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ROMAN LAW AND NEW TECHNOLOGIES – TIMELESS PRINCIPLES IN THE DIGITAL ERA

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Abstract. This article examines how technological innovations in ancient Rome – particularly in road construction – contributed to the empire's durability and efficiency. By analyzing legal sources, archaeological findings, and historical texts, the author demonstrates that modern digital technologies (AI, 3D modeling, laser scanning) facilitate the reconstruction of ancient infrastructure and highlight the continued relevance of Roman engineering and legal principles. The author argues that Roman engineering solutions, along with legal regulations pertaining to public infrastructure, contributed to the creation of a durable and efficient communication network throughout the Roman Empire. The study is based on the analysis of literary sources, legal texts, and archaeological findings. It demonstrates that Roman law focused primarily on safeguarding public access and ensuring the maintenance of infrastructure, rather than on prescribing detailed technical norms governing construction. Contemporary digital technologies enable in-depth investigations into ancient Roman construction techniques and facilitate the reconstruction of historical structures. The author emphasizes that the engineering and organizational accomplishments of ancient Rome remain relevant and continue to serve as an inspiration for modern interdisciplinary research concerning civilizational heritage. The article concludes by asserting that both ancient and modern technological innovations constitute vital drivers of civilizational development and progress.

Keywords: Roman law; infrastructure; road construction; digital technologies; heritage preservation.

INTRODUCTION

Contemporary scientific research across nearly all disciplines is predominantly focused on emerging technologies, while emerging social theories occupy a more peripheral position. In the former case, it may be observed that new technologies, particularly artificial intelligence, have garnered significant attention across a wide array of scientific fields, ranging from medicine, computer science, electronics, earth sciences, and engineering disciplines, to the humanities and social sciences. In the latter case, namely that of new ideologies, scholarly inquiry is most frequently undertaken within the domains of the social sciences and the humanities.

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Against this background, the question arises whether it is appropriate to speak or write about new technologies in the context of ancient Rome or Roman law. In my view, it is indeed possible to speak of the presence and function of "new technologies" in ancient Rome, albeit with the caveat that the very concept of "new technology" was unknown at the time. Within the historical context, what may be termed "new technologies" referred to innovative engineering, architectural, military, and administrative solutions that exerted a profound influence on the development of Roman civilization and its imperial strength.

However, the aforementioned question may also be reversed, namely, can representatives of broadly understood new technologies be interested in research concerning innovations that took place in ancient Rome? From the perspective of Roman law scholars, legal historians, or architectural historians, the answer to this question is, undoubtedly, affirmative. In contemporary scholarship, it is precisely Roman law specialists and historians of antiquity who identify potential areas of exploration for emerging technologies. Thus, professionals engaged in technological innovation are increasingly involved in spatial modelling of Roman cities and structures – such as the *Forum Romanum* or the *Colosseum* – through the use of 3D and virtual reality (VR) technologies. Furthermore, technologies such as laser scanning (LiDAR), drones, and photogrammetry are employed to map ruins and ancient road networks. Artificial intelligence (AI) and big data-based systems, in turn, support the analysis of primary texts and historical legal systems [Frischer 2008, 1-5; Guidi, et al. 2014, 663-70].

Proceeding from the premise that ancient Rome experienced technological development and innovation – phenomena which remain the subject of scholarly inquiry across various disciplines, not limited to historians or Roman law experts – one may identify numerous areas of such advancement. These include, inter alia, the construction of roads, aqueducts, military weaponry, as well as reforms in the organization of public administration [Oleson and Rihll 2008, 93-132]. The authors of this book have compiled an extensive compendium of knowledge on the engineering achievements of antiquity, including the construction of roads, aqueducts, war machines, and the administrative systems of Rome. However, due to the editorial word limit imposed by the publisher, this analysis will be confined to innovations in road construction and the development of infrastructure law pertaining to their protection.

1. ANALYSIS OF SOURCES

Sources concerning engineering techniques related to road construction and associated infrastructure are relatively scarce. This observation applies both to legal literature and to literary studies.

1.1. Literary sources

Marcus Vitruvius, arguably the most renowned Roman architect, who lived during the reign of Octavian Augustus, did not devote a separate chapter to road construction in his seminal work *De architectura*. Nevertheless, he makes reference in several passages to the methods by which Roman roads were constructed during his time.

Thus, in Book VIII (*De aquis*), Chapter 6, there are provisions concerning the gradient of terrain and the drainage of water. Such measures were necessary not only in the construction of aqueducts but also in the erection of roads. Vitruvius even delineates the recommended angle of inclination for water runoff as well as the design of drainage channels. The techniques employed in the construction of urban areas, aqueducts, and sewage systems were similarly applied in road building. The objective was to prevent the accumulation of water on the surface and to ensure its unobstructed flow.

Conversely, in Book X (*De machinis*), Chapters 1-2, Vitruvius addresses matters related to the transportation of various materials, including heavy loads. He emphasizes the importance of appropriate infrastructure, particularly the adaptation of road widths to correspond with the axle spacing of contemporary vehicles used for transport. Furthermore, in Book I, Chapter 3, Vitruvius discusses the proper planning of a city. According to him, builders ought to pay special attention to the arrangement of public utility spaces, such as public squares, promenades, and consequently, urban roads. In construction, durability, functionality, and aesthetic considerations must be taken into account. Durability constitutes the paramount attribute in building, achieved not only through skilled workmanship but also by the careful selection of building materials, without succumbing to excessive frugality, Vitruvius states.[1]

Other sources containing references to road construction include the work of Frontinus entitled *De aquaeductu urbis Romae*. The author provides valuable information regarding construction techniques, logistics, boundary delineation, as well as the design and maintenance of aqueduct infrastructure, which in many respects were analogous to issues pertaining to the construction and upkeep of roads. It is also worth noting the *Itinerarium Antonini Augusti*, a topographical and logistical compendium listing roads and stopping stations within the Roman Empire [Raepsaet and Löhberg 2013, 459-60].[2] Although this work does not contain typical engineering

[1] *Firmitas autem tunc erit, cum fuerit e fundamentis solidus, utilitas autem, cum sine incommodo erit usus et distributio locorum commodis apta, venustas autem, cum fuerit aspectus iucundus et elegans membrorum commensus.*

[2] *Itinerarium Antonini Augusti* is a Roman topographical document dating from the late 3rd century CE, serving as a register of roads (*itinerarium*) traversing the Roman Empire. It does not constitute a typical literary or narrative work but rather functions as a practical inventory of communication routes.

knowledge, it constitutes an important source of information on the extent and organization of the Roman road network.

1.2. Legal sources

Legal regulations concerning roads in ancient Rome have been preserved primarily in Book 43 of the *Digest*. The Justinianic compilers included several titles therein specifically dedicated to the issues of road maintenance and management.

The first title, *De locis et itineribus publicis* (D. 43.7), contains legal regulations concerning the status of public roads, which was conferred by the competent public authorities. At the same time, any person (*cuilibet*) was entitled to submit a petition to the appropriate public body requesting a decision recognizing a particular route as a public road. On public roads, the placement of any monuments or other objects that could impede the normal use of these communication routes was prohibited (D. 43.7.1 (Pomp. l. 30 ad Sab.)).

The second title, *Ne quid in loco publico vel itinere fiat* (D. 43.8), addresses various instances of violations of the prohibition against constructing or installing anything on public squares and roads, including those within urban areas, which could impede the normal use of these spaces (D. 43.8.1, Paul. 64 ad ed.). The prohibition extended not only to the erection of monuments but also, inter alia, to the construction of causeways across public roads for the drainage of water from private land to the sea or the grazing of animals on the road. Consequently, the unlawful occupation of a public road in a manner that restricted free use by all users was impermissible. In such cases, it was possible to petition the praetor to apply a legal-administrative protective measure in the form of the interdict *ne quid in loco publico fiat* [Procchi 2016, 527-74; Kamińska 2017, 197-98; Sitek 1999, 39-43].

The third title, *De via publica et si quid in ea factum esse dicatur* (D. 43.10), contains excerpts from the writings of Roman jurists, from which it is evident which public officials were responsible for the condition of roads within a given area and the scope of their duties. This obligation primarily consisted in supervision and oversight, since the principal responsibility for the maintenance and repair of public roads rested with the owners of the land adjoining those roads. In the event of failure to fulfill this duty, the official was authorized to commission the necessary work from a private contractor and charge the costs to the property owner (D. 43.10.1, *Ex Papiniani de cura urbium libro*).

Finally, it is necessary to mention the last title devoted to public roads, namely *De via publica et si quid in ea factum esse dicatur* (D. 43.11). Under this title, there are excerpts containing a prohibition against obstructing a person who is maintaining or repairing a public road running adjacent to their property. In the event of violation of this prohibition, the aggrieved party

could petition the praetor for the issuance of an interdict forbidding such conduct (D. 43.11.1, Ulp. l. 68 ad ed.). Furthermore, it was prohibited to alter the course of a public road onto neighboring land or to plough it over. Should such actions be undertaken, the perpetrator was obliged to restore the road to its prior condition at their own expense (43.11.3, Paul. L. 1 *senten*.).

As evidenced by this relatively brief analysis of Roman sources concerning the construction and maintenance of roads, few of them provide direct engineering knowledge. It may be assumed that such knowledge was transmitted primarily through practical experience within the profession. Perhaps it constituted a form of esoteric knowledge, closely guarded by specialists. This expertise was conveyed within the framework of professional practice and operated within specialized groups or enterprises engaged in the execution of such projects. Consequently, contemporary understanding of the methods employed in the construction of Roman roads, that is, typical engineering knowledge, derives predominantly from archaeological discoveries dating from the nineteenth century onwards [Matteazzi 2023, 167-94]. This publication examines the technical aspects of Roman road construction, drawing upon archaeological data from northern Italy

The foregoing analysis indicates that legal regulations concerning roads in ancient Rome primarily pertained to the protection of the public right of use and the obligation to maintain them in proper technical condition. However, there were no provisions specifically regulating the detailed constructional aspects of roads – thus, employing contemporary terminology, no legal-technical standards existed [Kamińska 2010b, 55ff; Sitek 2008, 180-82].

2. CHARACTERISTICS OF THE ROAD CONSTRUCTION POLICY IN ANCIENT ROME

The saying that all roads lead to Rome is widely known. Indeed, the Romans constructed a network of paved roads totaling over 80,000 kilometers in length. This presents a substantial subject for scholarly inquiry and constitutes an excellent source material for research across various academic disciplines.

Rome was the central point to which these roads led. This phenomenon initially manifested within the territory of Italy and subsequently throughout the entire empire. These roads connected various regions with the political, commercial, and cultural center that was the imperial capital – Rome [Laurence 2002, 38-79; Gallo 2006, 193ff]. However, their primary purpose was to facilitate the movement of Roman legions from one end of the empire to the other. From almost the very beginning – during the time of the tribune Gaius Gracchus, among others – these roads were most frequently constructed in a straight line, with only minor deviations, as noted by Plutarch (Plut. *The Life of Caius Gracchus* 7) [Wójtowicz 2021, 773-79].

The construction of roads in ancient Rome was not limited solely to the creation of a surface enabling transit but encompassed comprehensive engineering works related to the entire accompanying infrastructure. Roman engineers, primarily military, were required to possess expertise in the construction of bridges (*pontes*), stopping points (*mansiones*), intersections (*bivium*, *trivium*), viaducts, as well as drainage systems (*cloacae*) and rainwater channels. Equally important was the proper substructure of the road and attention to the terrain's gradient, designed to prevent erosion and the accumulation of water. Thanks to this approach, Rome's road infrastructure was distinguished by its durability and formed the foundation for the functioning of administration, commerce, and communication within the empire, especially for the Roman legions [O'Connor 1993, 20ff; Lugli 1991, 45; Morillo 2006].

3. ROMAN INNOVATIONS IN ROAD CONSTRUCTION

Roman roads were constructed in layers, employing several levels of materials differing in granulometry and function. The lowest layer (*statumen*) typically consisted of large, flat stones, which provided a solid foundation for the entire structure and enabled effective drainage. Upon this layer was placed the *rudus* – a layer of crushed stone or brick, often mixed with mortar – which imparted stability and a degree of flexibility to the surface. The subsequent layer, the *nucleus*, comprised finer crushed stone or sand mixed with lime, formed into a slightly convex surface to facilitate the efficient runoff of rainwater. The final, uppermost layer (*summum dorsum*) was composed of carefully fitted large stone slabs, most often durable basalt – that constituted the functional surface of the road [Chevallier 1976, chapter 2].

The use of concrete (*opus caementicium*) as a building material, particularly in the substructure of roads, bridges, and aqueducts, constituted a groundbreaking innovation that contributed to the acceleration of construction processes and significantly enhanced the durability of infrastructure [DeLaine 1997, 248].

The roads featured a convex cross-section, which facilitated the runoff of rainwater into ditches or channels situated alongside them. In urban areas, drainage systems – including small conduits and sewer manholes were also employed. The width of the roads was adapted to accommodate wheeled traffic: principal thoroughfares measured approximately 4.2 to 4.8 meters in width, allowing for the passage of two vehicles simultaneously (Fulford and Adam, chapter 2).

Road construction also required precise land surveying, which involved the use of geodetic instruments such as the *groma*. Sections traversing difficult terrain (e.g., mountainous areas) were often supported by retaining

walls, bridges, and cut tunnels, attesting to the advanced technical proficiency of Roman engineers.

The technique of Roman road construction was not only the result of practical knowledge but also an application of engineering and logistics principles on a vast scale. Today, it is recognized as one of the key civilizational achievements of Rome.

Regarded as one of the greatest achievements of ancient civil engineering, Roman roads stood out for their exceptional technical sophistication, particularly in the context of the era in which they were constructed [Kosiński 1966, 187-97]. Their durability and functionality were not matters of chance – the Romans designed them with great precision, attending both to practical usability and their strategic significance for communication within the empire. As a result, many of these thoroughfares have survived to the present day in remarkably good condition [Oleson and Rihll 2008, 93-132].

4. ADMINISTRATION OF CONSTRUCTION AND MAINTENANCE OF ROAD INFRASTRUCTURE

Beginning with the reign of Augustus, the construction and maintenance of roads were entrusted to public officials. At that time, the institution of the *curator viarum publicarum* was established – an imperial official responsible for overseeing public roads in Italy, and eventually also beyond its borders. The *curatores viarum* operated at both the central and local levels [Sitek and Krajewski 2005, 185-94; Kamińska 2015, 185-94]. In Rome itself, oversight of the roads was originally exercised by the *aediles curules* (curule aediles) and *censores* (censors) [Kamińska 2010a, 95; Robinson 1992, 96].

It is also worth noting that engineering knowledge in this domain was transmitted primarily through practical means within specialized building corps (*collegia fabrorum*) and through experience gained in the Roman army, which frequently organized and executed roadworks in conquered territories (Plin. HN, 36,24.).

The final element completing the picture of the scope of technologies employed in the construction of public roads is the emphasis that the principal investor in such undertakings was essentially the Roman state. This means that road construction was financed from public funds – during the Republic from the *aerarium populi Romani*, and from the Principate onward from the *fiscus*.

The contractors for these projects, however, were private enterprises (*redemptores*), selected through procedures analogous to modern public procurement processes. These enterprises employed laborers and engineers who executed the projects in accordance with established construction practices [Sitek 2016, 697-709; Idem 2011, 97-101; Trisciuoglio 1991, 22-27].

CONCLUSIONS

The Romans established a strong and well-organized state capable of adapting its political system to evolving social, political, and economic needs. Within these efforts, particular emphasis was placed on the development of infrastructure, especially roads. The construction materials, engineering techniques, and technologies employed in road building were subject to exceptionally high standards, evidenced, among other things, by the fact that many of these roads have survived for over two thousand years.

Interestingly, the primary sources of knowledge concerning the technologies employed at that time are not chiefly legal or literary texts – apart from a few exceptions, such as Vitruvius (*De architectura*) – but rather contemporary archaeological excavations. Artificial intelligence now plays a significant role in reconstructing Roman technological knowledge, enabling not only the identification of materials used but also the reconstruction of the technologies and engineering solutions applied during that period.

This knowledge was not widespread among the Romans themselves; it was specialized and primarily reserved for practitioners, especially construction enterprises (*redemptores*). It was transmitted from generation to generation through professional practice, without formal educational systems.

However, Roman legislators primarily focused on regulating the maintenance and repair of roads, their orderly management, and the legal-administrative protection of all citizens' right to use public roads and squares – both within cities and beyond.

In conclusion, technological development in various fields was already a major driver of civilizational progress in ancient Rome. Today, the advancement of new technologies – particularly in the field of artificial intelligence – enables us to fully appreciate and understand the engineering achievements of the ancient Romans.

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