DE MORGAN'S

ELEMENTS OF ARITHMETIC.

Translated into the Marathi Language,

BY

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"Raising up a Class of Subordinates for the Superintendence of Public Works": Early Technical Education in 19th Century Bombay Presidency

Abstract

Well before Charles Wood's Education Despatch of 1854[1] (in the context of colonial India), which made education a state obligation,[2] and in response to which Universities were established in Calcutta, Madras, and Bombay,[3] there existed in the latter two, state-instituted mechanisms to train 'subordinates' for built environment production. (Technical) education was a pragmatic consideration prior to its metamorphosis into a legitimating tool of Empire, and remained indispensable to the colonial project. While it expanded in scope in the late 1860s Bombay Presidency, allowing Indians to become full-fledged civil engineers in public and private sectors, it was initially intended to produce various classes of cheap(er) subordinates capable of understanding, mediating, and constructing civil works.

Restricting itself to this earlier period, the paper will explain why this need for subordinates arose, and the design of colonial institutions expected to supply them. Designed largely by military engineers, programs were formally taught but heavily supplemented by 'practical' training, due to the dominant culture of engineering training back home (apprenticeship), and the unfamiliar landscape of Indian construction, which necessitated learning-by-doing. They were expected to be jacks-of-all-trades, resourceful, literate in English, physically fit, and conduct themselves well. Even so, they were not guaranteed employment, with colonial officials reasoning this would induce complacency. They also remained closely surveilled, with biannual or annual reports listing their contributions, and were sporadically accused of incompetence and/or corruption. Despite their

1. Parshotam Mehra, *A Dictionary of Modern Indian History, 1707-1947*, 2nd ed. (Oxford University Press, 1987), 232–34.
2. Papers Relating to Technical Education in India, 1886-1904 (Calcutta, 1906), 1.
3. John Gray, Papers Connected with the Establishment of Universities in India (Calcutta, 1857), 2, India Office Records, British Library.

apparent utility and skill, their labour was undervalued and their prospects for promotion quite dim, with only a handful being promoted to the engineering ranks. Their emergence did, however, lead to a reorganization of social relations in the building sphere, which will be remarked on in closing.

Keywords
Technical education, subordinates, Bombay Presidency, colonial India

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[Cover] English cover of a Marathi version of De Morgan's Elements of Arithmetic, translated by Colonel George Jervis (former superintendent of the Engineer Institution), Vishnu Sundar Chatri, Gangadhar Shastri Phukde, and Govind Gangadhar Phukde, for the students of the Engineer Institution. Instruction in regional languages was, according to some commentators, one of the main reasons for the success of this early mode of technical education. Colonel George Ritso Jervis, *De Morgan's Elements Of Arithmetic* (1850).

Introduction

As early as 1843-44, East India Company [EIC] officials involved in the production and maintenance of the built environment in the Bombay Presidency began to formally and explicitly complain of "the *extreme want of subordinates* in the Department of Public Works [PWD]".[1] This was by no means a new problem, but the commencement of some rather ambitious projects in recent years – such as the Bombay-Agra road – had made this shortage acute. The Military Board of the Bombay Presidency [MBBP], the ultimate authority regulating built environment production, was instructed "to ascertain from the Military Board at Madras whether any aid can be afforded to this Government in procuring Public servants of this Class"[2] to meet the shortfall, but reported that "the prospect… is not very promising", due to regional variations in the division of labour.[3]

Four years earlier, when this need had not been as pressing, the MBBP were asked for their opinion "on the subject of educating in the Elphinstone College a class of men to fill the situations of Assistant Surveyors and Builders in the Engineer Department". While throwing their weight behind the existing apprenticeship model in the Bengal Presidency, through which "no difficulty… [had] ever found in filling vacancies in the Department of Public Works with subordinates of a very efficient description", they nevertheless believed that

> *the efficiency of the service and the eventual improvement of the country would be materially promoted by the establishment of the class and appointment of the Professor of Drawing and Surveying as contemplated by your Honorable Board – a measure which would not only tend to the advancement of that particular branch of Science which has long been a desideration in this country; but also by diminishing the necessity for expensive European agency to superintend the execution of public Works, however trifling their nature, ultimately effect a great saving to the state and numerically increase the controlling branch of the Department.*[4]

These exchanges offer a window into state thinking around early (i.e. semi-formal) technical education, and some of its informing impulses: exigencies of imperial governance, scientism, 'efficiency', and cost-reduction. These forces came to bear asymmetrically/unequally on technical education, and the importance of each varied with time. Their total effect was, first, a significant revision of the epistemic basis for comprehending, recording, and (re)constructing space, developed through surveying, and commented on briefly in the following two sections. This was followed by, and laid the foundations for, the introduction of new (subordinate) professional classes and the reorganisation of the division of labour through technical education, discussed at length thereafter. Far from being a civilising tool (as the mythographers of colonisation often claimed), 'science' in colonial India was germinated by enterprising individuals, only receiving state patronage if judged to be conducive to the Company's material interests, and more importantly, relatively cheap. Once sanctioned, the mode and content of science and scientific training was determined by administrative anxieties, and the self-image of the colonizing power as technologically and scientifically superior. Worthy colonial subjects therefore received an education similar to that imparted to its European officers in its seminaries, but their role was deliberately limited to being 'subordinates'. Assuming that racial loyalties were incapable of being supplanted, the state closely surveilled and routinely suspected these subordinates of fraud and deception, supposedly perpetrated in concert with other Indians.

Inceptive Impulses: Surveying and Cartography

According to Edney, "[g]eography and empire are… intimately and thoroughly interwoven", since "knowledge of the territory is determined by geographic representations, and most especially by

1. Military Board, "Letter to Sir James R. Carnac, Governor and President in Council, Bombay Presidency," April 23, 1840, Volume 49/566, General Department, Maharashtra State Archives. Emphasis mine. The Military Board, in this instance, was intervening to stop the dismissal of two Indian 'subordinates' due to the "inconvenience that would result", and recommending that their services be retained.
2. J.P. Willoughby, "Letter to the Military Board, Bombay Presidency, from the Secretary to Government, General Department," December 8, 1843, M–280 & 281, Volume 93/899, General Department (1844), Maharashtra State Archives. The provincial PWDs (of the North Western Provinces, and Bengal, Madras, and Bombay Presidencies) routinely conferred with, and looked to, each other for advice and precedent when confronted with new problems. For the geographical extents of these (main) administrative subdivisions in 1837 and 1857, please see Figure 1.
3. Military Board, "Letter to Colonel Sir George Arthur, Governor and President in Council, Bombay Presidency," February 23, 1844, Volume 93/899, General Department (1844), Maharashtra State Archives.
4. Military Board, "Letter to Sir James R. Carnac, Governor and President in Council, Bombay Presidency," M–329.

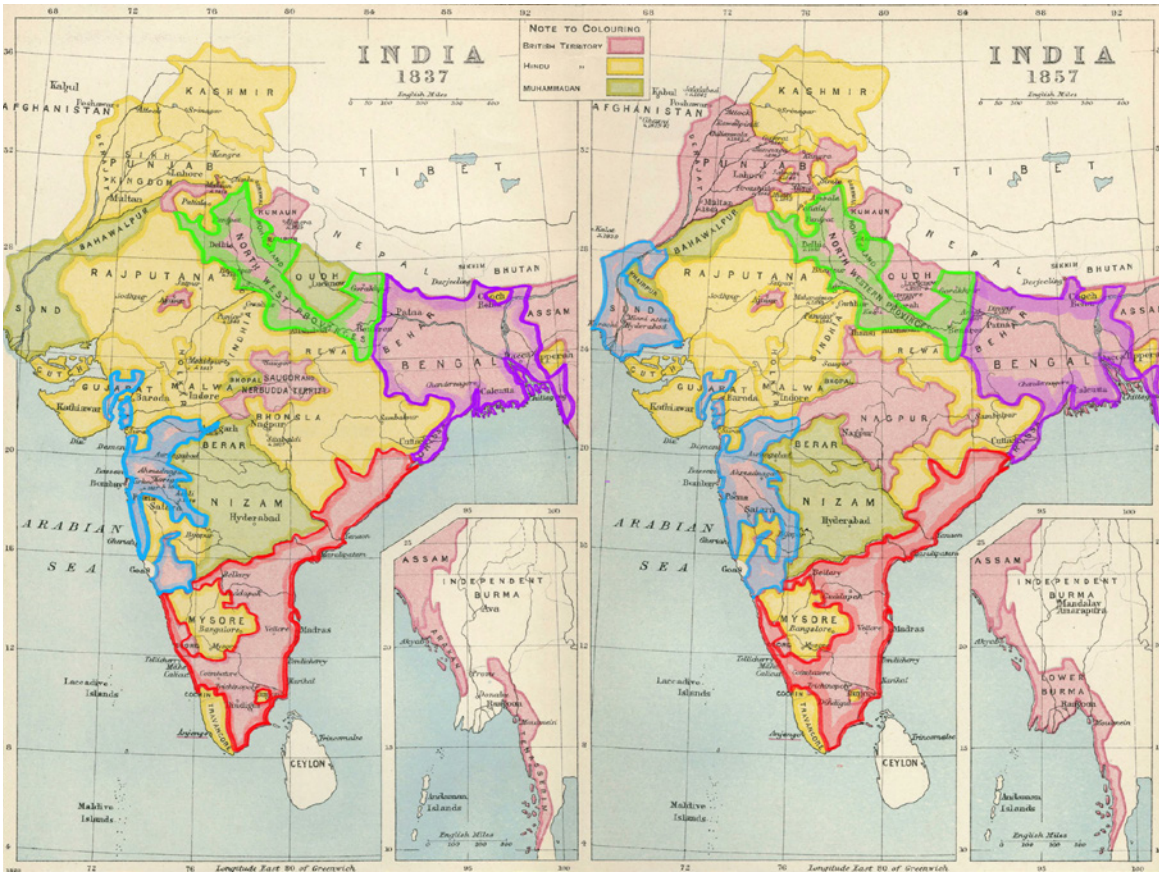

Figure 1. Extent of territories directly administered by the EIC in the Indian subcontinent in 1837 and 1857, with some major provincial subdivisions sketched: Bombay Presidency (blue), Madras Presidency (Red), Bengal Presidency (Purple), and Northwestern Provinces (Green). Institute, Edinburgh Geographical. Image of Map of India under the British East India Company, Comparing 1837 with 1857. 1907. Imperial Gazetteer of India, Secretary of State for India in Council, OUP, 1907. Scanned from personal copy Fowler&fowler, 2007.

the map".[5] Until setting its sights on "[t]erritorial acquisition in South Asia" for the extraction of land revenue, the EIC was content to rely on ununiform knowledge compiled by "travellers and missionaries… through constant enquiry or, more commonly, by hiring local guides".[6] During – and in anticipation of – military campaigns, the Company sent its servants to survey important routes and areas, and it was through such expeditions between the first (1775-82) and third (1817-19) Anglo-Maratha wars that the future Bombay Presidency became 'known' with some accuracy.[7] Charles Reynolds, who had obtained a commission in the EIC army at eighteen, and subsequently "taught himself the new science of surveying", was a key figure in these initial surveys.[8] Having surveyed various parts of India between 1783 and 1792, he convinced the Government at Calcutta to grant him "authority, and means, to work up his own great map".[9] In this, he hoped to succeed Major James Rennel, Surveyor General of Bengal from 1767-77, and the first Englishman to compile a detailed map of the Indian subcontinent (published 1783). Rennel used methods that integrated "disparate [Indian]

5. M.H. Edney, "The Ideologies and Practices of Mapping and Imperialism," in *Social History of Science in Colonial India*, ed. S. Irfan Habib and Zaheer Baber (Oxford University Press, 2007), 25.
6. Kapil Raj, "Circulation and the Emergence of Modern Mapping: Great Britain and Early Colonial India, 1764–1820," in *Relocating Modern Science: Circulation and the Construction of Knowledge in South Asia and Europe, 1650–1900*, ed. Kapil Raj (Palgrave Macmillan UK, 2007), 66–67.
7. R. H. Phillimore, *Historical Records of the Survey of India*, Volume I: 18th Century, I (1945), 121–23; 125–30; R. H. Phillimore, *Historical Records of the Survey of India*, Volume II: 1800 to 1815, II (1950), 165–67; 169–73.
8. David Miller, "The Black Bottle Affair and Its Family Background," *Journal of the Society for Army Historical Research* 79, no. 319 (2001): 209–18.
9. Phillimore, *Historical Records of the Survey of India*, Volume I: 18th Century, I, 125–32. Quote from pg. 132.

traditions together with those of European terrestrial and coastal surveying”, relying on Indian labour and sources such as the *Ain-i-Akbari*.[10] Reynolds made even more extensive use of Indian surveyors, and “[f]rom 1793… had a number of surveyors [27 in 1798] scattered in every direction” to complete his map of India. On his retirement in 1807, he left a sum of Rs. 22,000 for “annuities to the Native Surveyors for the remainder of their lives”. When accused of extravagance by the Court of Directors, Reynolds often alluded to the comparative inexpensiveness of Indians.[11]

In the first two decades following the Anglo-Maratha war, which significantly expanded the extent of the Bombay Presidency, public works remained quite marginal to government policy. Only two major projects – informed by military strategy and/or the need for (postal) communication – were undertaken, though these also rendered the ‘interior’ accessible: a road from Vingorla[12] to Belgaum[13] over the Ram Ghat, completed in February 1824,[14] and a mail road from Poona to Panwell (near Bombay), “greatly improved” in 1830.[15] Instead, the colonial state focussed its energies on setting up and rationalising its land revenue systems, from which it derived most of its

10. Raj, “Circulation and the Emergence of Modern Mapping,” 73–77.
11. Ibid., 287–89.
12. A port town established by the Dutch, and later taken over by the British, on the southern border of Maharashtra.
13. A city in northern Karnataka, home to a fort established in the 13th century.
14. R.D. Choksey, *Economic History Of The Bombay Deccan And Karnatak (1818-1868)* (The Oriental Watchman Publishing House, 1945), 325-36.
15. Ibid., 197.

Figure 2. Map of the Indian Subcontinent from 1909, with the extents of the (directly EIC-administered) Bombay Presidency (blue) and the Deccan Plateau (black) sketched. The region where these overlapped is referred to as the Bombay Deccan (hatched)-Sons, Edinburgh Geographical Institute; J. G. Bartholomew. Map of the British Indian Empire from Imperial Gazetteer of India. 1909. Oxford University Press, 1909. Scanned and reduced from personal copy by Fowler&fowler, 5 August 2007.

income.[16] Pivotal to this were revenue and cadastral surveys, which recorded the properties and boundaries of agricultural land, and determined the tax liability per field (i.e. 'assessment'). Thus, under the Governorships of Mountstuart Elphinstone and John Malcolm, "the Bombay Government became definitely map-minded".[17]

Precise knowledge and standardised 'physical' measures: Pringle's and Wingate's settlements

Revenue surveys, and the precise documentation of field properties they entailed, were not new to India. British officials often referenced with great admiration surveys carried out under Akbar, which "fixed the size of the unit of measurement—the *bigha*—and then standardized the instruments of land measurement—the *gaz* or rod and the *tenab* or chain".[18] These surveys had covered "a great part of the Deccan",[19] but by the time the EIC began to administer these territories

> *it would have been difficult to discover what the land assessment should be. Firstly, there was the absence of all correct accounts, due to the pernicious heritage of the farming system [developed under the last Peshwa, Baji Rao II], which precluded all attempts at gaining accurate knowledge… Secondly, there was the extraordinary variety of the land measures and methods of assessment, which must have rendered the introduction of a real Rayatvari system a matter of sheer impossibility without an accurate survey and radical changes in method.*[20]

Measurements used by the Marathas were based on productivity of the land (rather than physical dimensions), and therefore the absolute area of a 'bigha' varied between villages and regions.[21] Assessments were fixed for each village, and distributed among individual holdings by hereditary revenue officials. This discretionary method, according to William Chaplin, Commissioner of the Deccan, "owing to inexperience and sometimes to insufficient information" led to injustice for the peasant and/or loss of revenue for the government. A new settlement headed by Robert Pringle in 1827 was meant to overcome these difficulties. Through a "*survey of all the cultivable lands field by field*", recording physical dimensions and productivity of soil, and estimating the net produce, the Government was to collate comprehensive information and ascertain the liability of each cultivator.[22] Though ultimately unsuccessful – a failure blamed in no small part on improper supervision by Europeans, the intensive use of Indian 'subordinates' (several of whom were "criminally prosecuted and convicted"), their lack of firsthand knowledge about agriculture (by virtue of being Brahmins), and the "unholy alliance between the native officers of the Survey Department and the *meerasdars*" – Pringle's survey established the English acre as the standard measure of area.[23]

16. Land revenue, Akbari, and Sayer (tabulated under a single category) accounted for 75.98% of total net receipts in Bombay Presidency 1829/30, and 81.04% in 1839/40. By 1855/56, land revenue (not including Akbari and Sayer) accounted for 57.46% of the total gross revenue of the Presidency. For India, the proportion of land revenue to gross total revenue stood at 66.33% in 1827/28, 58.59% in 1837/38, and 48.31% for 1857/58. Figures calculated (respectively) from W.H. Sykes, "The Past, Present, and Prospective Financial Condition of British India," J*ournal of the Statistical Society of London* 22, no. 4 (1859): 474; Table A in Frederick Hendriks, "On the Statistics of Indian Revenue and Taxation," *Journal of the Statistical Society of London* 21, no. 3 (1858): 226; and Table 1 in Pilar Nogues-Marco, "Measuring Colonial Extraction: The East India Company's Rule and the Drain of Wealth (1757–1858)," *Capitalism: A Journal of History and Economics* 2, no. 1 (2021): 154–95.
17. R. H. Phillimore, *Historical Records of the Survey of India*, Volume III: 1815 to 1830, III (1954), 1.
18. R.G. Gordon, The Bombay Survey and Settlement Manual (Government Central Press, 1917), OA_000000002195, pp. 8–9, National Archives of India. Italics in original.
19. Ibid. The Deccan, referring to the Deccan Plateau, covers most of Maharashtra, Andhra Pradesh, Telangana, Karnataka, and parts of Tamil Nadu, Chattisgarh and Orissa. It is bounded by the Satpura range on the north, and the Eastern and Western Ghats on either side.
20. Ibid., 25. Emphases mine. In the Ryotwari (or Rayatwari) system, the state transacted directly with peasant landholders, rather than through intermediaries such as the Zamindar (landlord). This meant that the state had to keep records of each individual holding (as opposed to only the Zamindar's fields), greatly increasing its burden.
21. Ibid., 14; Sumit Guha, The Agrarian Economy of the Bombay Deccan 1818-1941, with Internet Archive (Oxford University Press, 1985), 57. Guha, in calculating the extension of cultivated land under Wingate's settlement, assumes these to be uniform across districts, though perhaps this was not the case. From government records, he calculates a 'bigha' as being equal to 0.75 acres in Nasik district, 0.87 acres in Ahmednagar district, and 0.67 acres in Poona district respectively.
22. Gordon, *The Bombay Survey and Settlement Manual*, 28. Emphasis mine.
23. Ibid., 31; Ravinder Kumar, *Western India in the Nineteenth Century: A Study in the Social History of Maharashtra* (Australian National University Press, 1968), 109

In 1836, Government decided that a new settlement ("commenced *de novo*") was required, entrusting it to Lieutenant George Wingate and Henry Goldsmid.[24] Following a "local experiment" in Indapur taluka,[25] it was gradually extended to other parts of the Presidency, and its practices standardised through an "authoritative statement of principles" in the Joint Report of 1847.[26] Besides reducing the liabilities of the cultivators and setting the stage for the extension of cultivation starting in the 1840s, the surveys also established a "permanent artificial unit",[27] laid down clear and permanent boundary markers for these, and starting in 1839, recorded them on scaled maps.[28] Its success was partly attributed to "[t]he insistence from first to last upon *direct and strict supervision of every operation by European agency*", with "small bodies of subordinates under the direct control of a European superior".[29]

The new revenue systems sought "to maintain the native system [as far as possible]… and, above all, make no innovations".[30] They followed Akbar's precedent in their measurement and classification of land, and the fixity of tenure for long periods. Early European surveyors, as we have seen, adapted Indian methods and conventions or modified European instruments to suit Indian conditions, steadily evolving a composite scientific practice;[31] nevertheless, the enlightenment episteme – premised on the reduction of the natural world to measurable quantities, enabling its 'objective' representation and the creation of a single, coherent archive of knowledge[32] – certainly determined which practices were chosen and how they were integrated. This spatial epistemology, developed primarily though surveying and cartography, was crucial to colonial architectural production.

Colonial necessities and anxieties, and early technical education

Institutionalised technical education, beginning with the founding of the Civil Engineering College at Roorkee in 1847, and similar colleges in Calcutta, Bombay, and Madras in the following decade, has been interpreted by scholars in different, albeit interrelated ways. Ambirajan highlights two dichotomous framings in this historiography: a "valuable legacy" born of an altruistic colonial benefactor, or yet another means of subjugating the colony (economically and culturally). Through an examination of technical education in the Madras Presidency, he concludes that there is insufficient evidence for either, especially since colonial educational policy was mostly improvised and lacked central direction; it was, however, was unable to produce scientific and technological self-sufficiency and development within the Presidency, and in India.[33] Baber believes that there was improvisation and "constant experimentation, trial, and error" in the "*early phase* of British colonialism", but by the mid-19th century, British India became a "social laboratory, or a testing ground, for a number of policies that could be transferred to Britain and other parts of the empire".[34] Mital and Kumar focus on the immediate needs that made technical education necessary,[35] before Charles Wood's Despatch of 1853 ordained the establishment of civil engineering colleges in each of the three Presidencies, and well before engineering became a recognised degree in Britain (1872). Kumar points out that

> *engineering education was not introduced accidentally. It had definite objectives; it evolved not from below, but was organized from above… [I]n India… [engineering education] was intended principally to meet the needs and requirements of the colonial government as and when they arose*.[36]

24. Gordon, *The Bombay Survey and Settlement Manual*, 32.
25. An administrative sub-division in a district.
26. Gordon, *The Bombay Survey and Settlement Manual*, 66-67.
27. Ibid., 70-71. These units varied by climate, soil, and nature of crop. For the Deccan, a standard unit was equal to 20 acres of light dry-crop soil, 15 of medium dry-crop soil, 12 of heavy dry-crop soil, or 4 acres of rice dry-crop soil.
28. Ibid., 43.
29. Ibid., 36. Emphasis mine.
30. Ibid., 20. This was a directive from Mountstuart Elphinstone, Governor of Bombay at the time.
31. Raj, "Circulation and the Emergence of Modern Mapping," 80–82.
32. Edney, "The Ideologies and Practices of Mapping and Imperialism," 39–48.
33. S. Ambirajan, "Science and Technology Education in South India," in Technology and the Raj: Western Technology and Technical Transfers to India, 1700-1947, 2nd ed., ed. Roy Macleod and Deepak Kumar (Aakar Books, 2022), 113; 127–31.
34. Zaheer Baber, "Science, Technology, and Colonial Power," in Social History of Science in Colonial India, ed. S. Irfan Habib and Zaheer Baber, Oxford in India Readings: Themes in Indian History (Oxford University Press, 2007), 103–4. Emphasis mine; by "early phase", the author means the mid-to-late 18th century, not the mid-19th century, the period with which Ambirajan is concerned.
35. K. V. Mital, History of the Thomason College of Engineering (1847-1949) on Which Is Founded the University of Roorkee (University of Roorkee, 1986), 15–18; Arun Kumar, "Colonial Requirements and Engineering Education: The Public Works Department, 1847-1947," in Technology and the Raj: Western Technology and Technical Transfers to India, 1700-1947, 2nd ed., ed. Roy Macleod and Deepak Kumar (Aakar Books, 2022), 216–18.
36. Ibid., 216. Emphasis mine.

In the mid-19th century, these needs revolved around the construction of roads and railways for the flows of input goods to England, and finished goods into India. Irrigation too, began to pay into the treasury: directly, as water rents; and indirectly, as increased land revenue.[37] The deeply instrumentalist thinking of the colonialist state was exemplified by the PWD's continued control over the colleges (even as they remained officially under the Department of Education), and the neglect of other branches of engineering in the four main colleges until 1930s.[38]

Scholarship has not, however, delved sufficiently into *semi-formal* technical education that preceded its institutional phase. It is here that its core tendencies began to crystalise, significantly shaping their ultimate form. Produced largely by historians of science and technology, their focus has been on *technical education*, rather than the *technics* (i.e. embodied skills) inculcated by such an education, and their consequences for built environment production. Surveying and cartography were perhaps the first scientific branches to receive the colonial state's patronage, and were crucial in developing the spatial epistemology later deployed in built environment production. Growing territorial ambitions and possessions also created a need to train personnel as surveyors. Technical education, when it arrived, offered a parallel (and perhaps more effective) arena for the development and dissemination of this episteme.

An 'Engineer Institution' [EI] was established in 1823, four years after the third Anglo-Maratha war, in Bombay, and placed under Captain George Jervis of the Engineers. It was modelled after "a plan successfully adopted at [the surveying school in] Madras",[39] founded in 1794 by Michael Topping. Topping was one of "many notable men outside the… civil and military services" employed by the Company (despite convention prohibiting employment of civilians for terrestrial surveys),[40] and in Phillimore's estimation, "undoubtedly the most talented surveyor who had yet reached India".[41] In 1794, Topping proposed that 10-12 boys be selected from the military orphanage and other English schools in the Presidency, and be "regularly trained to the business of practical surveying" through, first, formal instruction in the office "for the sake of a few rudiments", and subsequently, through "real field practice" as Surveyors' assistants. The only other alternative, he warned, was to import surveyors from Europe, and he was firmly in favour of training 'Native Assistants' because:

> *First, every European… would cost the Company as much, at least, as six Natives; besides tents, conveyances, and a liberal allowance, each European practitioner must have an Interpreter to attend him. …*
>
> *Secondly, each European would require a long and previous seasoning, before he could sustain the rigors of an Indian sun and climate; it is indeed hardly to be expected that one European in ten, after leaving Europe at a Mature age, could be brought to endure, for a constancy, the fatigues of so laborious an employ in the torrid zone. Thirdly, the ease with which the establishment might be kept up, from the same fountain, is a material consideration. …*
>
> *The Indian-born offspring of Europeans, educated in the public schools at Madras, might be rendered very useful to the public, and happy in themselves if, instead of being suffered to fall a sacrifice to idleness, and a vicious course, …some line of active employment were to be marked out for them.*[42]

By 'native', Topping meant Indian-born children with European ancestry. The Government had become deeply suspicious about how Indians – in the racial sense – might use their knowledge of surveying and cartography, and thus forbade their enlistment, even as European surveyors continued to testify to their

37. Ibid., 216-7; Elizabeth Whitcombe, "Irrigation," in The Cambridge Economic History of India: Volume 2: C.1757–c.1970, vol. 2, ed. Dharma Kumar and Meghnad Desai, The Cambridge Economic History of India (Cambridge University Press, 1983).
38. Kumar, "Colonial Requirements and Engineering Education: The Public Works Department, 1847-1947," 217–29.
39. "Report on the Progress of the Engineering School at Bombay.," 1 file, May 1826, IOR/F/4/959/27217, p. 5, British Library: Asian and African Studies.
40. Ibid. In a table on pg. 267, Phillimore offers a "rough analysis [enumeration] of the Company's servants employed on survey in the three Presidencies during the 18th century". Madras in particular seemed to employ a considerable proportion of civilians as surveyors – 11 out of a total of 36 (30%).
41. Phillimore, Historical Records of the Survey of India, Volume I: 18th Century, I, 268.
42. Ibid., 283-4.

competence and usefulness.[43] Topping's proposal met the Government's racial criteria while ensuring lower costs: children with European 'blood', raised in European institutions, were likely to feel a fidelity to the colonial state, and they had no family in Europe to demand wages commensurate with their forefathers. It was accepted by the Madras Board of Revenue, and the surveying school commenced its operations in October the same year. Such racial logic continued to pervade technical education well into the 20th century, albeit in increasingly indirect ways.

The EI, established some three decades later in Bombay Presidency, sought to "[instruct] Government Surveyors and Builders",[44] producing an "efficient body of men *to act under officers Superintending Surveys and Buildings in the Districts* and generally for the public service".[45] It also acted as a professional body, setting the terms for employment of it graduates and their entitlements with regards to pay and promotion.[46] Like the Madras surveying school, it originally looked to "charity boys… *born in the country, of European parentage*", but eventually renounced this racial exclusivity.[47] By this time, most officers carrying out surveys in the Bombay Presidency "had a staff *almost entirely Indian*", perhaps due to personnel shortages and budgetary pressures following the wars with the Marathas. William Tate, who took over the Bombay and Salsette revenue survey establishment in 1821, was only too glad to be "permitted [by Government] to employ …*any number of natives… required*", having complained previously that the two infantry officers assigned to him were insufficient. With the help of these surveyors, "the two surveys *were brought rapidly to a close*, …and the first plans drawn… by separate draughtsmen".[48] The EI reflected the evolving racial policy and admitted Indians in addition to 'East Indians',[49] training two distinct professional classes. 'Surveyors' were to be taught

> *Arithmetic and the elements of Geometry; Topographical plan-drawing, the use of the simple instruments ordinarily used in surveying, as the chain, plane, table, &c.; Topographical surveying and plotting, with a computation of the superficial extent, and a description, of the ground surveyed. When more advanced, they were taught Logarithms and plane Trigonometry, the use of the large Theodolite and level, and of the Sextant, Mensuration of heights and distances.*[50]

Builders, meanwhile, were to be instructed in

> *Arithmetic and the elements of Geometry and of Mechanics - Architectural plan drawing - the use of tools employed by handicrafts in building; the practical knowledge of Masonry, Carpentry, Joinery, Plastering, and Mensuration of planes and solids; Computation or the framing of estimates. As they became more advanced, they went through a course of experiments to guide the builder in the choice and preparation of the most fit materials for building, as of the best kind of limestone for mortar, earth for bricks and tiles - stone, timber, and other materials; the construction of bridges, temporary and permanent; the construction of roads.*[51]

In practice, however, it was found that maintaining such a bifurcation was logistically and financially infeasible, and "it was deemed better to educate all on the same principles and to render them capable of being employed in either way".[52] Both classes were thus merged, creating a new class of subordinate officials that was to last at least until 1857: *Surveyors and Builders*. Instruction in plan drawing and estimation were particularly significant, and exemplified the new spatial epistemology. Design ideation and communication in India had been accomplished largely through oral and literary traditions; the most common graphical medium had been full-scale line-drawings done on or near the construction site, reflecting the inextricability of the two processes. Design in the 'Peshwa region' had been organised around a 1:2 rectangular module called the khan

43. Phillimore, Historical Records of the Survey of India, Volume II: 1800 to 1815, II, 354–55. The correspondence quoted by Phillimore here is from 1812 and 1813, about two decades after the founding of the surveying school in Madras.
44. Board of Education, Bombay Presidency, "Report of the Board of Education for the Year 1847 & 1848" (Bombay: American Mission Press, 1850), 168, India Office Records, British Library.
45. Military Board, "Letter to Sir James R. Carnac, Governor and President in Council, Bombay Presidency." Emphasis mine.
46. Superintendent of Revenue Survey, "Letter to J. Vibart, Revenue Commissioner," March 4, 1839, Volume 49/566, General Department, Maharashtra State Archives.
47. Phillimore, Historical Records of the Survey of India, Volume III: 1815 to 1830, III, 384. Emphasis mine; original emphases have not been reproduced here.
48. Ibid., 392-3. Emphasis mine; original emphases have not been reproduced here.
49. A term used to refer to Indian-born persons with European ancestry.
50. Board of Education, Bombay Presidency, Report of the Board of Education for the Year 1847 & 1848, 169.
51. Ibid.
52. "Report on the Progress of the Engineering School at Bombay," 9.

with no fixed dimensions.[53] Scaled plan drawings quantified these dimensions and rendered design and construction separable, paving the way for a paper(ed) mode of architectural production and practice.[54] Colonial estimates, in contrast to those of the Peshwa period, relied on precisely measured dimensions to calculate the cost of each *item of work*, rather than being disaggregated by *space*.[55] Plans and detailed estimates, by offering scaled representations of projects and quantifying their potential cost, also helped the colonial bureaucracy exert administrative and financial control.

The EI was dissolved in 1832 following an order from the finance Committee in Calcutta. Some two decades after its demise, JP Willoughby, formerly the Chief Secretary to the Governor of Bombay, deemed it a "kindred institution" that had produced "one of the most valuable classes of public servants at the disposal of Government". Had the EI still been around, he conjectured, it could have trained "a valuable body of *auxiliaries* for the construction of railways" currently underway.[56] In 1840,[57] 75 graduates of the EI were employed by the government, with the highest number (35) engaged in bodies responsible for built environment production; 28 others were employed under various arms of the revenue administration.[58] By 1844, in line with new government priorities, several Surveyors and Builders had been transferred out of collector's offices into various agencies for built environment production, now numbering 53.[59] Starting in 1840, Government also mandated half-yearly reports on these subordinates, including information on their activities and conduct over the past year.[60] This mode of surveillance continued well into the 1880s, and reports on the activities of subordinates even appeared in early annual reports. In 1841, out of a total of 54 such 'subordinates' reported on, almost two-thirds (35)

53. C.V. Sahasrabudhe, "Architecture in Eighteenth Century Maharashtra: A Focus in Commissioning and Construction of Buildings in Pesva Period" (Savitribai Phule University, 2017), 131–35, 139. The 'Peshwa Region' is identified by Sahasrabudhe as a 'culture region', with a 'core area' made of Pune, Nashi, Kolhapur, and Satara.
54. I adapt the term here from Scriver and Srivastava. Peter Scriver and Amit Srivastava, *India, Modern Architectures in History* (Reaktion Books, 2015).
55. Sahasrabudhe, "Architecture in Eighteenth Century Maharashtra: A Focus in Commissioning and Construction of Buildings in Pesva Period," 138–39.
56. Board of Education, Bombay Presidency, Report of the Board of Education for the Year 1847 & 1848, 169–70. Emphasis mine.
57. The first year for which I have been able to find records on these 'subordinates', and the year in which a considerable redistribution of them across the various departments took place.
58. Volume 49/566, General Department," Bombay, 1840, M–351 to 360, Maharashtra State Archives.
59. "Volume 93/899, General Department," Bombay, 1844, M–305 to 307, Maharashtra State Archives.
60. One such half-yearly report for 1st July to 31st December 1843 recorded 'Conduct' and 'Qualifications'; the latter was subdivided into 'Surveying and Plotting', 'Drawing', 'Planning and Estimating', 'Building', and 'English'. Both were scored on three-point scales: 'exemplary', 'good', and 'objectionable' for conduct, and 'proficient', 'middling', and 'indifferent' for each of their qualifications. Formats varied, and some even recorded caste. "Volume 93/899, General Department."

Branch of Administration	1840		1844	
	Number	(% Total)	Number	(% Total)
Built Environment Production				
(i) Engineering Establishments	28	37%	37	52%
(ii) Road and Tanks Department	17	23%	16	23%
Revenue				
(i) Administration / Collection	20	27%	8	11%
(ii) Surveys	8	11%	6	8%
Other	2	3%	4	6%
Total	**75**	**100%**	**71**	**100%**

Figure 3. Distribution of Surveyors and Builders across various state bodies in 1840 and 1844. "Volume 49/566, General Department," Bombay, 1840, M–351 to 360, and "Volume 93/899, General Department," Bombay, 1844, M–305 to 307, Maharashtra State Archives.

Nationality/Race/Caste/Ethnicity	Number	Percentage
Brahmins		
(i) [no subcaste recorded]	31	57%
(ii) Chitpavan Brahmin	1	2%
(iii) Konkan Brahmin	1	2%
(iv) Gaud Saraswat Brahmin	1	2%
(v) Deshast Brahmin	1	2%
Artisanal Castes		
(i) Suttar (Carpenter)	1	2%
(ii) Goldsmith	1	2%
(iii) Coppersmith	3	6%
(iv) Simpee (Tailor)	1	2%
Khatri	5	9%
East Indian	2	4%
Indo-Briton	2	4%
Parsi	1	2%
Others	3	6%
Total	**54**	**100%**

Figure 4. Castes of 54 Surveyors and Builders, recorded in 1841. "Volume 49, General Department," Bombay, 1841, Maharashtra State Archives.

were Brahmins.[61] Given their historical literacy and the severely underdeveloped state of the school system, Brahmins continued to dominate collegiate education and government employment, with Henry Coke, the Principal of the College of Engineering at Poona [CoEP], bemoaning in 1859 that "[t]he greater number of pupils hitherto educated at this School have been Poona Brahmans".[62]

In stark contrast to the training mechanisms that succeeded it, the EI taught its Indian students in their native languages (Gujarati and Marathi). This was made possible by Jervis' translations of textbooks, and the employment of a 'native instructor', Juggunnath Shastree.[63] Some, such as the Chief Engineer, were visibly impressed with its results, remarking that Indian students exhibited a "proficiency… at least equal, if not superior, to that of the East Indians or children of mixed parentage".[64] Others argued that

> *the general ignorance… of any but the vernacular languages, has rendered the services of many of them much less useful than would have been the case, could t[hey] have received their orders in English, or coul[d their] labors in Mahratta and Goozerattee have been directed [and] checked, and therefore turned to more useful account by their European Superiors.*[65]

Knowledge and 'proficiency' of English became non-negotiable in later training 'schemes', following the resolution of the Anglicist-Orientalist question. The passing of the English Education Act of 1835 expanded state patronage "for instruction in English and Western science" and curtailed that for education in 'native' languages.[66] By 1860, the examination committee appointed to examine the 'Maistry Class'[67] at the CoEP suggested that "a Knowledge of English should be made *an indispensable qualification* for Candidates for the Public Works Department, trained in the Poona Engineering School".[68]

61. "Volume 49, General Department," Bombay, 1841, Maharashtra State Archives.
62. Henry Coke, "Letter to E.J. Howard, Director of Public Instruction, Bombay Presidency," November 8, 1859, Volume 6, Education Department, Maharashtra State Archives.
63. "Report on the Progress of the Engineering School at Bombay.," 1–2.
64. Board of Education, Bombay Presidency, Report of the Board of Education for the Year 1847 & 1848, 170.
65. Military Board, "Letter to Sir James R. Carnac, Governor and President in Council, Bombay Presidency." Emphasis mine. Words and letters in square brackets indicate interpolations made necessary by partially torn pages.
66. Baber, "Science, Technology, and Colonial Power," 113; Mehra, A Dictionary of Modern Indian History, 1707-1947, 234–36.
67. Meant to be a part of the 'lower subordinate establishment', ranked below Surveyors and Builders.
68. H Wilkins et al., "Report of the Examination Committee [for the Maistry Class] to Director of Public Instruction, Bombay Presidency," September 5, 1860, Volume 8, Education Department, Maharashtra State Archives.

As the opening exchange demonstrates, by 1840 it once again became necessary to train more subordinates. A 'Class of Civil Engineers' was thus introduced in 1844 at the Elphinstone College, but shut down just three years later after the graduating class failed to impress the examination committee. All of them, were, however, taken on as subordinates (of varying ranks) in the PWD.[69] No further Presidency-wide 'schemes' were implemented until the founding of the CoEP in 1856. In the meantime, subordinates were trained via a system of apprenticeship, being hired on a probationary basis for six months and expected to learn requisite skills on-the-job. At the end of the probationary period, a superior officer submitted a 25-point evaluation[70] and letters of recommendation, and an examination committee recommended the candidate for employment (or otherwise). Thus, by the time the CoEP was established in 1856, the recruitment of Indians to fill 'subordinate' positions in the PWD (and elsewhere) had become government policy – initially due to financial pressures, and later, a realisation that men educated and employed by the government may prove to be loyal subjects.

The social division of labour in built environment production

It was clear from the outset, however, that such men were never meant to be more than 'subordinates'. The Company's servants were quick to acknowledge the capabilities of Indians, even if their attitude was on the whole paternalistic. Surveyors and Builders were expected to have wide-ranging technical expertise, which included operating multiple survey instruments; recording their observations and making calculations; communicating in English; writing reports; framing estimates; understanding construction materials and processes; supervising repairs and construction; keeping accounts; and resourcefulness.[71] These abilities were judged by their superiors, and a great majority of them reported favourably on their subordinates. Nevertheless, only four ever made it into the ranks of Engineers: Vasudev Bapuji (joined 1849), Mukund Ramchandra (1853), Lalubhai Keshavlal (1853), and Muncherjee Murzban (1857).[72]

For the colonial state Indians simply *could not* be trusted with authority, not just because they were 'unscientific', but also because their loyalty lay, first and foremost, with other Indians; other divisions (such as caste and religion) were acknowledged, fetishised, and exploited, but racial loyalties were deemed almost insurmountable. Indian 'subordinates' therefore had to be overseen, in all but the rarest of circumstances, by European officers.[73] This coexisted with, but did not strictly map onto, another axis of hierarchisation, where *cognitive* authority was deemed superior to executive authority. The plan had rendered design and construction two separate processes, the former being handled by higher-ranking officers, and the latter being generally entrusted to subordinates. Access to cognitive authority depended on formal qualifications.

69. Board of Education, Bombay Presidency, Report of the Board of Education for the Year 1846 (American Mission Press, 1847), 16–18, India Office Records, British Library.
70. These were mainly yes/no questions evaluating whether they could adequately perform various facets of their job – using instruments, drawing plans, etc.
71. "Statement of the Qualifications and the Conduct of Assistant Surveyor and Builder Wasoodew Gunnesh of the Executive Engineer Department at Surat Division," Bombay, 1853, Volume 99, General Department, p. M-S-92, 93, Maharashtra State Archives.
72. Here I have used a modern version of their anglicised spellings. This list is limited to those who joined as 'subordinates' before the reorganisation of the PWD in 1857; yet another, Bomanjee Sorabji, seems to have joined as a subordinate in 1859, before going onto complete a LCE (Licentiate in Civil Engineering) and rejoining as an Engineer. It was only in 1869 that an Indian, Gopal Raoji Tilak, joined the Engineering ranks directly. "Volume 1728, Public Works Department (1868-89)," Bombay, 1879, M–132 and 133, Maharashtra State Archives. Murzban's rise was particularly meteoric; he was promoted from the lowest position of a probationary sub-overseer to an assistant engineer of the 2nd grade (11 grades) in just 16 years, skipping over the 'sub-engineer' rank entirely, though he had been retained for 7 years in the position of an Overseer (1st Grade). His promotion to the Engineering ranks only happened after a great deal of lobbying by JHE Hart and Colonel Fuller, both senior engineers in the PWD. The fact that he was a Parsi – who were seen as being a 'race' in themselves – and his several influential European mentors also most likely helped. Murzbanji Murzban Muncherji, Leaves from the Life of Khan Bahadur Muncherji Cowasji Murzban, C.I.E. (F. B. Marzban & Co., 1915), 45–51. Preeti Chopra, A Joint Enterprise: Indian Elites and the Making of British Bombay (University of Minnesota Press, 2011).
73. The state also differentiated (racially) between similar classes of workers through its nomenclature. 'Surveyors and Builders' were mostly Indian, while 'Overseers', tasked with similar duties, were European military officers. Similarly, Phillimore took pains to differentiate between European 'surveyors' and Indian 'explorers' in the early phase of colonial rule.

The Road and Tanks Department [R&TD] in the Bombay Presidency was established in 1835 to oversee major projects stretching across multiple districts, such as the Bombay-Agra and Poona-Panvel roads. It had a three-tiered hierarchy of officers: a 'superintendent' at the top, responsible for "the *general control and supervision* including the examination, of all accounts, plans and estimates"; assistant superintendents below him, "entrusted with the *preparation of all the Plans and Estimates*… and the care of their execution"; and 'subaltern assistants' below them. In 1842, reorganization was made necessary by the dearth of engineer officers for the assistant superintendent positions.[74] It was meant to ensure "the greatest procurable degree of scientific and practical skill" in its officers, with two interventions:

> *introducing a system in which the projective would be in a greater degree separated from the executive, and a division of labour introduced.*
> *The assistants who with one exception, are all infantry officers, are now required to pass an examination upon certain points in engineering which will enable them to be (what they have certainly not hitherto been) independent of the assistance of their subordinates, in every drawing, or calculation, which required the least professional acquirement…*[75]

Assistant superintendents became 'first assistants', constituting the 'projective'; they were to be "[o]fficers of talent and experience", tasked exclusively with "the *designing* of all considerable works", and "free from all money [i.e. accounting] responsibility". Subaltern assistants became 'second assistants', responsible for oversight of construction ('executive'), and entrusted with estimates for simple projects. These changes were based on the reasoning that an engineer officer (or someone with adequate technical skill) was needed to make the 'projective' decisions, but that their execution could be done with a "zealous and active officer… with a little instruction", who need only "secure order and economy".[76] Cognitive authority, therefore, was to rest exclusively with the superintendent and first assistants, who were formally trained and had scientific expertise. The second assistants, given only executive authority, had to be technically adept enough to not rely on their Indian subordinates, as they had been thus far. The R&TD had therefore manoeuvred itself into a corner: Indian subordinates were skilled enough to handle some aspects of the work entrusted to the second assistants, but had to be supervised by a higher-ranking European officer, lest their venality be enkindled. This need for European supervision at every step, combined with the lack in such supervisors of "professional knowledge, which can only be acquired by study and experience", translated to greatly increased establishment costs. As A.C. Peat, the Superintendent of Roads realised:

> *Another great difference between the management of engineering works in England and India, is the division of labor that is adopted in the former country. The talent that is there thought necessary for the projection of the general plans of important works is not misapplied by being obliged to carry through all its details [as it is in India], which duty is left to subordinate agents of different ranks.*[77]

Between 1840/41 and 1845/46, salaries and allowances accounted for 53% of total expenditure of the department, and were as high as 68% in 1842/43 and 1843/44.[78] As Alexander Mackay later pointed out, these were mainly due to the department not being employed to its full capacity,[79] but the high salaries of European officers certainly played a part. When Balakrishna Kanoba, an Indian Surveyor and Builder, acted as a second assistant between 1841 and 1844, his establishment costs were an average of 15% of total expenditure for those three years – one of the lowest

74. Engineer officers (i.e. military engineers trained at the Company's seminaries) formerly appointed to 'assistant subordinate' positions had been promoted to "superior and better paid appointments", and "infantry officers [with no such training] were necessarily appointed to fill the vacancies". Since they had no formal training in the work they were supposed to perform, "several large works [had] been allowed to lie over for a considerable length of time, without any properly detailed plans". "Volume 62/787, General Department," Bombay, 1843, M–45 to 51, Maharashtra State Archives.
75. "Volume 62/787, General Department," M–45 to 51.
76. A.C. Peat, Annual Report of the Roads and Tanks Department, 1841-42 (Bombay, 1842), 5–7, British Library: Asian and African Studies.
77. A.C. Peat and W.R. Morris, Annual Report of the Roads and Tanks Department, 1840-41 (Bombay, 1841), 6, British Library: Asian and African Studies.
78. Calculated from the Annual Reports of the Roads and Tanks Department for those years.
79. Alexander Mackay, Western India: Reports Addressed to the Chambers of Commerce of Manchester, Liverpool, Blackburn, and Glasgow (Nathaniel Cooke, 1853), 433–34. Mackay had been sent to India to "to investigate the possibility of extending the growth of the plant in our Eastern possessions". "The Death of Mr. Alexander Mackay," The Morning Chronicle (London), June 5, 1852.

in the department.[80] A less dogmatic colonial state would have given more authority and autonomy to Indian Surveyors and Builders; instead it deliberately undermined its own objectives to soothe its anxieties, and kept its Indian employees in a state of permanent dependency.

Conclusion

Indian 'subordinates' were thus hybrid across two registers. They were a hybrid class of professionals, between the 'traditional' *karigar* (master-craftsman) and the 'modern', 'scientific' engineer. By being knowledgeable about construction details and materials, and supervising construction, they took on the executive authority formerly vested in the *karigar*, who regressed to either supervising smaller spheres of work, or merely a skilled craftsman. At the same time, they were formally trained and possessed scientific expertise, though not quite on the level of Engineers (a position that did not open up to Indians until the late 1860s).[81] Indian subordinates were also hybrid in the sense that they had no precedents in either pre-colonial India, or England: 'subordinates' in England were generally apprentices (i.e. not formally trained), and given a lot more autonomy than they were in colonial India; there was simply no structural need to scrutinise them so closely. In colonial India, meanwhile, they had to be formally educated to instil the enlightenment episteme and render them 'scientific', before acquiring 'practical' knowledge (considered indispensable by senior PWD officials) on the job.
In this way, the colonial Indian state created a large body of cheap technicians to supervise public works. The reorganisation of the PWD, the creation of the engineering colleges in the three Presidencies, and the transfer of power to the Crown only institutionalised this strategy; in 1871, there were almost 3 subordinates to every engineer in the Bombay PWD.[82] Technical education in India also "provided the [model] for replication in England in the later nineteenth century",[83] contributing not only to engineering education in Britain, but also the larger co-constitution of Britain and its empire.

80. Calculated from the Annual Reports of the Roads and Tanks Department for those years.
81. The creation of the Royal Indian Engineering College shortly thereafter in 1872, however, created a qualitative distinction within 'Engineers'.
82. "Volume 1704, Public Works Department (1868-89)," Bombay, 1871, M–43, Maharashtra State Archives. There were 115 engineers and 312 subordinates (upper and lower).
83. Baber, "Science, Technology, and Colonial Power," 118; Raj, "Circulation and the Emergence of Modern Mapping," 64.