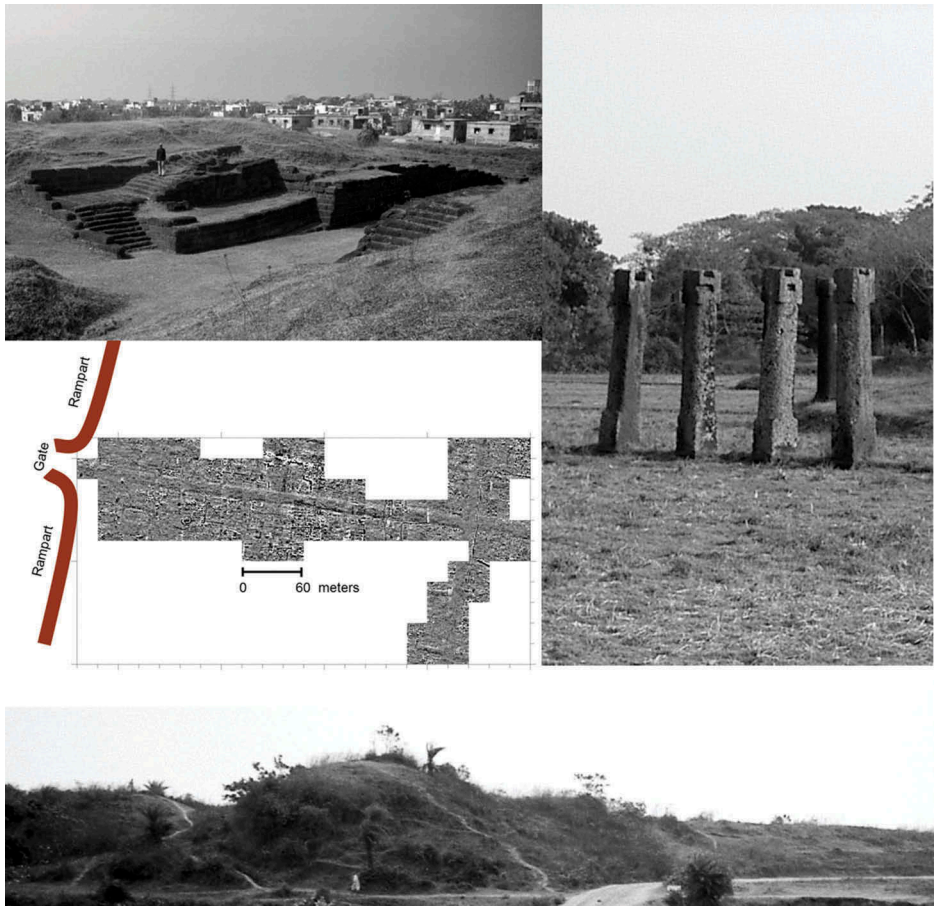

Figure 3 Sisupalgarh, India (clockwise from top left): monumental gateway; central monolithic pillar area; rampart; geophysical survey indicating presence of linear avenue between gateways. Photographs by author; geophysical map by T. Matney, A. Donkin and J. Sutter.

performance are implicitly encoded in the presence of the formal rampart and equally spaced gateways standing up to nine meters above the surrounding floodplain, as well as monolithic pillars over four meters high made from solid laterite stone whose quarrying, transportation and emplacement would have required specialized skills. Expert language is also directly evidenced in the nearby first-century BC Hathigumpha inscription, in which the ruler notes that he had underwritten the repair of the fortification and gateway that had been damaged by storms (Sahu 1984). Financial expertise is evident in this and other actions, in which cash expenses indicate a monetized economy and a specialized cadre of accountants.

At Sisupalgarh, performance is indicated both in initial construction and through ongoing maintenance and refurbishment. The central pillar structure has at least one layer of modest antecedents, and the gateway underwent at least four episodes of augmentation and aggrandizement. Each episode was a testament to the presence of specialized engineers and architects; a wall of stone and brick traced on the top of the rampart also indicates the presence of skilled stonemasons and bricklayers teamed with less-skilled manual laborers who carried tools and raw materials. The presence of unskilled workers in the daily life of the rampart is indicated not only by these major construction episodes but also through the augmentation of the rampart through many lenses of heaped-up material whose stratigraphy paralleled that of the habitation areas. The tenacity and effectiveness of urban authorities in guiding episodes of maintenance and repair can be interestingly contrasted with the smaller contemporaneous site of Talapada located 40km to the southwest. There, a similar layout of ramparts showed evidence of only a single construction episode and no further augmentations, indicative of less intensive mutualisms at a town-sized site compared to a genuinely urban configuration (Mohanty, Smith and Matney 2014).

At Sisupalgarh, turn-taking is visible through the archaeological evidence of infrastructure upgrades and maintenance. While the layout of the ramparts and gateways indicates top-down efforts of coordination, the fact that augmentations were not uniform suggests that many aspects of upkeep appear to have devolved to neighborhoods. Within the rampart walls, domestic architecture was comprised of do-it-yourself constructions that were idiosyncratic in size and orientation. Yet as also seen in modern cases, the materialized conversations between civic authorities and inhabitants indicate subversion as well as acquiescence: one house-sized structure on the inside of the rampart blocked the projected alignment of the street, indicating a deliberate rejection of the site's master-plan grid (see Mohanty and Smith 2006).

Conclusion

People in urban centers need a degree of consensus to accomplish both ordinary and extraordinary tasks, given the high population densities and multiple, overlapping forms of hierarchical and non-hierarchical interactions that characterize urban environments. At the same time, consensus is a dynamic condition, undertaken in recognition that all parties to a dialogue cannot be perfectly satisfied and that urban life involves ongoing accommodation rather than perfect agreement. Infrastructure provides a strong parallel to conversation, in that it is designed to *do* something, but is never 'finished'. In both predictable and unpredictable ways, human activities and infrastructure's own agency of physical changes result in degradation and failures that require ongoing mitigation through modification and repair. Infrastructure also serves as a

focal point for individual and communal memory that highlights past intentions and hoped-for futures. Ongoing dialogues among builders and users of infrastructure are thus infused with symbolic and practical aspects encompassed within expert language and characterized by turn-taking in conversations about the emplacement, use, maintenance, repair and replacement of the working parts of the built environment. These interactions are physically embedded, providing an 'architecture of consensus' whose narrative can be read in material remains.

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