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SEISMIC RISK ASSESSMENT FRAMEWORK, REGULATORY EVOLUTION, AND REGIONAL SEISMICITY OF SAMSUN, TÜRKIYE

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Abstract. This paper discusses the legal framework, rapid assessment methodologies, and regional seismicity concerning existing reinforced concrete (RC) buildings under earthquake risk, with a specific focus on Samsun Province. Given Türkiye's high seismicity, identifying vulnerable structures prior to a catastrophic event is a matter of public safety. This study highlights the necessity of first-level seismic risk assessment methods and argues for the prioritization of public buildings. Furthermore, the geological and seismotectonic characteristics of Samsun and its districts are analyzed alongside historical earthquake data to contextualize the regional risk.
Keywords: Seismic Risk Assessment, Reinforced Concrete Buildings, Rapid Visual Screening, Public Buildings, Samsun Seismicity, North Anatolian Fault Zone (NAFZ), Türkiye Earthquake Building Code (TBDY-2018)

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1.Introduction. Located on active seismic zones, Türkiye relies heavily on laws and enforcement regulations during the structural design and planning phases. These legal frameworks play a paramount role in establishing the fundamental principles for transforming buildings in high-risk areas following their seismic evaluation. Minimizing the impact of ground motions—the timing and magnitude of which remain unpredictable—on structures depends strictly on the design parameters and structural requirements defined by these regulations. Furthermore, constructing cities to specific standards by keeping abreast of advancements in earthquake engineering and innovations in building technology is only possible through seismic codes; these codes comprehensively delineate the structural models used in structural system analysis and design, as well as analysis methods based on seismic performance [2,4].

The inaugural earthquake regulation in Türkiye was drafted following the aftermath of the 1939 Erzincan earthquake and entered into force in 1940, utilizing the Italian seismic code of that era as its basis. Since no study regarding the seismic hazard mapping of Türkiye had been conducted until that date, seismic calculations were performed uniformly across all regions, irrespective of the building's actual location. Following the preparation of the earthquake zones map for Türkiye in 1942, seismic regulations published from 1947 onward conditioned structural calculations upon the seismicity of the specific region where the building is located. The seismic code, which was substantially revised in 2007 for the purpose of evaluating and retrofitting existing buildings, underwent its final revision in 2018 and entered into force in 2019.

With the 2018 revision executed in the Earthquake Regulation, the seismic hazard and its correlation with soil parameters—which had previously been addressed superficially—were rendered more realistic through the introduction of the seismic hazard map concept.

Table 1. Historical Overview of Earthquake Regulations

Regulation Title	*Effective Date*
Italian Construction Code for Structures to be Built in Earthquake Zones	1940
Provisional Construction Code for Earthquake Zones	1944
Building Regulation for Earthquake Zones in Türkiye	1949
Regulation on Structures to be Built in Earthquake Zones	1953
Regulation on Structures to be Built in Disaster Areas	1962
Regulation on Structures to be Built in Disaster Areas	1968
Regulation on Structures to be Built in Disaster Areas	1975
Regulation on Structures to be Built in Disaster Areas	1998
Regulation on Buildings to be Built in Earthquake Zones	2007
Türkiye Building Earthquake Regulation	2019

2. First-Level Seismic Risk Assessment Framework and Regional Seismicity of Samsun

2.1. First-Level Seismic Risk Assessment Approach. Considering that a vast majority of the building stock in Türkiye, which approaches nearly 20 million structures, was constructed prior to the Earthquake Regulation that entered into force in 1998, was updated in 2018, and took effect in 2019, it is imperative to rapidly inspect the existing building stock and practically rank these buildings in terms of risk severity to mitigate potential loss of life and property in anticipated earthquakes. Conducting detailed, individual structural analyses for a building stock consisting of millions of structures is both highly time-consuming and cost-prohibitive. For this reason, Tiered Assessment Methods, which yield results more rapidly and require less data, should be utilized in the seismic evaluation of the building stock. The Tiered Assessment Method is a methodology that progressively evaluates structures, moving from a preliminary observational inspection toward a more detailed and comprehensive seismic analysis. The initial step of this methodology is the First-Level Assessment Method (FLA) [1,3].

While developing FLA method, the objective is not to reach a definitive conclusion regarding the seismic safety of the inspected buildings, but rather to provide a preliminary insight for subsequent decisions such as retrofitting, strengthening, or demolition. Furthermore, in cases where a high volume of buildings must be inspected, a practical screening and prioritization for seismic evaluation can be established owing to these FLA method. Through this approach, it is possible to identify the buildings that require detailed inspection and to foresee the order of priority in which these identified risky structures should be subjected to comprehensive analysis. With the FLA method, also referred to as the First-Level Assessment Method (Street Screening Method), the seismic risk assessments of buildings can be rapidly completed using formulations constructed with various parameter values, either without entering the building or by incorporating a partial interior inspection. Consequently, structures requiring "immediate intervention" in terms of seismic safety can be identified within a short period.

Following the First-Level Assessment Method, the inspected buildings are ranked based on their risk scores for the Second-Level Assessment, which incorporates as-built architectural surveys (measured drawings) and structural system parameters [5,6]. Consequently, prior to the Third-Level Assessment—wherein detailed seismic evaluations are performed—the existing building stock is thoroughly screened by prioritizing minimum cost and time efficiency [7].

In the earthquakes that Türkiye has experienced, public structures have suffered severe damage and rendered unusable just like other buildings, despite being designed with high importance factors. Public structures such as hospitals, police stations, and dormitories utilized for health, education, administration, and security purposes are high-occupancy buildings that must remain resilient and operational in the aftermath of a potential earthquake; thus, they require seismic evaluation as a matter of priority.

The formulation of the first-level assessment method was established on a legal framework through the Principles Regarding the Identification of Risky Structures, which is embedded within the Implementing Regulation of the Law on the Transformation of Areas Under Disaster Risk that entered into force in 2013. Containing distinct parameters and inspection criteria for reinforced concrete and masonry structures, this method is utilized exclusively to determine the seismic risk prioritization of buildings and to generate regional seismic risk distribution maps. These data can also be utilized to identify priority areas within urban transformation planning.

2.2. Regional Seismic Characteristics of Samsun. With a surface area of 9,083 km^2, the province of Samsun is situated between the deltas where the Yeşilırmak and Kızılırmak rivers discharge into the Black Sea. Geographically, it is located between latitudes 40° 50’ and 41° 51’ N, and longitudes 34° 25’ and 37° 08’ E. The province of Samsun is divided into 17 districts, namely 19 Mayıs, Alaçam, Asarcık, Atakum, Ayvacık, Bafra, Canik, Çarşamba, Havza, İlkadım, Kavak, Lâdik, Salıpazarı, Tekkeköy, Terme, Vezirköprü, and Yakakent.

Fig.1. Samsun Province and Its Districts

In terms of landforms, the province of Samsun exhibits three distinct topographical features: the mountainous region in the south, the plateaus situated between this mountainous terrain and the coastline, and the coastal plains stretching between these plateaus and the Black Sea. The Bafra and Çarşamba plains are located along the coast, formed within the delta areas of the Kızılırmak and Yeşilırmak rivers. The Black Sea coastal areas of the province comprise lowlands, whereas the inland areas extending southward are covered by mountain ranges of moderate altitude. The region lies between the Black Sea coast and the high mountains running parallel to the coastline further inland. In the Ünye-Çarşamba sector, these mountains consist of the Canik and Çangal ranges, which follow an east-west orientation, while trending east-south and west-northwest in the Samsun-Bafra sector.

Fig.2. Map of Samsun Province

According to 1:100,000 scale studies conducted by the General Directorate of Mineral Research and Exploration (MTA), the following geological units have been observed in Samsun: Within the province of Samsun and its districts, the Kapanboğazı Formation (Kk), Yemişliçay Formation (Ky), Cankurtaran Formation (Kc), Akveren Formation (Kta), Atbaşı Formation (Ta), Kusuri Formation (Tk), Tekkeköy Formation (Tt), Sarıyurt Formation (Ts), Mahmurdağı Volcanites (Tmv), Samsun Formation (Ts), İlyas Member (Tsi), Karasamsun Member (Tsk), Palaeo-alluvium (Qe), Modern Floodplain Deposits (Qt), and Alluvium (Qal-Qa) are present (Yılmaz, 2012) [10].

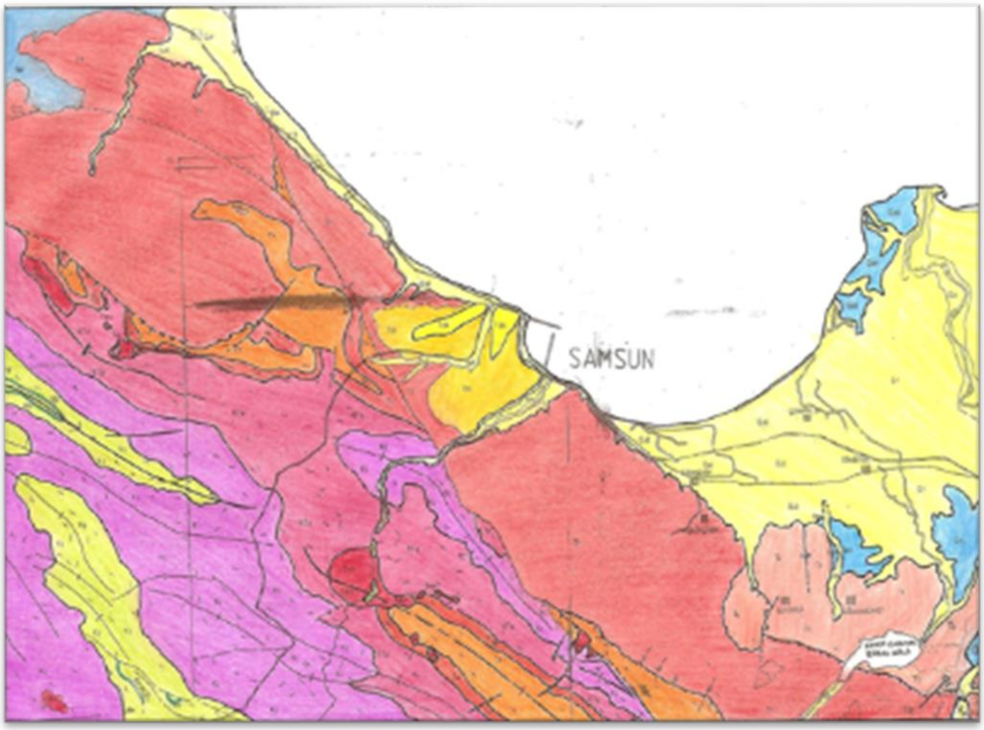

Fig.3. Geological structure of Samsun province (MTA)

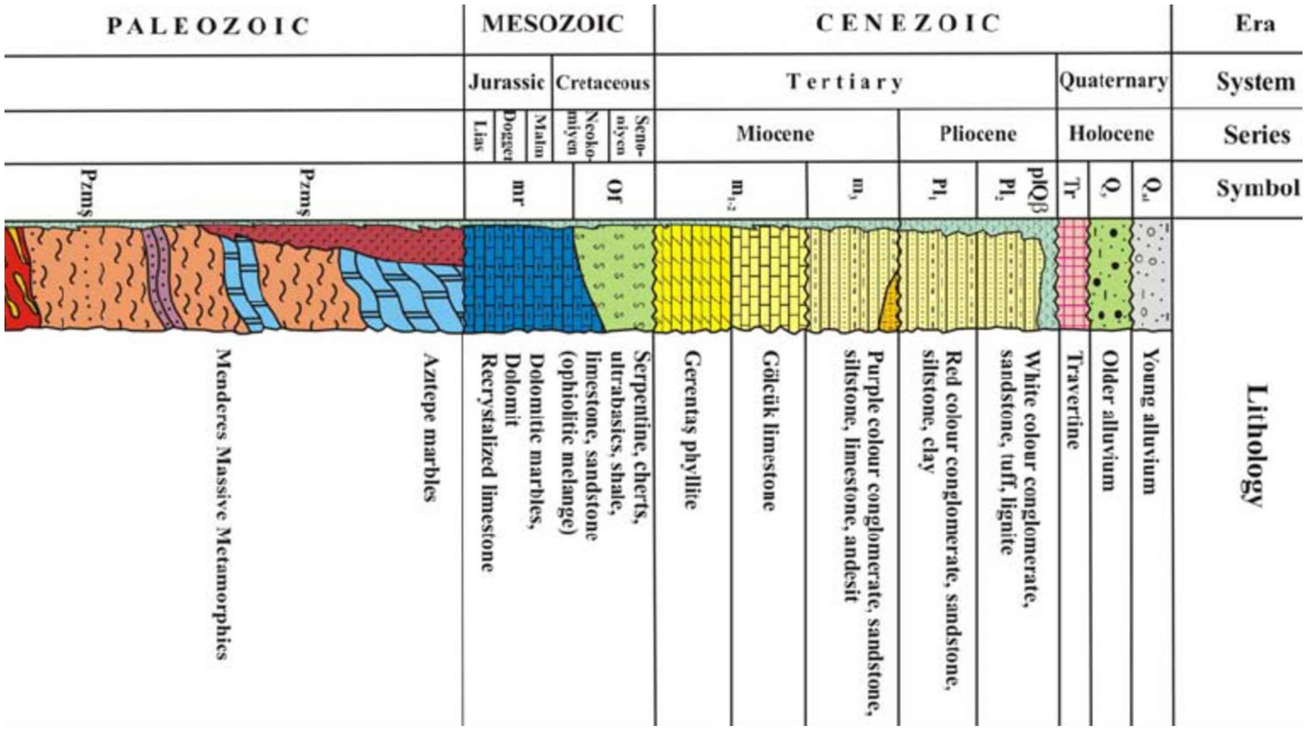

Fig.4. Stratigraphic columnar section template (MTA)

The geological framework for the city center of Samsun can be summarized as follows: alluvial extensions are prominent along the coastline, particularly on the Atakum beach and around Tekkeköy, whereas the center comprises gray-blue marine marl, gypsum, and clay interlayers within the Samsun Formation. The geological formations for the Samsun city center and all its districts have been detailed in Appendix 1.

Local soil conditions directly influence the characteristics of seismic motions and induce damage to structures built upon them. The earthquake zones of the Samsun city center and its districts are listed below.

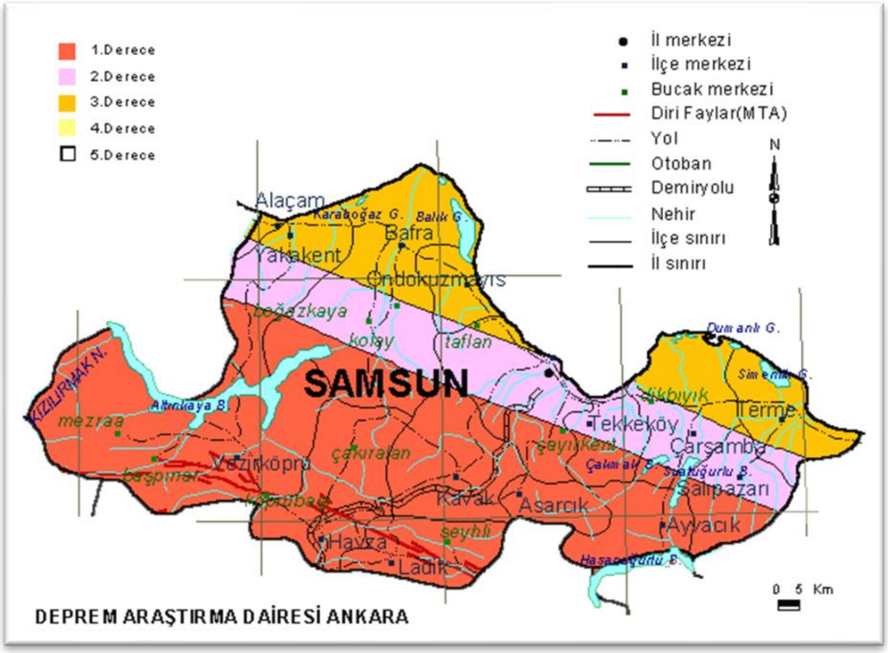

Fig.5. Earthquake map of Samsun province (2019)

According to the former Turkish Earthquake Zones Map, which was used before the implementation of the 2018 Türkiye Building Earthquake Regulation (TBDY-2018), the districts of Ayvacık, Asarcık, Kavak, Ladik, Havza, and Vezirköprü were classified as first-degree earthquake zones. The North Anatolian Fault (NAF) extends northwestward, passing through the northern margin of Lake Ladik and across the villages of Tatlıcak, Hasırcılar, and Aslantaş. This line passes 2.5 km north of the Akpınar Dam and immediately north of the dikes of Lake Ladik. On this right-lateral strike-slip fault, the foci of past and potential future earthquakes are shallow-seated. Consequently, the destructive impact of earthquakes in this region is substantially high. Due to tectonism, fractured formation structures are observed across the region. In addition to the North Anatolian Fault, the Erikli Reverse Fault, and the Ekinveren Fault, the thrust faults, reverse faults, vertical faults, and normal faults located in and around the province of Samsun are categorized and detailed below.

According to the former Turkish Earthquake Zones Map, the central districts of Samsun and the southern parts of Çarşamba were classified as second-degree earthquake zones, whereas the northern part of Çarşamba and the districts of Terme, Ondokuzmayıs, Bafra, Alaçam, and Yakakent were classified as third-degree earthquake zones. However, due to their specific soil characteristics, it is anticipated that the northern part of Çarşamba and the districts of Ondokuzmayıs, Bafra, and Terme will be more severely affected by an earthquake occurring along the North Anatolian Fault line compared to other regions.

A highly destructive earthquake with a magnitude of M_w=7.2 occurred along the North Anatolian Fault line between Ladik and Tosya on November 26, 1943. Centered in the Ladik district, this earthquake was effective across an area 300 km long and 20 km wide, extending from Erbaa in the west to Ilgaz in the east, and was strongly felt in neighboring towns and villages. In this earthquake, which caused catastrophic losses, 75% of the buildings collapsed, and extensive damage occurred along highways and railway lines. Post-earthquake fires further compounded the loss of life and property. Approximately 2,300 citizens lost their lives, and 5,000 individuals were injured. The earthquake generated a 265 km long surface rupture; these fractures developed with a right-lateral strike-slip character, accompanied by a relative down-drop of the northern block (Özdoğan, 1993).

3. Conclusion. This study demonstrates that effective seismic risk mitigation in Samsun requires the integration of regulatory frameworks, rapid assessment methodologies, and regional seismotectonic evaluations. First-Level Seismic Risk Assessment methods provide a practical and cost-effective approach for prioritizing vulnerable reinforced concrete buildings, particularly critical public facilities requiring post-earthquake functionality. The seismic characteristics of Samsun indicate significant hazard variability, with fault-controlled strong ground motions in southern districts and soil-amplification effects in coastal alluvial regions. Therefore, combining rapid structural screening with site-specific seismic hazard assessments and modern earthquake-resistant design principles is essential for improving urban resilience and reducing future earthquake losses [8,9].

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Data Availability. The data supporting the findings of this study are available from the corresponding author upon reasonable request.

Declarations

Conflict of Interest. The authors declare that they have no competing interests or conflicts of interest related to this work.

Ethical Approval. This article does not involve studies with human participants or animals. Therefore, ethical approval was not required.

Informed Consent. Not applicable.

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