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A Close Examination of Ankara's Reinforced Concrete Buildings Designed and Constructed between 1923 and 1938

Gokhan Tunc [1,*] and Tanfer Emin Tunc [2]

[1] Department of Civil Engineering, Atilim University, 06830 Ankara, Turkey
[2] Department of American Culture and Literature, Hacettepe University, 06800 Ankara, Turkey
* Correspondence: gokhan.tunc@atilim.edu.tr; Tel.: +90-312-586-8355

Abstract: The Republic of Turkey was established in 1923 out of the remains of the Ottoman Empire. Between 1923 and 1938, the Turkish republic underwent fifteen years of rapid expansion and growth, with Ankara as its new capital and Mustafa Kemal Atatürk (1881–1938) as its first president. During this period, reinforced concrete (RC) played a significant role in the construction of Ankara's public-use buildings. This study focuses on 57 of these structures, built either partially, or entirely, out of RC. The buildings are classified with respect to their duration, soil properties, foundation types, structural design details, construction types, materials and overall costs. In order to provide a better picture of the time period in which these buildings were designed and constructed, the technical, financial and political aspects of the projects, and the difficulties and challenges involved in their design and construction, are also discussed. Furthermore, this study outlines the impact of foreign engineers, construction workers, firms and the educational system on the development of civil engineering and use of RC in Turkey.

Keywords: reinforced concrete buildings; public-use buildings; Ankara; Turkey; early republican period

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1. Introduction

In 1923, the Republic of Turkey was established out of the collapsed Ottoman Empire. With Ankara as its capital, and Mustafa Kemal Atatürk (1881–1938) as its first president, the Turkish republic underwent a fifteen-year period of rapid expansion and growth (1923–1938), with reinforced concrete (RC) playing a significant role in the construction of its new public-use buildings. Modern, safe and efficient, RC structures symbolized the strength and durability of the new nation and consequently became synonymous with the development of the Turkish Republic. Ankara became a center of RC design and construction since the building material complemented the social, political and economic goals of the new capital. The popularity of RC continued to increase in Turkey over the course of the twentieth century due to its hygienic qualities, durability and cost/performance ratio. Reinforced concrete's excellent load-resisting capacity, particularly in medium- to high-rise buildings and in structures with complicated designs, also enhanced its attractiveness as a construction material [1,2].

The focus of this study is to understand the early significance of RC in the buildings of Ankara. For this purpose, a total of 57 public-use buildings, designed and constructed either partially, or entirely, out of RC between 1923 and 1938, were investigated from an engineering perspective in order to understand the issues and challenges of the construction sector at the time. Table S1 in the Supplementary Materials accompanying this article was prepared based on the available data, obtained through archival research, for these buildings. They were classified with respect to their construction materials, structural design details, construction types and overall costs. When applicable, additional information is provided for their construction duration, soil properties, foundation types, structural member details and other design and construction-related issues (for maps of their locations, see Figure S1 in the Supplementary Materials accompanying this article).

In order to provide a better picture of the time period in which these buildings were designed and constructed, the technical, financial and political aspects of the projects, and the difficulties and challenges involved in their design and construction, are also discussed. Furthermore, the study outlines the impact of foreign engineers, construction workers, firms and the educational system on the development of civil engineering and use of RC in early republican Turkey.

2. RC Construction in Ankara

Initially, reinforced concrete was typically used in structural members in constructing bridges, ports, piles, industrial facilities and dams in countries such as France, Germany and the United States. The widespread use of RC in building construction began in the West in the late 1800s. RC greatly helped the evolution of the construction sector, and the turn of the twentieth century is still referred to as the golden age of cement. In some textbooks, the cement age was also called the concrete age, which replaced the nineteenth century iron age [3,4].

Similarly to RC itself, the golden age of concrete began in Turkey 50 years later, and spanned the second half of the twentieth century. Reflecting the worldwide trend in early RC use, in 1920s Turkey, building construction was not as important as the construction of roads, railroads, dams, bridges, and sewage and power supply systems [5–9] (p. 28). Almost all construction companies operating in Turkey preferred large-scale lucrative infrastructure projects, leaving smaller ventures to local architects, engineers and masons. This created a vacuum in the construction sector, and the quality of building design and construction had to be carefully screened by well-trained foreign engineers. This gradually changed in the 1930s when universities where engineering was taught (such as *Yüksek Mühendis Mektebi*, *Nafia Fen Mektebi* and Robert College) and the Ministry of Public Works took control of the construction sector [10,11].

The heavy influence of foreign actors and entities was initially justified due to the shortage of Turkish engineers and local construction materials and an overall lack of experience with RC design and use [9] (pp. 92–99), [12–16]. These issues were gradually resolved by the early 1930s, after international firms and experts had dominated the Turkish construction sector for about a decade. During the early years of Ankara's construction, there was a huge demand for residential and public-use buildings. The city was essentially one large construction site, and the newly-formed Ankara municipality was in charge of what seemed to outsiders as chaos. The municipality had serious budget issues and lacked educated and trained engineers [17,18]. Additionally, until 1934, the design and construction of most public-use buildings were managed by different offices from various government agencies [19]. This practice added disorder to an already haphazard system. Consequently, these inadequacies took their toll on the quality of some RC buildings constructed between 1923 and the early 1930s, resulting in extra expenditures for maintenance and repair [13]. The Ministry of Public Works was the most critical player in resolving these matters in the early 1930s [1,19,20]. It hired Turkish and foreign engineers and took control of building management and inspection. Therefore, construction quality increased in the mid to late 1930s, as compared to the early years of the republic.

Another hurdle affecting the quality of construction work was the bidding method that existed during this period. In the early to mid-1920s, the eligibility requirements for project bidding strongly favored foreign firms and marginalized local ones. Starting in the late 1920s, building projects began to follow the price-centered bidding method, where the lowest bidder is always awarded the contract. This favored small firms lacking technical expertise [20,21]. Yet, problems with steady cash flow continued to affect these vulnerable firms since they had no financial stability and often ended up declaring bankruptcy. Those that were saved, more often than not, had the right political connections [22–24]. Nevertheless, despite the problems and challenges associated with building construction, based on the findings of recent renovation projects, most of the fifty-seven RC buildings investigated in this study survived with no major structural deficiencies [25,26].

2.1. Soil Properties

First-hand sources describe the area where the new city was established as a large, odorous swamp, with soil that had to be treated before construction [27–31]. The earliest detailed geological study of Ankara was conducted in 1930 by geologist Ernest Chaput. A pioneer in the field, he helped establish the principles of geological studies in Turkey during his stay between 1928 and 1935 [32,33]. In his work, Chaput states that his findings would assist civil engineers as they designed the foundations of Ankara's new buildings. Figure 1 illustrates one of Chaput's maps, describing the soil conditions in and around the city. As shown in the figure, the new city, Yeni Şehir, is mostly located in an area with old and new alluvial soil.

More in-depth information on the soil properties of Ankara was provided in a later report, again authored by Chaput [33]. This study investigated the geology and geomorphology of the different districts through previous fieldwork, borehole tests and additional field surveys. These findings verified the details conveyed in Figure 1. Chaput confirmed that the alluvial soil that dominated most of Ankara had low load-bearing pressure and needed to be improved or strengthened if heavy distributed or concentrated loads were to occur. This is why most of the RC, or RC mixed with masonry, buildings either had piles or foundations with continuous or mat footing (see Table S1). It is also why most of the buildings either had one or no basement floors (constructing them was prohibitively expensive). The typical safe load-bearing capacity of alluvial soil is around 5 to 7.5 tons/m^2 [34,35]. If a service load of 1.5 tons/m^2 per floor is considered a practical value in determining the total weight of a building, then 3 to 5 story buildings with no basements would be considered to be the limit for buildings without piles. As listed in Table S1, most of the RC buildings did not exceed five stories, which made them particularly cost-effective.

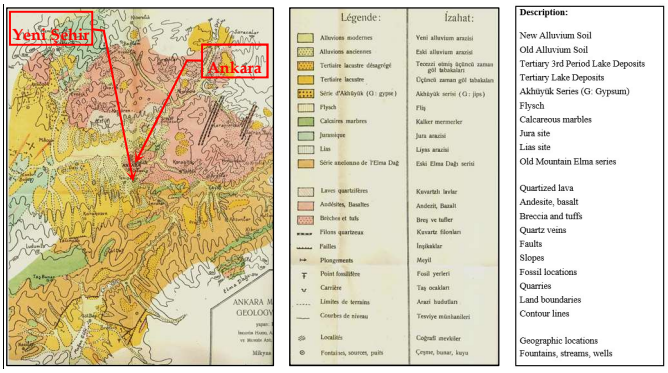


Figure 1. Geological map of Ankara, indicating Yeni Şehir, or the new part of the city, 1930 (adopted from [32]).

A more detailed geological study of the area was conducted in 1942 by the General Directorate of Mineral Research and Exploration, or MTA (*Maden Tetkik Enstitüsü*) [36]. Figure 2 illustrates the overall geological formation of the area in and around Ankara. The findings of this study support the soil types defined in Figure 1. Once again, alluvial soil was the dominant soil type of the new city, Yeni Şehir. Although further geotechnical studies were conducted in most public-use buildings, Chaput's findings were significant in determining proper foundation types. One example is the article on the geotechnical work of the Central Railroad Station's Gar Gazinosu and Clock Tower that appeared in the science section of the Ministry of Public Works' journal, *Bayındırlık İşleri Dergisi* [29]. The article provides in-depth information regarding the geotechnical studies used in determining soil properties.

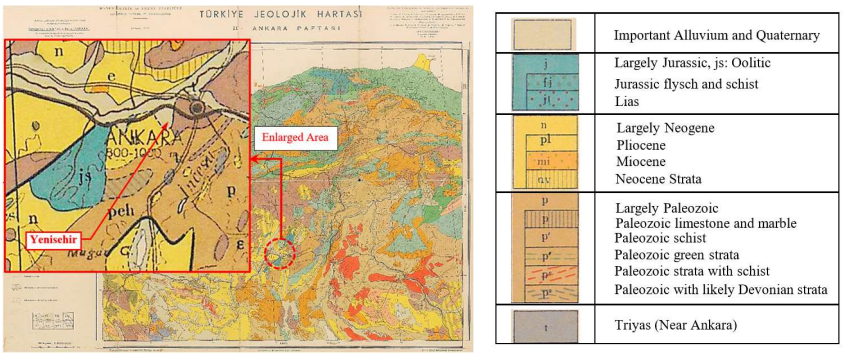


Figure 2. Geological map of Ankara, 1942 (adopted from [36]). Source: SALT Research, The Institute of Mineral Research and Exploration Archive (used with permission).

2.2. Foundation Types

During the interwar years, most of Ankara's buildings were constructed with reinforced concrete elements and heavy masonry infill load-bearing walls. This type of construction imposed larger loads on the soil than a typical building. Initially, a great deal of consideration was given to the soil in order to accurately determine its mechanical and physical properties. A pioneer in geotechnical engineering, Karl Von Terzaghi played a significant role in this field. Born in Prague in 1883, he graduated from Graz Technical University with a mechanical engineering degree in 1904. His work in Turkey began in 1916, where he relocated to escape World War I. Until 1925, he worked at what became Istanbul Technical University (ITU) and Boğaziçi University, where he taught soil mechanics and foundation design courses. He also established the first geotechnical lab at ITU, and his research in geotechnical engineering helped practicing engineers and academics, while raising awareness about proper soil testing and foundation types [37,38].

As previously stated, during the early Republic, the construction sector depended heavily on road, railroad and bridge construction, all of which required sensitive and detailed geological studies. Although building construction was not a top priority, adequate soil studies were also conducted. Therefore, in almost all building construction, soil studies were considered to be an important part of design, not just by practicing engineers but architects as well. Advances in soil-related studies were almost always incorporated into university engineering curricula; thus, engineers' knowledge of geotechnical concepts was generally up-to-date [39–42]. The buildings in the new city, Yeni Şehir, took advantage of this practice. The soil was studied thoroughly for almost all public-use buildings. For example, in the Ankara 19 May Stadium project, the soil-bearing capacity was found to be low and therefore RC piles were proposed (see Figure 3). A similar solution was proposed for the foundation of the İşbank and Ziraat Bank buildings, the Numune hospital, the Hıfzısıhha School Complex, and the İlbank, Sergi Evi and Main Train station buildings (see Table S1 for the foundation details; refer to Figure S1 for their locations).

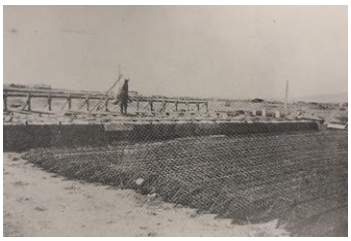


Figure 3. Ankara 19 May Stadium: reinforcement of RC piles [43] (p. 56).

Until 1937, almost all of Ankara's public-use buildings had less than five floors (see Table S1 and [44,45] (p. 38). However, as structural engineers became more familiar with RC in the mid-1930s, the construction of taller buildings was encouraged for economic and political reasons. This prompted structural engineers to increase their use of mat

foundations, or foundations with RC piles. Continuous and mat footings became the most common foundation type since the dead and live loads imposed by these buildings had to be uniformly distributed across the soil. However, in certain cases, the point load imposed on the footing exceeded the soil's allowable bearing pressure, leading to the use of piles (for example, the Stadium and Sergi Evi projects, in Table S1).

The early republican period lacked modern equipment to construct foundations. Therefore, foundation construction depended heavily on the physical strength of laborers. In cases where deeper foundations were needed, footing excavation was mostly performed by hand using a railing system to transport loose soil (i.e., for buildings with one or more basement floors) since modern construction equipment was rare, difficult to acquire and prohibitively expensive in Ankara [1,46]. The few pieces of equipment available were mostly used to construct roads, railroads, bridges and dams, which were higher priority. Figure 4 illustrates such a system, in situ:



(**a**) (**b**) (**c**)

Figure 4. Foundation excavation for a residential home near the junction of Sakarya and Adakale streets, circa early 1930s: (**a**) general view 1 [47]; (**b**) general view 2 [48]; (**c**) general view 3 [49].

During the interwar years, architects and engineers worked hand-in-hand due to the severe shortage of engineers. It was very common to find architects designing structural members since they possessed the required technical knowledge due to their educational background (see Section 2.3, for further details). This was also the case for foundation design. Therefore, both engineers and architects expressed their concerns over the importance of choosing the right foundation type. In an article entitled "*Keşif*" ("Cost Estimate"), published in 1931, Macit Rüştü outlines how to construct a proper foundation [50]. Another article by Naci Meltem, "*Temel Sisteminin İntihabı*" ("Selection of a Foundation Type"), discusses how to choose a proper foundation [51]. Such recommendations helped reduce ground and foundation failures during the early republican period.

2.3. Setbacks in RC Design and Construction

The first RC structures in Turkey date to the early twentieth century, approximately 50 years after France and the United States. However, RC technology and education quickly synchronized with the rest of the developed world. Advances pertaining to RC calculations were closely followed by academics through foreign publications, translated books and conferences. Arguably, the interaction between Turkish and foreign engineers had the greatest impact on promoting RC and professional training during the early republican period. The structural design of Ankara's public-use RC buildings was mostly performed by civil engineers. However, initially (i.e., in the early 1920s), some of the buildings were designed by architects or architectural engineers [52]. This was common at the time because only a few universities had civil engineering departments, and those with architecturally-oriented curricula focused on building design. The severe shortage of engineers prompted the establishment of new universities and departments as well as modifications to existing curricula to align them with those in Europe and the United States [24,53,54].

One major setback for RC use was the serious shortage of construction materials during the interwar years, specifically the rebar and cement that form the core of RC construction. Rebar was imported until steel factories were built in Zonguldak Ereğli in 1937 and Karabük in 1939. However, there were difficulties obtaining this material from Europe, which was still trying to recover from World War I, causing major delays in the

construction of buildings such as the Ethnographic Museum and the Ankara Art and Sculpture Museum. Circular-shaped smooth rebar was used for almost all RC buildings in Ankara [55]. This was the most commonly used rebar in Turkey until the 1980s due to its availability and low cost. Post-earthquake findings also verify this observation [56,57].

The same issues were valid for cement until the 1930s. As with rebar, the majority was imported since few factories produced it in Turkey and those that produced it had quality issues [15,58]. Therefore, the quality of locally produced cement was always questioned by academics, who suggested testing it before use, especially for bridges and dams. Quality tests were conducted at the construction materials laboratory established in the late 1920s at *Mühendis Mektebi Alisi* (today's ITU). To ensure further safety, academics and engineers always recommended using brand name cement, and frequently referred to ITU's lab results, which increased demand [59,60]. Figure 5 illustrates the number of requests sent to the lab by private and public entities between 1930 and 1937 [61]. The data emphasize the importance of the lab, and of testing, since demand rose by 100% over a span of 8 years, between 1930 and 1938. Increased reliance on these tests clearly indicate the importance of constructing good quality buildings during the early republic.

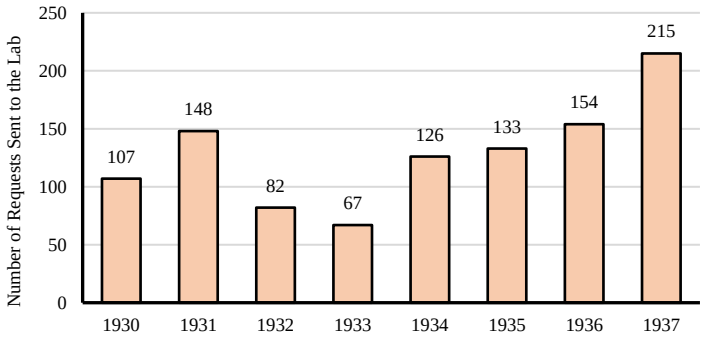


Figure 5. Number of lab documents issued by ITU, 1930–1937 (data extracted from [61]).

Another hurdle in RC construction was the fact that local contractors were not always eligible for various reasons (e.g., inadequate work experience, understaffing and difficulty accessing construction materials) to undertake construction work [52,62]. Therefore, during the interwar years, foreign firms were overwhelmingly awarded public contracts. A few Turkish contracting firms did exist, but they mainly focused on infrastructure construction (roads, railroads and bridges), rather than buildings, which were low priority. Some minor Turkish firms became involved in constructing small-scale government projects and private homes. However, it was not until 1933 that Turkish engineers and contractors began working on the construction of public-use buildings in earnest. The first major project was the Sergi Evi, known today as the Opera and Ballet Hall [25].

A lack of standardized design rules and regulation of RC structures was another concern during this period. Most turn-of-the-twentieth-century RC studies depended heavily on personal experience and unstandardized testing results since the material was new [3,63]. Moreover, scientific progress was almost always conveyed through technical books and the work of academic scholars and practicing engineers. Accessing these technical books in a timely manner was essential during the early years of RC use in Turkey. Yet, these books were scarce, and the practical aspects of RC were generally left to a few engineers working mostly on behalf of foreign contractors. This was another factor that delayed the widespread use of RC in Turkey until the late 1920s.

2.4. Construction Types

Several construction types existed during the early republican period. These examples, outlined in Law no. 2290 (6 June 1933), are enumerated below [45]:

(a) Buildings with reinforced concrete: Buildings that contain reinforced concrete structural members, such as columns, beams and slabs.

(b) Buildings with masonry: Buildings that contain walls, slabs and staircases built with stone, brick and reinforced concrete elements.
(c) Buildings with half masonry: Buildings that contain exterior walls built with stone, brick or reinforced concrete and interior walls built with timber.
(d) Buildings with partial masonry: Buildings that contain walls built with timber framing. Stone, brick or mud brick in-fills are used in between the timber frames.
(e) Buildings with half-timber: Buildings that contain walls built with timber having no stone, brick or mud brick in-fills. Timber is either exposed or plastered.
(f) Buildings with timber: Buildings that contain walls built with timber, where timber is fully exposed.
(g) Buildings with mud brick: Buildings that contain walls built with mudbrick.

As listed in Table S1, the fifty-seven public-use buildings examined in this study all fall into the "*a*" and "*b*" construction categories. Construction categories "*c*" through "*g*" were used in private home construction, mostly in rural areas, villages and towns. Between 1923 and 1927, masonry was commonly used in building construction since large numbers of skilled workers were familiar with this construction material. However, starting in 1928, more buildings or structural members (such as beams, columns or slabs) were constructed out of RC due to increasing expertise, its cost-effectiveness and its structural ability to span the relatively large openings of modern architectural design. This uptick in RC use impacted construction workers as well. Masons and timber workers were in demand during the early years of the republic. However, as RC began to dominate the construction sector towards the late 1920s and early 1930s, more concrete experts were needed. Consequently, the demand for masons and timber workers eventually diminished [1]. Since Turkey is an earthquake prone country, effective building design against earthquakes played another role in favoring RC construction. This was particularly the case after the 1939 Erzincan Earthquake, which represents a turning point in the promotion of RC over other types of construction materials [16].

From a seismic activity perspective, Ankara is located in a relatively safe area where earthquakes do not cause any major threats to its buildings. In fact, historically, the buildings in the city have not experienced moderate to major damage due to earthquakes. The first official Turkish earthquake-resistant code was published in 1940, and was a translation of the 1937 Italian Seismic Code. The 1940 code appeared after the 1938 end date used in this study. Therefore, no information has been provided regarding Ankara's earthquake-resistant design rules and regulations. However, since a large portion of the country is under major earthquake threat, earthquake-resistant design eventually became a concern with respect to buildings located in and around the country's major fault lines. The turning point was the 1939 Erzincan earthquake, which prompted immediate action in terms of designing accurate and usable seismic maps, writing new laws and formulating original codes that were specific to Turkey, and not mere translations [16]. These rules and regulations became an integral part of Ankara's building design in the 1940s, which is beyond the scope of this study.

2.5. Construction Details through Period Photos

In this section, 57 of Ankara's early RC buildings are examined from their construction perspective. RC construction photos from that period are presented so that early RC construction details can be revealed, interpreted and understood. The workmanship, construction techniques and quality of work are also evident in these photographs—the only visual sources currently available for these buildings (see Table S1). The construction photos of these buildings are listed in the same order as they appear in the Supplementary Materials (refer to Figure S1 for their locations).

Figure 6 shows the two-way ribbed slab with hollow tile floor construction details used in Ankara University's Faculty of Languages and History–Geography building. In the background, a partial view of a man-made construction tower (a modern tower crane) can be seen.

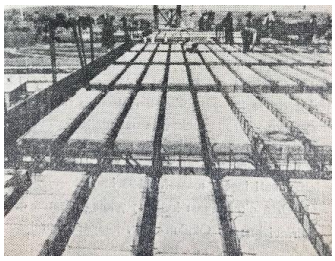
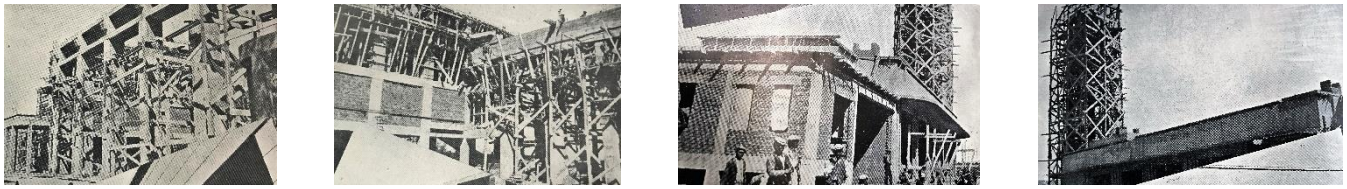


Figure 6. Ankara University, Faculty of Languages and History–Geography Building: slab construction [64] (p. 65).

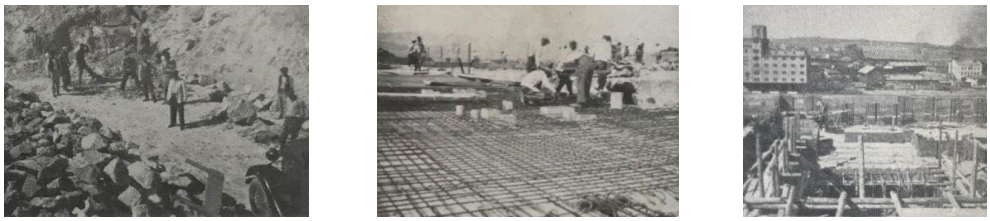
The construction photos of the main Central Railroad Station building reveal its structural details (see Figure 7a,b). In these photos, the RC exterior columns and scaffolding are displayed. Figure 7b shows the column, beam and slab formwork, along with the brick partition walls. Figure 7c depicts the reinforced concrete columns with brick partitioned walls of the Central Railroad Station's Gar Gazinosu and Clock Tower. The construction and scaffolding of the Clock Tower are displayed in the background (see Figure 7d for a close-up photo of the Clock Tower).



(**a**) (**b**) (**c**) (**d**)

Figure 7. Main Central Station (MCS) with Gar Gazinosu and Clock Tower Buildings (GGCT): (**a**) MCS Front View; (**b**) MCS Exterior View; (**c**) GGCT; (**d**) a close-up photo of Clock Tower [65] (pp. 37–39).

Figure 8 displays the construction photos of the Radio House. The first photo indicates the preparation of perimeter or retaining walls made of rock. In the second photo, typical slab reinforcement can be seen. In the background, concrete pouring and placement are evident. The photo on the right depicts a general view of the building's construction.

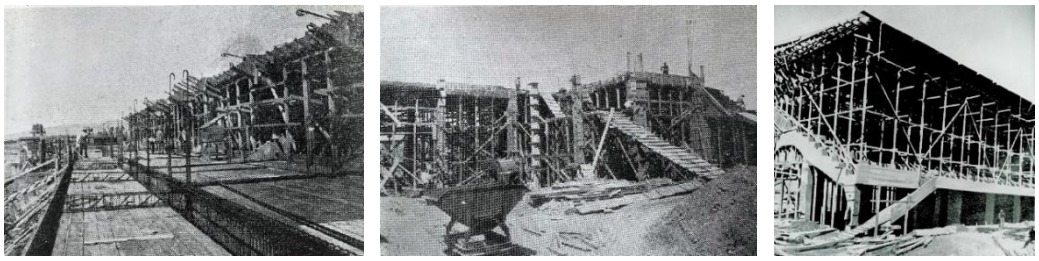


(**a**) (**b**) (**c**)

Figure 8. Ankara Radio House: (**a**) excavation; (**b**) rebar layout and concrete pouring on a slab; (**c**) general view of the construction [66] (p. 233).

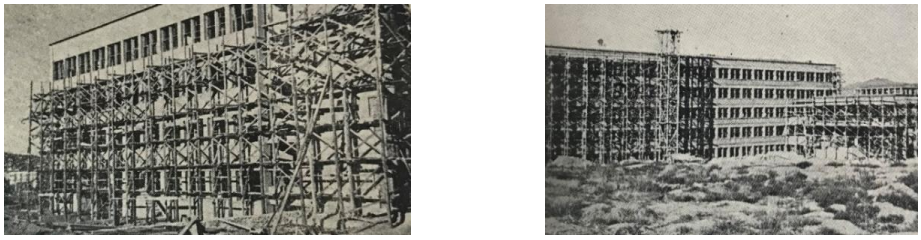
Figure 9 shows the construction photos of Ankara's first RC stadium. In the first photo, on the left-hand side, is the reinforcement layout of the stadium platforms, columns and beams. The second photo displays the construction of the columns and slabs that were used for the presidential grandstand. The third photo, on the right-hand side, depicts the concrete formwork and scaffolding of the bleachers.

Figure 10a depicts the scaffolding on the exterior wall of the Prime Minister's Office, which was used for the façade work. Figure 10b is a similar photo, with a wooden construction tower, frequently used since modern tower cranes were unavailable.



(**a**) (**b**) (**c**)

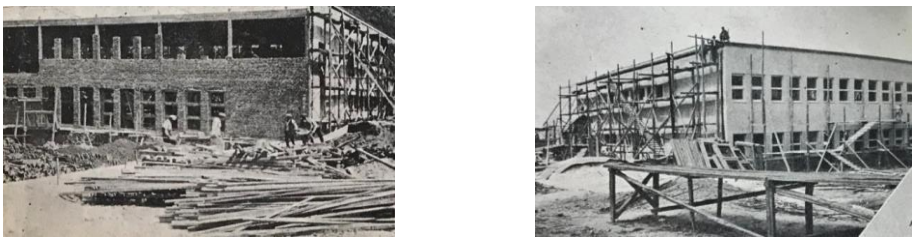
Figure 9. The 19 May Stadium: (**a**) platforms, columns and beams [43] (p. 56); (**b**) presidential grandstand [43] (p. 56); (**c**) scaffolding of the bleacher [67] (p. 21).



(**a**) (**b**)

Figure 10. Prime Minister's House: (**a**) scaffolding for façade work; (**b**) general view and wooden construction tower [65] (pp. 115–117).

Figure 11 exhibits the construction photos of Ankara University's Faculty of Political Science building. The first photo illustrates the brick façade work over an RC frame system. The second photo is of the plasterwork on the exterior of the building.

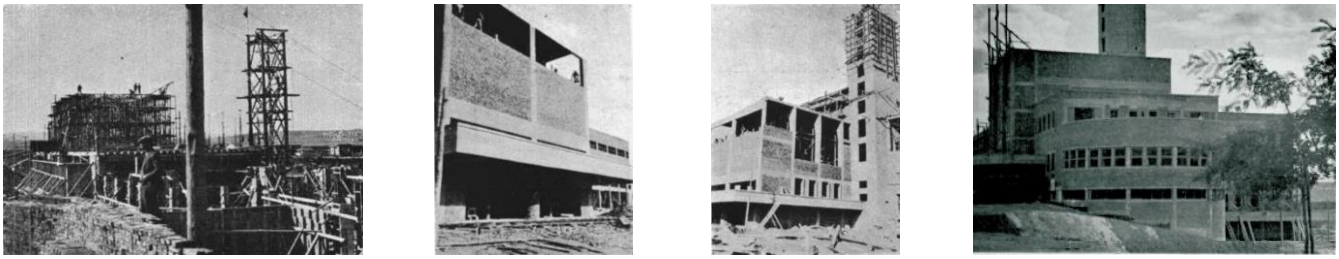


(**a**) (**b**)

Figure 11. Ankara University's Faculty of Political Science building: (**a**) exterior view; (**b**) overall view [65] (pp. 115–117).

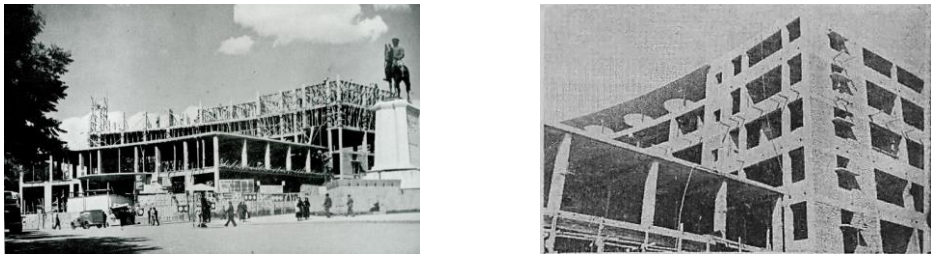
Figure 12 presents the construction photos of the Sergi Evi building. In the first photo, the overall construction of the building is shown. It displays the formwork for the columns, beams and slabs. In the foreground, the brickwork can be seen; in the background (right-hand side) is the construction tower. The second and third photos depict the exterior view of the building. Brick was used as infill walls in between the RC columns. It is important to note that the height of the brick wall, with no lateral support in the second and third photos, well exceeds today's limits of 3 m. In Figure 12d, a general view of the building is exhibited at a later stage. In this figure, the concrete work and exterior brick walls are complete.

Figure 13 shows the construction photos of the Sümerbank building. The first photo depicts the overall construction site, where some of the columns were cast and the formwork for the others was prepared. A wooden construction tower can be seen in the background, on the left-hand side. The second photo is a close-up view that includes the floor columns. The columns on the top floor, left-hand side, were supported by flat slabs (a slab with no beams), each having a column capital to prevent punching shear from the live and dead loads.



(**a**) (**b**) (**c**) (**d**)

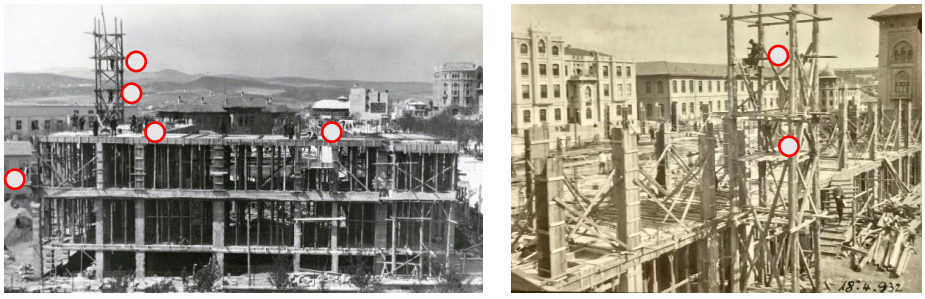
Figure 12. Sergi Evi: (**a**) general view [68] (p. 103); (**b**) exterior walls [68] (p. 103); (**c**) exterior walls and tower [68] (p. 103); (**d**) exterior view [69] (p. 28).



(**a**) (**b**)

Figure 13. Sümerbank: (**a**) general view [70] (p. 31); (**b**) close-up view and floor construction [71] (p. 1).

As conveyed by these photos, construction work was labor-intensive with the minimum involvement of construction equipment. Moreover, in almost all construction, there was practically no protection against falls. A closer look at Figures 6–13 clearly verifies this fact. Figure 14 further emphasizes it. The red circles next to the workers identify clear work safety violations.



(**a**) (**b**)

Figure 14. Work safety violations, Central Bank construction site: (**a**) floor and tower construction; (**b**) column formwork and tower construction (property of the author). Source for (**a**): SALT Research Archive, Mehmet Galip, Fesçi Zade İbrahim Galip ve Erzurumlu Nafiz (Kotan) Bey'in Ankara, İstanbul, Bursa ve Eskişehir'de gerçekleştirdiği inşaatların fenni idare heyeti tarafından düzenlenmiş, 1933 tarihli prestij albümü (a photo album) (used with permission) [72].

These photos also indicate the technology and equipment used to construct buildings during this period, and emphasize the quality of the workmanship involved. The formwork for the structural members was adequately completed and the scaffolding that supported slabs was achieved through closely spaced timber posts, signifying the importance of slab construction. The exposed concrete on the columns, beams and slabs indicates good quality workmanship with minimum segregation issues.

3. Cost Comparison

In this section, a cost comparison study is performed using the construction fees and material quantities of the 57 buildings. Table S1 provides the cost per square meter data for 26 out of the 57 buildings. Cost is plotted in Figure 15 and arranged according to construction year. Based on the available data, the most costly building was the Military Guest House (1929), with a unit cost value of 93 TL/m^2 (Turkish Lira per square meter). The Gazi and Latife Schools (1924) had the lowest unit cost value at 16 TL/m^2.

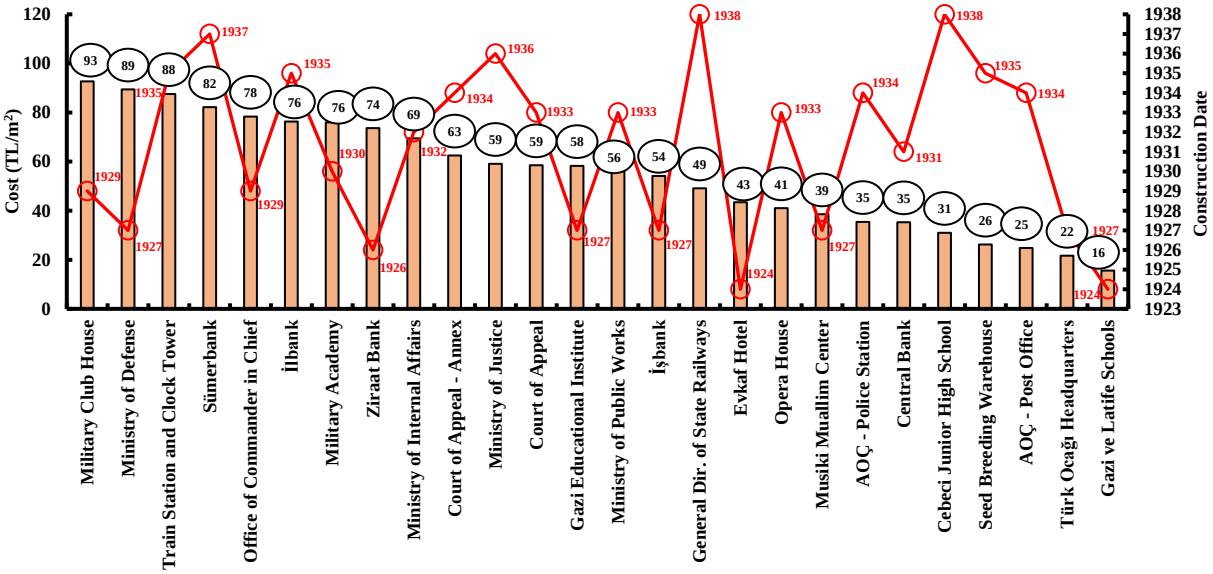


Figure 15. Cost comparison of select buildings from Table S1 in the Supplementary Materials.

The data in Figure 15 represent the net cost at the time the projects were completed (not adjusted for inflation). Based on available data, today's buying power (as of December 2022) was calculated as a multiple of 180. Therefore, the costs indicated in this study should be multiplied by 180 to approximate its current value in Turkish Lira. For example, a unit cost value of 93 TL/m^2 in 1929 is equal to around 16,740 TL/m^2 today. As the figure illustrates, cost distribution is not directly related to construction year. Larger buildings, with greater construction areas, were more costly, regardless of the year in which they were constructed.

Seven public-use buildings are further investigated with respect to their cost analysis. Data extracted from the Ministry of Public Works' journal reveals additional information regarding these buildings, all of which were constructed between 1927 and 1933. Figure 16 displays the fee distributions of these buildings, as a percentile, for each discipline involved in their design and construction [73]. As the data suggest, the combined fee of the structural and architectural work was almost steady, at an average of 75% of the total fee. However, the fee for the mechanical and plumbing work varied between 11% and 20%. A similar pattern was also observed for the electrical work; this variation fluctuated between 4% and 9%. The design fees (i.e., project fees) were also compared for the seven buildings as a percentage of the total construction fee. Based on the data plotted in Figure 16, the numbers varied between 1% and 5%. These fee distributions are comparable to current (2022) fees for similar RC buildings.

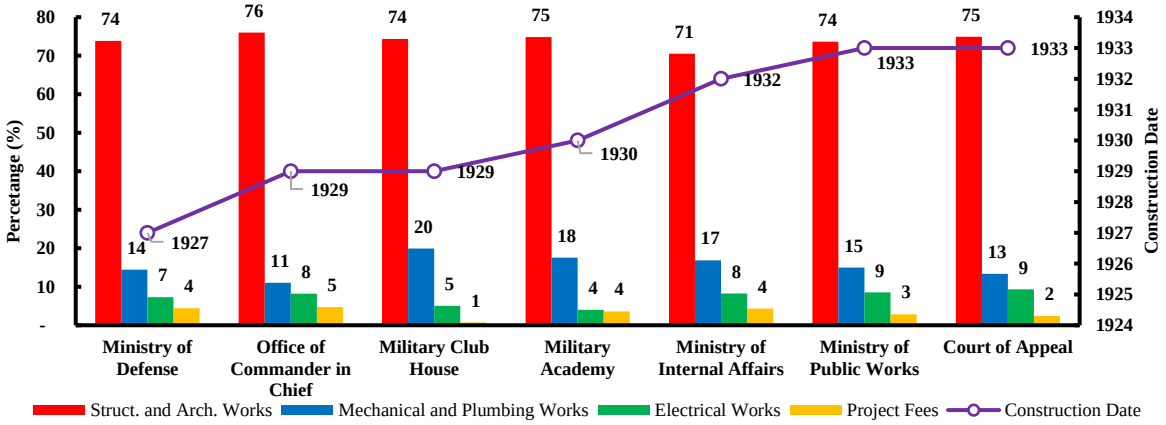


Figure 16. Unit cost comparison of project disciplines as percentiles (data extracted from [73]).

4. Common Issues of Building Construction

Numerous issues were encountered from the client's (i.e., the government's) and contractor's perspectives during the planning and construction phases of these projects. Such concerns fall into five categories: (a) contract awarding and budgetary issues, (b) the procurement of construction materials, (c) building inspection, (d) politics and the Ankara Municipality's role in management issues, and (e) others.

(a) Contract Awarding and Budgetary Issues:

During the early 1920s, the quality of building contractors was under question; large construction firms were more interested in railroad and bridge projects since they were plentiful and lucrative [74]. The remaining contractors, many of whom were of doubtful reputation, were channeled into building construction. In general, cost was the key parameter in determining the winner among bidders. This money-driven contract awarding method significantly diminished the quality of construction work [75]. It almost always benefited unqualified contractors since their proposed fee was much less than the initial estimated cost. In order to profit despite severely reduced contract fees, these contractors cut corners with respect to the quality of design and construction. As a result, it was always challenging to maintain job quality on site, leaving almost no room for good quality work. This process usually led to unexpected fees since repair and maintenance had to be performed, even on newly completed projects [62] (pp. 86–87).

During this time, acquiring a project was essential; however, this did not ensure that contractors would survive. Interrupted payments from the government was always a possibility, as was bankruptcy. In order to prevent this, an alternative solution was proposed: contractors were advised to apply for loans from banks such as İşbank and Emlak Eytam bank. However, this proposal created another serious problem. It constrained contractors financially, as their loan payments could not be made on time due to long delays in receiving funds from the government. As a result, some well-known contractors, including Arif Hikmet Koyunoğlu and Erzurumlu Nafiz Kotan, had no choice but to declare bankruptcy [22,44].

The other issue was the contract-awarding process. Each building project had an initial cost estimate before it was prepared for bidding. Originally, only foreign firms and a few Turkish contractors were allowed to bid on public-use buildings. This was because government agencies mistrusted Turkish firms' ability to access and acquire construction materials such as steel reinforcement bars. Specific contractors were preferred by architects who wished to forego the formal bidding process. These preselected contractors often caused serious budget issues since, ultimately, architects had the final say before accepting contractors' work. Consequently, the final fee of some public-use buildings exceeded their initial estimates [46].

(b) Issues Related to the Procurement of Construction Materials:

During the early republic, structural steel sections and steel rebars were not manufactured in Turkey, and therefore had to be imported. However, due to major shipping delays, customs regulations, and economic and political factors (initially, recovery from WWI, followed by the global depression of the 1930s), they were not always received on time, or at all. Consequently, project deadlines had to be rescheduled, causing the unintended extension of construction periods [9] (pp. 92–99), [24,46,62] (pp. 86–87).

In order to meet demand as the popularity of RC increased, cement also had to be imported from other countries, particularly Germany. Initially, accessing cement was impacted by Turkey's poor transportation infrastructure since travel time to Ankara from nearby coastal cities, such as Istanbul and Izmir, which received the shipments, was well over 24 h. Therefore, higher priority was given to the country's infrastructure system (extending the poor railroad network was at the top of the priority list). However, time was essential and solutions had to be found. As a result, these challenges forced architects and engineers to explore good quality local quarries that could provide the raw materials to make concrete and/or cement (see Figure 17). Eventually, several cement and building material factories were opened in Turkey [76,77].

(c) Issues Related to Building Inspection:



(**a**) (**b**)

Figure 17. (**a**) A photo of a local trachyte stone quarry, used for masonry walls and sidewalks, near Ankara, December 1932 (property of the author); (**b**) a local gravel factory for concrete production, Ankara, March 1932 (property of the author).

During the early republic, construction quality was inspected by different parties. In some cases, architects themselves were assigned as supervisors since they spent most of their time on site anyway. Examples include Arif Hikmet Koyunoğlu for the Ethnographic Museum, Giulio Mongeri for Ziraat Bank, and Paolo Vietti-Violi and Ladislas Kovacs for the Ankara 19 May Stadium (for additional examples, see Table S1). For other buildings, such as Ankara University's Faculty of Languages and History–Geography, and the Ministries of Justice and Internal Affairs, government agencies undertook this role. For Ankara University's Faculty of Agriculture building and the main Central Train Station building, engineers employed by government agencies were put in charge (for additional examples, see Table S1). Yet, the design and construction inspection of buildings by different entities created chaos for clients since no standard procedure was followed. In the early 1930s, the Ministry of Public Works undertook this role completely and became the only body that inspected the design and construction of public-use buildings.

The practice for private building projects was, however, slightly different. For the Gülhane Business Center and the Koçhan building, the site inspection was solely the contractor's responsibility. The permits for the construction and occupation of these types of buildings required frequent visits to the job site by municipal engineers. These visits were also considered to be free site inspections by the buildings' owners. Additionally, for some buildings, highly regarded academic experts were contacted to review the design calculations or construction details, which is still the case in Turkey today [46].

(d) Politics and the Ankara Municipality's Role in Management Issues:

The construction of Ankara was initially governed and managed by the governor/mayor of the city. This lasted until the early to mid-1930s, when the Ministry of Public Works was placed in complete charge. The following two documents, prepared 5 months apart by the Governor of Ankara, Asaf Bey, in 1927, explain the management issues he encountered and how they were directly related to politics:

- 8 June 1927 (summarized in English, from Ottoman Turkish) [17]
  This report was presented by Asaf Bey to Prime Minister İsmet İnönü and described the public work issues of the Ankara Municipality. It stated that in 1926, under the previous mayor, Ali Haydar Bey, most of the city's construction work was put on hold since the Municipality possessed almost no cash assets. Consequently, construction expenditures had to be financed through bank loans, which created serious payment issues. This decision halted many construction projects in the city and forced some small, local contracting firms to declare bankruptcy because they could no longer be paid by the city. In order to protect construction firms and the new republic's reputation, small payments were made to these firms so they could survive. However, this was not enough to complete the building of the new capital in such a short period of time. The urgent need for cash was expressed to the Prime Minister. Without it, the municipality had no option but to suspend all its construction work. This request was sent directly to the Prime Minister since finding a quick solution was necessary. Thus, the early years of Ankara's construction relied on political connections.
- 23 November 1927 (summarized in English, from Ottoman Turkish) [18]
  This document criticized the method that was chosen to construct Ankara. A major concern was the absence of laws and regulations. Mayor Asaf Bey stated that obtaining the approval of a majority of the municipal administrators would not resolve this issue since problems were generally not handled professionally. He provided examples of good management by French and Austrian cities and strongly urged the use of government financing and the establishment of a commission protected by special laws. This was the beginning of a new division in the Ministry of Public Works that orchestrated public works projects in Ankara in the 1930s and beyond. The report also criticized the existing bidding method, in which the lowest bidder was awarded the project, since it completely eliminated the selection of the most qualified and experienced companies and diverted work to low-budget firms. The mayor commented on the lack of construction planning and the unnecessary influence of outsiders with status who often knew nothing about building. He emphasized the significance of establishing a special commission to address these problems because he believed that politics should not interfere with construction work, and that budget management should not be left solely to the mayor or the Minister of Finance. Otherwise, the future of Ankara could depend on the character, ability and honesty of just one or two individuals.

(e) Other Issues:

During the early republic, there was a shortage of competent, reliable contractors and engineers. Therefore, until the mid-1930s, foreign firms were frequently employed, and the government hired foreign inspectors to review the work of these contractors and engineers. During the early to mid-1920s, there were so many foreign experts in Ankara that foreign languages could be heard at construction sites and in government agencies [13,78–80]. Nevertheless, such experts were not always welcome. Emin Sazak, a partner of the firm *Cumhuriyet İnşaat Türk Anonim Şirketi* and a parliament member, repeatedly warned of the risks involved in utilizing foreigners and blamed Turkish engineers for being passive with respect to this foreign invasion. He publicly criticized state policy regarding this issue since it significantly diminished the power of Turkish engineers and contractors [23].

Politics were always at the center of construction in Ankara. Architects were sometimes personally invited to be in charge of design and construction, solely based on political

connections. For example, Arif Hikmet Koyunoğlu assumed full responsibility of the design and construction of the Ethnographic Museum and Art Center projects because of his social influence during the early republic. Similarly, Guilio Mongeri was in charge of the Ziraat Bank project, while Vedat Tek was invited for the Evkaf Apartment project due to their extensive networking abilities. Another leading figure was Austrian architect Ernst A. Egli, who was directly appointed to several government projects. All of these prominent figures, in one way or another, had close personal and/or professional relationships with politicians [9] (pp. 92–99), [14,62] (pp. 71–73), [81–83].

5. Conclusions

During the early Turkish republican era, reinforced concrete building construction was a challenge on every level. A brand new capital had to be constructed in a very short period of time, and there was a lack of engineers and construction workers who knew how to design and handle this building material. Expertise was initially sought from foreign construction firms, architects and engineers already in Turkey, who helped build the city and played an important role in training and educating their local counterparts. The trend of employing foreign actors in building construction continued steadily until the early to mid-1930s. After that, the Turkish educational system and trust of local engineers had grown to the point where they could be self-sufficient. This led to a decrease in the influence of international interests on the Turkish construction sector. Nevertheless, building a brand new capital in such a short period of time meant that political connections and profit were often prioritized over quality and safety. The repair of recently completed projects was a reality, as was injury and death on construction sites. In order to prevent such problems, a strong, central entity was established that would inspect and manage public-use projects: the Ministry of Public Works.

As evident from the structural details of the buildings listed in Table S1, until the late 1920s, masonry construction was frequently used in Ankara's buildings, along with RC elements to some degree. However, as the number of educated engineers and local contractors increased, so too did the use of RC. Initially, the number of floors was mostly kept under five in order to prevent the use of piles and additional expenses to strengthen the soil. However, this changed as the new city grew in the direction of areas with better soil properties. Gradually, construction shifted towards taller buildings (buildings with 5 to 10 floors) with almost all RC elements.

As a modern construction material, RC also allowed the construction of earthquake-resistant buildings. However, its use came with a price. Steel and concrete were not always readily available, and sometimes took weeks to arrive at job sites since most of it was imported, delaying the completion of projects. The transportation of these materials even within the country was an arduous task, taking days, as it was heavily dependent on antiquated railroads. These challenges forced architects, engineers and contractors to find alternate sources by exploring nearby quarries. Geologists assisted in resolving some of these matters since they prepared detailed soil analyses of Ankara and the rest of the country.

Quality control of the construction of public-use buildings began to improve in the 1930s once an appropriate bureau was established by the Ministry of Public Works. As the number of local factories producing construction materials increased, the use of RC became more popular. Academics also played a significant role in promoting this material since there was a major trust issue with local engineers and inspectors. Furthermore, academics became experts who facilitated RC technology transfer from western countries to Turkey.

The construction of the new capital, Ankara, was a difficult task. In the first decade of the republic, it was a chaotic process that took its toll on architects, engineers and contractors, forcing many firms into bankruptcy. RC construction became more popular in the 1930s, and its use encouraged the standardization of building materials, techniques and procedures. Thus, during the early republic, the complicated nature of using RC (compared

to masonry and timber) served as a catalyst for reform in government, management, academia, professional training, the legal system and the construction sector.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/buildings13010046/s1, Figure S1: Overall view of the area under investigation; Table S1: Summary of buildings with RC components in Ankara, Turkey.

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