# EARTHQUAKE ENGINEERING IN TURKEY: A BRIEF HISTORY

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**ABSTRACT:** This paper is an account of earthquake-related science and engineering in Turkey from what we propose to be its beginning in 1894 until the present. This account describes advances in the academic institutions of the country as well.

**KEYWORDS:** Earthquakes in Turkey, National Committee for Earthquake Engineering, earthquake geology, design codes in Turkey, seismic hazard maps in Turkey, North Anatolian Fault

## 1. INTRODUCTION

An attempt to write the history of anything draws with it the temptation to mark its beginning, the date or event that, with hindsight, can be said to have changed the course of a particular scientific or other field of activity so drastically that nothing was the same afterwards. This runs parallel with the implicit need to be balanced, and omit nothing important between that genetic event and the current time. The ambition to compose an account of earthquake engineering in Turkey is no different. It began with earthquakes being examined with an earth science slant, and then gradually was transformed into the broad discipline whose global progress through time we are discussing today.

There seems to be acceptance in Turkey that the defining event for Turkey was the 27 December 1939 **M**7.9 event centered near Erzincan, 700 km east of Ankara. This cataclysmic earthquake served to launch what we may now identify as the genesis of earthquake risk mitigation measures to be put into effect in Turkey. The timing (after mid-night during an unnaturally cold winter in mountainous terrain) of the earthquake was extremely inauspicious for the country that had taken extenuating military and economic measures due to WW2 that had just broken out in western Europe. By current estimates 33,000 people perished and 100,000 were injured with 120,000 dwellings suffering severe damage. The ground rupture extended 350 km, and foreshadowed a series of ruptures that have progressed westward, generating frequent major earthquakes. This apparent causality of each earthquake on the North Anatolian Fault (NAF) triggering the next has lasted until 1999, and is expected to continue (Parsons et al., 2000).

In this paper we re-examine this popular but misconceived birthday, and move it another 45 years further back, to the 10 July 1894 earthquake that struck Istanbul, then the imperial capital of Turkey. We base our decision to deviate from conventional wisdom to assert that this earthquake was a turning point for the country not only because of its magnitude (**M**7) or the fatalities or injuries (each estimated to lie between 1500-2500) it caused within and in the vicinity of the city (where the population was about one million), but upon the fact that this earthquake was the first in the country's history that was scientifically surveyed and reported. Its visible consequences were recorded photographically so that we can run elementary estimates of local ground motion intensities from damages on un-reinforced masonry buildings. It also generated recommendations from scientists on how to mitigate future damages.

In the remainder of this paper we examine the progress of earthquake engineering within three broadly defined epochs, each melding into its successor with a markedly different character. The first period spans 1894-1939, enclosing the conspicuous dates of the 1906 San Francisco, 1908 Messina and the 1923 Kanto earthquakes whose scientific ripples reached the country. Turkey was highly occupied on the military and political fronts during this period, so advances along the earth sciences front were modest and reactive. This period ends with the 1933 University reform and the creation in 1935 of the Mineral Research and Exploration Institute for the

purpose of discovering and exploiting the country's minerals wealth. This act enabled the fortuitous influx of many highly qualified foreign (central European) professors and geologists into the country, changing the way earth sciences were taught and practiced.

The occurrence of the **M**7.9 Erzincan earthquake in 1939 and its closely-spaced (both in time and in geography) successors along the North Anatolian ushered a new period when the notion of seismic mitigation was officially enunciated, and corresponding legal measures were enacted. In 1958, the Turkish Grand National Assembly, as the parliament is called, passed into law the creation of a new Ministry of Reconstruction and Resettlement among whose mandates were the enforcement of the seismic code and the preparation of the earthquake zones of the country, as well meeting post-disaster needs in housing and urban planning. We end this period in 1965, when the Ministry created the Turkish National Committee for Earthquake Engineering for membership in IAEE that had come into existence in 1963, following the Second World Conference in Tokyo in 1960. The final epoch that we will describe covers the time period from 1965 until the present.

The following account is academically oriented because advances along earth sciences or earthquake engineering have occurred in pace with developments in universities. This has proven to be an enduring trait because in the absence of a strong professional organization such as SEAOC the engineering community has traditionally looked up to the academics in Turkey for regulating the guidelines of practice. This has led on occasion to codes of practice that are impracticable or incorrect.

## 2. THE FORMATIVE PERIOD: 1894-1939

Istanbul has suffered many major earthquakes during its 2500-year long history, so the **M**7 on 10 July 1894 at noon time should not have been particularly surprising. But human memory is shorter than the recurrence period of major earthquakes, so this destructive event still caught the city's population by surprise. The statistics cited for deaths and injuries range between 1500-2500 each, but both may be grossly in error because they have been found by multiplying the official numbers by subjective factors on account of the censorship that was in effect at the time. Much more reliable are the statistics for building damages and their visual images that have survived. The scientific account for the earthquake was written by Mr. D. Eginitis, "Directeur de l'Observatoire d'Athènes" who was assisted in his exploratory mission by Messrs. D. Coumbary and E. Lacoine, the director and vice-director, respectively, of "Rasathane-i Amire," the Ottoman Imperial Observatory then located in mid-town, precursor of today's Kandilli Observatory (Genç and Mazak, 2001; Öztin, 1994; Sezer, 1996).

Eginitis was an astronomer but his report submitted to the Palace on 15 August 1894 provides an accurate account of the observed effects of the earthquake that was felt as far as Crete, then a Turkish island, Romania, Crimea and much of Anatolia. An isoseismal map, description of ground ruptures and an estimate of its hypo-central depth (34 km) comprise it. He characterizes the earthquake as "tectonic," and recommends the procurement of seismic instruments. A seismograph was duly ordered from Rome, but we have no information on how this was later used. Eginitis' account was complemented by a photographic image album for the earthquake and its effects on buildings that was ordered by Sultan Abdülhamid II who was keen to leave a lasting visual testament. We provide two frames from this collection in Figure 1. With hundreds of similar images documenting perishable data it is now possible to estimate local ground shaking intensities, making this the first scientifically well-documented earthquake for Turkey.

The state of the university education system in the country during this period deserves description. In Ottoman Turkey, training in the physical sciences was initiated in late eighteenth century because of military conflicts with the encroaching European powers. The engineering institutions had strong vocational emphasis, and were followed by the Imperial Medical College in 1827 and the Imperial Military College in 1834. Other institutions, affiliated with various ministries, were the School of Public Administration (1877), Law (1878), and theImperial School of Fine Arts (1882). The first Turkish university called "Darülfünun" became operational in 1863 with lectures in physics and chemistry. The first 450 students were admitted in 1870, and placed in four

faculties: Philosophy and Letters, Law, Natural Sciences and Mathematics (Barblan et al. 2008). The university experienced many changes of fortune since its foundation, and needed to be re-opened several times. In 1912 the Darülfünun was reorganized to include institutes and laboratories in order to structure it along continental European lines. The shortage of qualified professors was addressed by hiring foreign professors-20 from Germany and one from Hungary. We surmise that Wegener's continental drift theory may have been included in the curriculum in geology. On the eve of World War I, the country had 25 institutions of tertiary education employing 531 staff who provided training for 5,600 students. Ten years and two wars later, numbers in each category had fallen to about one-half.

Figure 1. Damage in the 10 July 1894 Earthquake

Three professional schools were created in late 19th century: the Higher School of Commerce in 1882, the School of Fine Arts and School of Civil Engineering in 1883. Most teachers in the engineering school were seconded from the existing naval and military engineering schools. These were merged in 1909 into the Higher School for Engineering that in the 1930s took in the departments of mechanical, electrical and aeronautical engineering and naval architecture, forming the origin of today's Istanbul Technical University, created in 1944.

Following the creation of the Turkish Republic in 1923 a reformative act created today's Istanbul University in 1933 by disbanding the Darülfünun. Importantly for this account an Institute of Geology was created as part of the Faculty of Science. In 1934, seismic observation was appended to Kandilli's duties. The reform law enabled hiring foreign scientists and scholars as faculty staff at internationally competitive salaries. This allowed the national academic community to welcome some three hundred professors in many different disciplines from Germany. Many of these scholars were Jewish expatriates fleeing persecution in their country. The Central European character in many Turkish universities was stamped by these academics three generations ago when they served with distinction in transplanting their age-old traditions in a temporarily adopted country.

Another development that occurred at about this time was the creation of the Minerals Research and Exploration Institute (MTA in its Turkish acronym) in 1935 as a branch of the government for discovery and exploitation of the country's mineral wealth. MTA has broad similarities with, e.g., the USGS. The policy of hiring qualified foreign professionals was exercised here as well; this would have major consequences in the geological sciences because some of these individuals did seminal work of lasting value in their areas. We refrain from any attempt to be comprehensive in quoting the names of geologists who arrived to interact with their Turkish peers but our emphasis on earthquakes will permit us to mention those who have left a mark on the geological interpretation of earthquakes in an age when plate tectonics had not yet been invented. The names of these men are E. Parejas, P. Arni, E. Lahn, W. Salomon-Calvi and M. Blumenthal.

## 3. MAJOR EARTHQUAKES DICTATE GOVERNMENT POLICY: 1939-1965

Until the occurrence of the **M**7.9 earthquake in Erzincan in 1939, governmental understanding for hazard mitigation had been non-existent and post-disaster activities reactive and case-driven. Following Erzincan there was a rapid succession of other major earthquakes on the North Anatolian fault, as though one earthquake triggered the next one (**M**7, Erbaa, 1942; **M**7.2, Ladik, 1943; **M**7.4, Gerede, 1944). Each caused wide-spread destruction. It became clear that the effects of earthquakes needed to be contained prior to their occurrence, so the Ministry of Public works called upon the Institute of Geology at Istanbul University, the school that provided education in civil engineering, Higher School for Engineering in Istanbul, Kandilli Observatory (then under the Ministry of National Education) to formulate remedies. Representatives from these institutions examined governmental policies in Japan, USA and Italy, and geologists soon produced a two-zone earthquake map for the country dividing it into "more" and "less" damageable areas. Engineers translated the Italian seismic code of 1937 that formed the backbone of the 1940 "Provisional Construction Requirements in Earthquake Regions." From that date lateral forces were in principle considered in the design of buildings.

Foreign geologists at MTA had all been in well-versed in the stable orogeny of Central Europe, and geology of earthquakes was new and mostly unknown for them. While they were active in the field during the first half of the 1940s, reporting on the visible effects of the Erzincan and following earthquakes the geologic context they used was representative of the prevailing accepted thought. Correct interpretation of the North Anatolian Fault Zone that had been identified as early as 1921 within the context of a westward movement of the Anatolian Block relative to the stable Eurasian block was first made by the Turkish Geologist Ketin (1948) in a paper that received little immediate appreciation. At the time Professor Ketin (Fig. 2) was with the Institute of Geology at Istanbul University. He moved to Istanbul Technical University, Faculty of Mines when it was created in 1953.

Figure 2. Professor İ. Ketin (1914-1995)

The Ministry of Public Works perceived the legal vacuum that existed in enforcing the construction requirements for buildings, so a law on "Measures to Be Put into Effect before and after Earthquakes" was passed in 1944. This was an all-in-one legal document that described duties incumbent on local administrations for loss mitigation, principles of hazard zones map and codes, site selection for safe construction, professional and public training. The zones map and construction guidelines were duly revised and made mandatory for the country as a whole in 1945. There was still no building design and construction code so the Ministry of Public Works led the way in organizing a "Building Congress" in 1946.

A noteworthy achievement of the Congress was its comprehensive treatment of diverse topics in "foundation and soils," "ground vibration," "architectural principles," "construction legislation," and "development plans." It produced a white paper, but implementation of its recommendations turned out to be glacially slow and bureaucratic. Development of national codes of practice would await the creation of Turkish Standards Institute in the 1960s. The seismic zones map was renewed in 1947, 1963, 1972 and lastly in 1996. A number of landmark developments occurred in the 1950s. The first comprehensive earthquake catalog for Turkey was compiled by Pınar and Lahn (1952), expanding the work of Salomon-Calvi (1941). An Institute of Geophysics was formed within Istanbul University in 1952, and the Institute of Seismology within Istanbul Technical University the same year. While the Ministry of Public Works formed an "Earthquake Bureau" as part of its General Directorate of Construction Affairs, academic units in Istanbul benefited from a group of professors from Japan who arrived as UNESCO experts hosted by ITU: T. Hagiwara, H. Umemura, S. Omote and T. Rikitake whose lectures in seismology, engineering seismology and earthquake engineering were attended with much interest, and formed a professional bridge between the two countries that has existed for over a half-century. The nexus with Japan had been established as a result of the determined work of Professor Yarar (Fig. 3) who was among the founders of the ITU Institute of Seismology.

Figure 3. Professor R. Yarar (1913-2004)

The emphasis placed on seismic mitigation during the 1940s was loosened during the next decade when the country experienced an economic boom starting in 1950, and became urbanized and industrialized. The societal transformation produced an adverse effect on the seismic code of practice when the basic lateral force coefficient for high-hazard zones was reduced to 0.04 in the 1947 and 1953 code versions from its 1940 value of 0.1, contravening the 1946 Building Congress. The justification was that the poor performance of the building stock stemmed not from the severity of the ground motion in Turkey but from their poor construction. Interestingly, the country did not have a building code as such: designers could use German or other foreign codes so the base shear force coefficients of 0.04 or 0.1 were irrelevant as they were not anchored to other design criteria. Approval of their design by the local administration was all that was required.

The unchecked urban growth served as reminder that the duties of the Ministry of Public Works could not meet the country's needs in urban development supervision and coordination with disaster mitigation, so in 1958 the Ministry of Reconstruction and Resettlement was created by parliament. It was followed a year later by adoption of the Disasters Law #7269. Article 5 of the Law stated that the Ministry was empowered to create public entities for the purpose of mitigating earthquake and other natural disasters, enabling cooperation with universities and other public agencies to direct research and development. Preparation and promulgation of the seismic hazard zones map and the building seismic design provisions were brought under the responsibilities of the Ministry. The code has since been renewed in 1961, 1968, 1975, 1998 and 2007. The ample "Disasters Fund" as supplement to the budgetary appropriations could be used to support academic research. This provision was used in 1968 first to create the "Earthquake Research Division," that was transformed in 1971 into the "Earthquake Research Institute" that reported to the minister directly. Through the support provided by the Institute, much useful research, development and implementation activity has been completed in Turkey in earthquake engineering and engineering seismology with participation from public and private sectors, NGOs and the academia. When public funds were disallowed in the 1980s earthquake research funded by the Ministry suffered a setback.

The only participant from Turkey in the World Conference on Earthquake Engineering held in Berkeley in 1956 marking the 50th anniversary of the San Francisco earthquake had been N. Pınar, professor of geology from Istanbul University (who was at the time a deputy from Istanbul in parliament, and signed her name as such in her paper). The Berkeley conference was followed by another in Tokyo in 1960, and the International Association for Earthquake Engineering (IAEE) was formed in 1963. After the Third World Conference on Earthquake Engineering had been held in New Zealand in 1965, it became clear that a national entity needed to be created in Turkey for the purpose of joining IAEE. Professor Yarar led the way for this action, with support from the Ministry of Reconstruction and Resettlement. A ministerial "approval" in 1965 formed the Turkish National Committee for Earthquake Engineering; Professor Yarar was appointed as its president. Another important milestone at this time was the establishment in 1963 of the Scientific and Technological Research Council of Turkey (acronym: TÜBITAK) that has since been a major supporter of earthquake science research.

## 4. DEVELOPMENTS SINCE 1965

The period 1966-1971 witnessed a spate of major earthquake activity in Turkey: **M**6.9, Varto, 1966; **M**7.2, Adapazarı, 1967; **M**6.5, Bartın, 1968; **M**7.2, Gediz, 1970; **M**6.7, Bingöl, 1971. Site reconnaissance reports following these earthquakes were now prepared with earthquake engineering criteria and papers in peer-reviewed journals were published in increasing numbers with contributions from national experts. During this period formal education and training in earthquake engineering began to be offered in several universities

including Middle East Technical, Istanbul Technical and Boğaziçi. The cooperation with Japan that had started in 1962 with two students being dispatched to the International Institute of Seismology and Earthquake Engineering (IISEE) in Japan continued, and helped in creating a strong cadre of professionals in government positions with backgrounds in hazard mitigation.

Turkish Standards Institute was established in 1960 primarily for the purpose of preparing material, services and production standards for industry. The Institute expanded its responsibilities to preparing design standards for the construction industry from the late 1960s so that the arbitrary use of foreign procedural codes would be ended. The first reinforced concrete design code, an allowable stress document, was published in 1969. It was then appreciated that even when stress combinations were made for gravity and lateral forces, a rational balance needed to be struck between them to enable a fair assessment of how safe a given design was. The 1975 version of the code permitted a 1/3-increase in allowable stresses but the basic conflict between the seismic provisions and articles governing design and proportioning was not eliminated until the 1998 version of the code (Aydınoğlu, 2007).

With the National Committee Turkey gained a natural contact point in its international activities. Through the good offices of the Committee, Turkey was an active participant in three successive regional projects: UNDP/UNESCO Survey of the Seismicity of the Balkan Region (1970-1974), UNDP/UNDRO Project for Earthquake Risk Reduction in the Balkan Region (1979-1983) and UNDP/UNIDO Project for Building Construction under Seismic Conditions in the Balkan Region (1980-1985). The last two were merged into an ongoing UNESCO program entitled “Permanent Coordinating Committee for Seismic Risk Reduction in the Balkan Region” that continued its work until conflicts in the former Yugoslavia ended it. The Committee, supported with sufficient budget by the Ministry, served as hosts for two important events during this period: the Fifth European Conference on Earthquake Engineering in 1975, and the Seventh World Conference on Earthquake Engineering 1980 were both held in Istanbul. Four European Regional Seminars on Earthquake Engineering were organized in 1976, 1979, 1982 and 1987, respectively. The Committee has also served six times as the umbrella organization for the quadrennial National Conference on Earthquake Engineering, the last of which was in 2007. Through these activities, the National Committee facilitated the professional development for many hundreds of young engineers, architects and earth scientists in earthquake engineering and related fields. Professor Yarar was once more in the lead when the Turkish Earthquake Foundation was set up in 1983. Financially better appointed than the National Committee, the Foundation took on the duty of raising public awareness for earthquake mitigation through publications, films, reconnaissance and technical reports, providing grants to deserving graduate students in earthquake sciences.

We end this account with a simple alphabetical listing of academic and governmental entities that have an earthquake engineering or engineering seismology component in their current activities or responsibilities in Turkey.

►Ankara University
►Atatürk University, Earthquake Research Center (Erzurum)
►Boğazici University, Kandilli Observatory and Earthquake Research Institute (Istanbul)
►Dokuz Eylül University (Izmir)
►Gazi University, Earthquake Research Center (Ankara)
►General Directorate of Disasters Affairs (Ankara)
►General Directorate of Electrical Power Resources Survey and Development Administration (Ankara)
►General Directorate of Mineral Research and Exploration (Ankara)
►General Directorate of State Hydraulic Works (Ankara)
►Hacettepe University, Geological Engineering Department (Ankara)
►Istanbul Technical University
►Istanbul University
►Karadeniz Technical University (Trabzon)
►Middle East Technical University (Ankara)

►Osmangazi University, Earthquake Research Center (Eskişehir)
►Süleyman Demirel University (Isparta)
►The Scientific and Technological Research Council of Turkey (Ankara/Gebze)
►Turkish Atomic Energy Agency (Ankara)
►Yıldız Technical University (Istanbul)

There are also many other academic entities, consulting engineering firms, software development companies, NGOs, public-private partnerships that are active in many of the peripheral areas of earthquake engineering. It is impossible to do justice to all of them by including them in the list above. We will refrain from providing any numerical data on the number of articles that have been published in international peer-reviewed journal by the research community in earthquake engineering and affiliated sciences in Turkey where again the possibility for error would be large.

## 5. SUMMARY

The current state of earthquake science in Turkey owes much to the pioneering men and women whose work we have outlined in this paper. An historic account of only eight pages is likely to omit facts, persons or developments when it draws from its many sources. We hope that no great injustice has been done to anyone by this text. That earthquakes continue to exact severe punishment from the existing building stock and infrastructure in the country has causes that are linked with other factors than strictly engineering or science; this fact has its root causes with basic deficiencies in code enforcement and quality control (Gülkan, 2000). The country is now part of the European Research Area (ERA), so international collaborative programs and support from the EU are also current drivers of research and development.

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## ACKNOWLEDGMENT

We thank the Yarar family for Figure 3.