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Conservation of Armenian Historical Heritage in East Azerbaijan using the Italian Conservation Guidelines; Case Study: St. Sarkis Church in Tabriz*

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ABSTRACT

The architecture of Armenian churches holds a significant place in the history of Iranian architecture, particularly in northwest Iran, due to their age and cultural importance. One notable example is the St. Sarkis Church in Tabriz, which dates back to 1821 AD and represents the existence of various cultures and religions in the region. Unfortunately, this church has been neglected, and there has been limited research on it. The present study aims to investigate the architecture and typology of the St. Sarkis Church to assess its seismic behavior. It is mixed-method (qualitative-quantitative) research, in which the data are collected through library and field studies. In the qualitative section, the church is assessed according to the Italian conservation guidelines at the project site. In the quantitative section, its seismic behavior is examined using 3Muri software. The results demonstrate a seismic safety index of less than 1 for the building in both quantitative and qualitative assessments, indicating that the structure doesn't provide sufficient safety when facing significant seismic events. Sensitivity analysis further confirms these results. A comparison of the qualitative and quantitative assessment approaches reveals that the qualitative method is more conservative, while the quantitative method shows a higher accuracy. The findings advocate for a hybrid(qualitative-quantitative) assessment approach as an effective tool for reaching a more comprehensive understanding of the seismic performance of historical buildings and identifying their seismic vulnerabilities. It is crucial for designing appropriate conservation strategies. Given the location of St. Sarkis Church in Tabriz, a seismic-prone area, and its cultural significance, the results underscore the importance of conserving and strengthening this building as a vital part of the region's historical identity.

Keywords: Conservation of Historical Monuments, Churches of East Azerbaijan, St. Sarkis Church, Italian Conservation Guidelines, Seismic Vulnerability.

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1. INTRODUCTION

Armenian churches in Iran, especially in the northwest region, are vivid examples of cultural, social, and religious interactions that reflect the area's rich history and cultural diversity. These historical Armenian churches embody Armenian culture and architecture, spanning from ancient times to the present, and they illustrate the ethnic coexistence and interactions in the history of Iran. East Azerbaijan Province, recognized as one of the regions with various historical and cultural heritage, is renowned for its cultural richness, particularly during different historical periods. This province is situated in a seismic-prone area of the world (Standard No.2800 2014), making it necessary to protect and conserve historical monuments and assess their seismic vulnerability through structural and seismic analyses to prevent potential destruction. The seismic performance assessment of historical monuments is critical for the conservation and safety of architectural heritage. It aids in developing appropriate conservation strategies. Understanding the structural behavior of these buildings is a crucial first step in this direction, and analyzing the collapse mechanisms of buildings during earthquakes can provide valuable insights that help experts ensure the safety of these valuable monuments by enhancing their resistance (Mariab and Borri 2009). In this context, the Italian guidelines DPCM: Evaluation and mitigation of seismic risk of cultural heritage with reference to the technical standards for constructions (PCM 2011), serve as a useful reference for the conservation of cultural and historical heritage. These guidelines help identify structural weaknesses, assess vulnerability, and propose aseismic strategies (Torelli 2020). These guidelines were chosen since, unlike many international codes, such as FEMA, Eurocode 8, ASCE41, and the Iranian Instruction for Seismic Rehabilitation of Existing Buildings, they were originally developed with a focus on historic buildings and traditional materials, such as stone and brick. Developed after experiencing devastating earthquakes in Italy, they aim to protect cultural-historical heritage, especially buildings. So, they draw on practical experience in this field. Other guidelines may have been developed for modern buildings or offered only a general framework and recommendations, lacking specific guidelines for architectural heritage. Although the ICOMOS international charters (such as the Venice Charter and the LIMA Declaration) have outlined general principles of conservation, and documents, like ISCARSAH, NZSEE, and FEMA guidelines, have made significant strides in introducing seismic assessment methods, they propose no specific practical approaches tailored to historical monuments made of masonry materials. Conversely, the Italian guidelines directly cover both qualitative and quantitative assessment methods, material considerations, and the requirements for minimal intervention, making them more practical. They introduce vulnerability assessment methods for various historical monuments, including villas, residential buildings, churches, and towers.

Additionally, the present research focuses on historical churches that hold a special place in the architectural traditions of Iran, especially those of the Armenian community. Armenian churches, characterized by both linear and centralized domed plans, have greatly influenced Byzantine and Western European church architecture. Many early examples of European domed churches can trace their origin back to this architectural tradition. Armenian churches and those in northwest Iran are notably featured by a coherent and unified structure, attention to proportions, and the conical dome resting on polygonal drums (Simoni and Hojjat 2020). Moreover, the typology of Italian churches spans a range from simple to complex plans, revealing significant similarities with Iranian-Armenian churches in terms of materials (stone, brick, or combinations of these) and geometry (Cescatti et al. 2021). This historical and architectural overlap illustrates the superior effectiveness of the Italian seismic code compared to other seismic codes. This provides a scientific and practical basis for the conservation and seismic assessment of cultural heritage, especially the Armenian churches of northwestern Iran. To confirm and validate the results from qualitative assessments based on Italian guidelines, a quantitative assessment was carried out using 3Muri software, which aligns with the Italian code, and a nonlinear pushover analysis was used to investigate the in-plane behavior of buildings subjected to various seismic levels.

Given the limited research on the structural and seismic evaluations of Armenian churches in Iran, this study seeks to bridge this scientific gap. Historical data demonstrate that East Azerbaijan Province once had forty-nine churches, of which only fourteen remain, some in deteriorating conditions. Currently, just four churches are actively utilized as religious spaces, and Armenian Gregorian churches are more prevalent than those of other denominations. Research highlights that St. Sarkis Church, an Armenian church belonging to the Gregorian order, has a rich history dating back to 1821 AD (Karang 1972) and is among the most important and oldest Armenian churches in Tabriz. It possesses a high potential for seismic vulnerability assessment, which can help provide conservation strategies. As an active religious venue, this church requires conservation measures to preserve its cultural and historical values. Therefore, in addition to examining the architectural features and history of this church, the present research will qualitatively and quantitatively assess and analyze its seismic behavior in accordance with the Italian guidelines, using authentic software.

2. RESEARCH BACKGROUND

Numerous studies have addressed the conservation of historical monuments and cultural relics, as well as their seismic vulnerability, both in Iran and worldwide. For the first time in Iran, Hejazi and Mirghaderi (1987) have conducted extensive studies on the important historical monuments in this country. They have identified the structural systems of these buildings and evaluated their safety regarding gravity loads and seismic activity. Finally, based on their findings, they have provided some suggestions for the conservation and preservation of these monuments. Azizi and Sadeghi (2015) have investigated the seismic vulnerability of St. Stepanos Church in Jolfa, East Azerbaijan, using a finite element model. They have utilized ANSYS software to model the church, analyzing it under linear static loads and conducting modal analyses to identify its structural weaknesses. Next, they have assessed the seismic vulnerability of the structure under several strong earthquakes. Their finite element analyses under horizontal seismic loading demonstrated that sensitive points included the main dome and the entrance arch of the church (Azizi and Sadeghi 2015).

Casarin and Modena (2008) have assessed the seismic vulnerability of the Reggio Emilia Cathedral in Italy. In addition to the seismic investigation of this historical building, they have sought to compare the results of different modeling methods (limit analysis and numerical approaches). The analyses involved examining the construction date and structural evolution, evaluating damage caused by historical earthquakes, studying existing crack patterns, and conducting extensive field studies. Finally, the structural parts of the cathedral were analyzed using both experimental and numerical methods, including kinematic limit analysis and finite element analysis, via DIANA software (Casarin and Modena 2008).

Fazzi et al. (2021) have proposed a comprehensive method for assessing the seismic vulnerability of a specific type of historic churches in central Italy. This mid-scale study aimed to bridge the gap between macro-level and single-building assessments. The proposed method takes into account historical, environmental, geometrical, technological, and mechanical issues. This study has investigated a set of basilica churches damaged by the 2009 L'Aquila earthquake to uncover the seismic weaknesses of these types of structures. The vulnerability of key elements, such as the altar and façade, was analyzed, with a focus on the kinematic mechanisms and the quality of connections among the components. Different assessment tools, including geometric indices, masonry quality, qualitative vulnerability analysis, and linear kinematic analysis, were used to identify the weaknesses in this type of church. Additionally, this study has examined the general trends related to the typology of churches in the region, exploring changes in construction technology, masonry quality, and overall vulnerability, based on building scale and historical significance (Fazzi et al. 2021).

This review reveals that there has been limited research on St. Sarkis Church and its seismic vulnerability in Iran. Most studies have investigated it in general terms rather than addressing the specific details of this building. Therefore, it is necessary to conduct a comprehensive study on the structural condition of this church and its seismic behavior.

3. METHOD

The present study is mixed-method (qualitative-quantitative) research. It aimed to investigate the seismic behavior of St. Sarkis Church. In the qualitative phase, the church was examined according to the Italian guidelines, which provide a framework for qualitatively studying historical monuments with various geometric characteristics. To gather qualitative data, historical documents, maps, and old photographs of the church were reviewed to understand the history, structure, and previous earthquake-induced damage. Moreover, a field study was performed to investigate the status quo of the church, focusing on structural damage, cracks, signs of deterioration, and the surrounding area. Photographs and videos were captured from various angles to ensure thorough documentation.

In the quantitative phase, the collected data were used to model and simulate the behavior of the church during an earthquake. This was achieved using the 3Muri software, which facilitates static and nonlinear pushover analyses of historical structures. This phase enabled us to validate the qualitative assessment, predict the church's vulnerability, and determine its risk level under different conditions. Finally, the results from qualitative and quantitative assessments were compared to identify the strengths and weaknesses of each approach. Overall, this hybrid approach has proven to be an effective tool for decision-making in the conservation and strengthening of similar historical monuments.

3.1. Qualitative Assessment Approach

This study has utilized the method described in the DPCM guidelines for qualitative assessment. These guidelines, developed since 2005 and aligned with Italian technical standards, aim to mitigate seismic risks and protect historical monuments. The primary objectives of these guidelines are to establish methods for identifying buildings, assessing their seismic safety, and proposing aseismic interventions, all while considering their historical significance. These guidelines provide a specific method for qualitatively assessing structures featuring a large hall without an intermediate diaphragm, facilitating the assessment of buildings with varying geometries. This method involves breaking down structures, such as churches, into macro-elements, such as facades, naves, altars, campaniles, and more. It is based on a systematic analysis of structural damage to churches during significant earthquakes in Italy, starting with the 1976 Friuli earthquake. The qualitative method is the simplest approach for assessing the seismic performance of a structure, making it particularly suitable for evaluations on a territorial scale. This method relies solely on visual inspections and requires the definition of an overall vulnerability index, i_v, which is calculated as a score based on 28 possible damage mechanisms using the following equation (Akhoundi and Kheyrollahi 2023):

Equation 1: Overall Vulnerability Index of Churches

$$i_v = \frac{1}{6}\frac{\sum_{K=1}^{28} \rho_k (V_{ki} - V_{kp})}{\sum_{K=1}^{28} \rho_k} + \frac{1}{2}$$

where iv may vary between 0 and 1, and for the other parameters, the following values may be considered:

ρk is the mechanism score, which varies from 0.5 to 1.

vki and vkp, for the generic kth mechanism, denote the vulnerability and anti-seismic measures, respectively.

Equations 2 and 3 define the accelerations corresponding to the damage limit state (upper) and the ultimate limit state (lower), respectively

$$a_{SLD} = 0.025 \cdot 1.8^{2.75 - 3.44 i_v}$$

$$a_{SLU} = 0.025 \cdot 1.8^{5.1 - 3.44 i_v}$$

Equation 4 is the seismic safety index, where γI is the importance factor of the building, S is the index related to soil type and seismic risk, and ag is the design ground acceleration. In this equation, if I_s >1, the building is resistant to seismic events; otherwise, the building does not have the expected safety.

Equation 4: Seismic Safety Index

$$I_S = \frac{a_{SLU}}{\gamma_1 S\, a_g}$$

3.1.1. Performance Levels

It is possible to predict how a building will behave during a specific earthquake, which helps mitigate damage to structural and non-structural components, as well as minimize injuries and casualties to a certain, predictable extent. The Italian guidelines outline three performance levels, each describing the expected conditions and status of the building immediately after the earthquake, based on anticipated losses and casualties, as well as the extent of structural and non-structural damage.

In the near-collapse state, the structure suffers significant damage and experiences reduced lateral strength and stiffness. While the vertical elements can still support vertical loads, most non-structural elements are destroyed. The likelihood of experiencing such an earthquake is less than 2% over a fifty-year period, which corresponds to a return period of 2475 years. In the significant damage state, the structure is significantly damaged but retains its lateral strength and stiffness to a limited extent. The vertical elements can continue to withstand vertical loads, while non-structural components are compromised. The likelihood of experiencing this group of earthquakes is less than 10% over fifty years, equivalent to a return period of 475 years. In the damage limitation state, the structure experiences minor damage, with structural elements retaining their strength and stiffness. Non-structural components may show scattered cracks. The probability of this group of earthquakes is less than 20% over fifty years, estimated to have a return period of 225 years. A qualitative assessment has been made using empirical correlations. Based on available data, the maximum thickness-to-span ratio of a semi-circular arch should be one to eight to ensure stability (Huerta 2006). Additionally, a width-to-height ratio for walls in historical monuments should be maintained at 1:8 to ensure the safety of these buildings (Arya, Boen, and Ishiyama 2014).

3.2. Quantitative Assessment approach

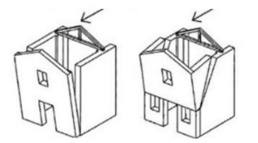
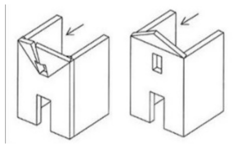
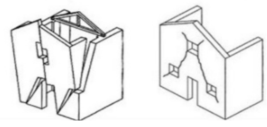
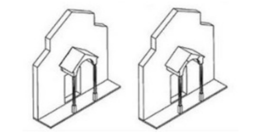
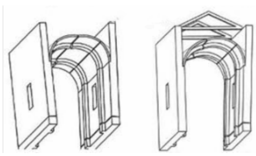
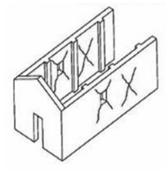
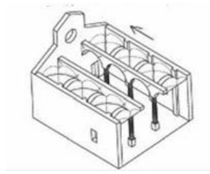
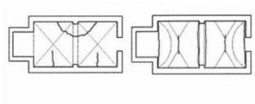
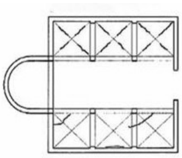
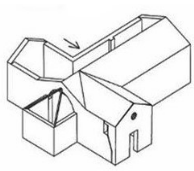
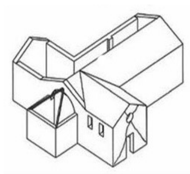
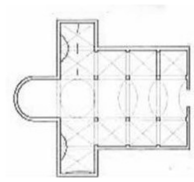
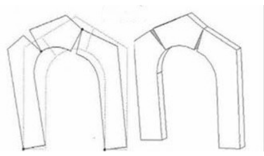
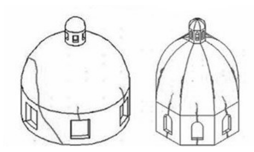
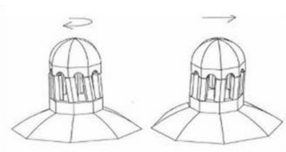
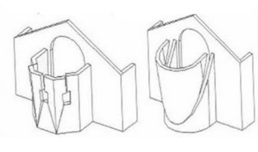
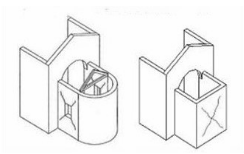
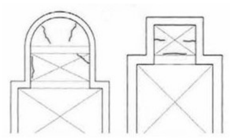
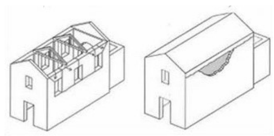
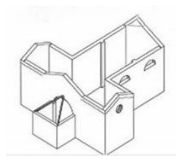
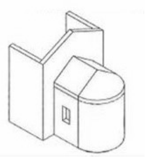
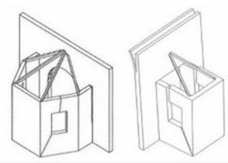
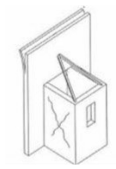
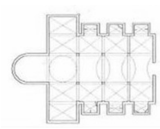
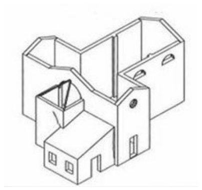
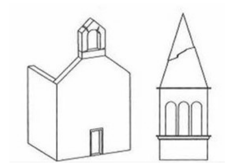
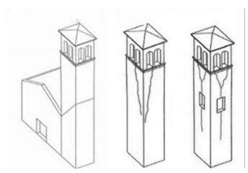
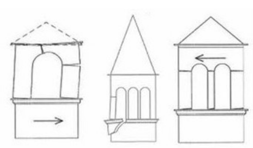
3.2.1. 3Muri Software

3Muri software is a powerful tool designed for the static and nonlinear analyses of masonry buildings. Its standout feature is its capability to deliver more comprehensive and accurate insights into a structure's real behavior against seismic events, all while simplifying practical applications. It can conduct analyses rapidly without encountering convergence issues, making it easier to perform a large number of nonlinear static analyses in a short period. In large-scale structural strengthening projects, applying 3Muri software is particularly effective because of its speed in modeling and analysis. This efficiency allows for the implementation of various seismic strengthening designs promptly, enabling comparison of their impacts to select the optimal design.

3.2.2. Nonlinear Pushover Analysis

Nonlinear Pushover Analysis is a static method used to evaluate the seismic performance of structures. It operates on the premise that the seismic behavior of the structure under study can be simulated as a single-degree-of-freedom system. In this method, inertial forces generated by ground motion are modeled as a lateral load pattern applied to the structure. The analysis process involves applying both gravity and lateral loads in a predetermined manner, continuing until a target displacement is reached. The target displacement is determined based on the desired performance level (Xu 2018). According to Xu (2018), the relationship between the control displacement and the base shear force can be illustrated, resulting in the formation of the Capacity Curve (Noortman 2019).

Table 1. Damage Mechanisms in the Churches

Mechanism			
1- Overturning of the Facade	2- Damage at the Top of the Façade	3- Shear Mechanisms in the Façade	4- Nartex
			
5- Transversal Vibration of the Nave	6- Shear Mechanisms in the Side Walls	7- Longitudinal Response of the Colonnade	8- Vaults of the Nave
			
9- Vaults of the Aisles	10- Overturning of the Transept Façade	11- Shear Mechanisms in the Transept Walls	12- Vaults of the Transept
			
13- Triumphal Arches	14 - Dome, Drum, and Tiburio	15- Lantern	16- Overturning of the Apse
			
17- Shear Mechanisms in the Presbytery and the Apse	18- Vaults in the Presbytery and the Apse	19- Roof Mechanisms: Side Walls of Nave and Aisles	20- Roof Mechanisms: Transept
			
21- Roof Mechanisms: Apse and Presbytery	22 - Overturning of the Chapel	23- Shear Mechanisms in the Chapel Walls	24 -Vaults of the Chapels
			
25- Interactions with Adjacent Buildings	26 - Projections(Gable Belfry, Spires, Pinnacles, Statues)	27 - Bell Tower	28- Belfry
			

(Akhoundi and Kheyrollahi 2023)

4. CASE STUDY: ST. SARKIS CHURCH

The Persian term “Kelisa” is derived from the Greek word “Ecclesia”, which has a broad meaning that encompasses the Hebrew word “Qahhal,” as well as concepts such as invitation, gathering, assembly, and religious festival. In the Old Testament, Ecclesia referred to a holy assembly to which people were invited or, as mentioned in the Bible, gathered for a Jewish festival (Deravansian and Karim Masihi 2017).

St. Sarkis Church was built in 1281 AD with funding from the Petrossian family in the “Baron Avak” neighborhood of Tabriz. This church collapsed a few years later and was rebuilt in 5481 AD. Figure 1 (right) illustrates an old photograph of the northeast façade of the church, which exhibits an Armenian architectural style and features three entrances: one from the north, one from the east, and one from the south. At the eastern entrance, a priest, “Hakob Karapetyan,” was buried. Its structure was constructed using stones, and its domes were made of bricks (Karang 1972). The church has a cruciform plan supported by four high brick columns with stone bases. On these columns, the drum of the church dome is built, topped by a conical dome (Hoviyan 2003). Figure 1 shows the cruciform plan, cross-section, and eastern façade of St. Sarkis Church. The walls are covered with cement, and inside the church, columns separate the altar and secondary prayer rooms from the assembly hall. The altar floor is approximately eighty centimeters higher than the main church floor (Karang 1972). Figure 2 presents contemporary photos of this church.

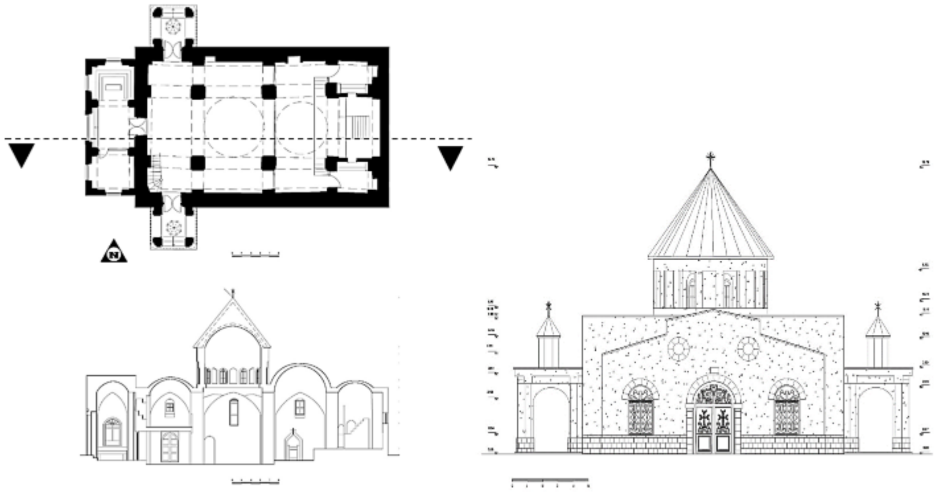


Fig. 1. Right - Eastern Facade of St. Sarkis Church, Left - Plan and Cross-Section of St. Sarkis Church (Cultural Heritage Organization of East Azerbaijan Province)

Fig. 2. Right – Eastern Façade of St. Sarkis Church, by Hamo Vartanian (Karang 1972); Left - Contemporary Photos of St. Sarkis Church

5. FINDINGS

5.1. Qualitative Assessment of St. Sarkis Church

As outlined in the Italian guidelines, various macroelements in different churches can trigger the activation of the related mechanism, without the necessity of cracks or visible damage. For example, the mere presence of an altar can activate the associated shear mechanism, even if no shear cracks are observed in this element (Akhoundi and Kheyrollahi 2023). In the qualitative assessment of the studied church, the section on aseismic measures from the Italian guidelines was referenced to identify factors that enhance the strength of the structure during an earthquake. These factors included measures such as wall sheathing and the installation of supports, both during and after the construction phase. Additionally, the guidelines discuss vulnerability indicators, examining factors that weaken the structure against earthquakes, such as the presence of thrusting vaults and heavy roof covering. According to the empirical equations presented in Section 3.1.1, the vaults of the central nave were deemed unstable, with the obtained ratio of 1:22. Conversely, the vaults of the aisles (as shown in Figure 3, left image), apse, and transept were found to be stable with ratios of 1:10, 1:15, and 1:13, respectively. The width-to-height ratio of the walls was also estimated to be 1:5. Table 1 lists the general mechanisms found in churches, as specified in the Italian guidelines. Table 2 provides a qualitative assessment of St.Sarkis Church, detailing active mechanisms, vulnerability indicators, and the measures taken to enhance seismic strength. The impact of the items listed in Table 2 on the structure varies and is assessed qualitatively. Table 3 illustrates how different mechanisms at the St. Sarkis Church are scored. It reflects the inspector's analysis of the impact of aseismic measures (V_{kp}) and their evaluation of vulnerability indicators (V_{ki}). These analyses are based on the inspector's opinions, and as a result, the qualitative assessment results can differ with varying perspectives. To account for this variability, a sensitivity analysis was also carried out to explore the range of results obtained from different inspector perspectives.

Table 2. Qualitative Assessment of St. Sarkis Church: Active Mechanisms

Active Mechanisms	Aseismic Measures	Vulnerability Indicators
Overturning of the façade	Good quality clamping between the façade and side walls of the nave	Presence of thrusting elements (vaults and arches)
Damage at the top of the façade	-	-
Shear mechanisms in the façade	-	-
Nartex	-	Presence of thrusting (vaults and arches)
Transversal vibration of the nave	-	Presence of vaults and arches
Shear mechanisms in the side walls	-	-
Longitudinal Response of the colonnade	-	-
Vaults of the nave	-	Presence of thin vaults
Vaults of the aisles	-	-
Overturning of the transept façade	Good quality side wall to façade clamping	Presence of heavy roof coverings(dome)
Vaults of the transept	-	Presence of concentrated loads from the roof structure
Dome, Drum, and Tiburio	-	Presence of large openings in the drum (illustrated in Fig.3-right)
Overturning of the apse	-	Presence of thrusting vaults
Shear mechanisms in the presbytery and the apse	-	-
Vaults in the presbytery and the apse	-	-

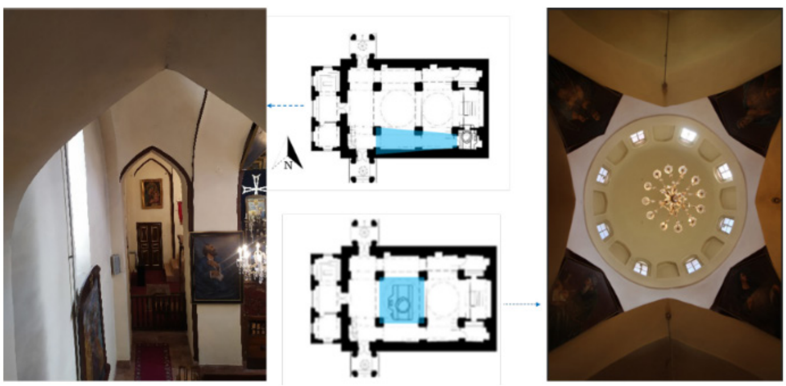


Fig. 3. Right – The Dome of St. Sarkis Church; Left - The Vaults of the Aisles

Table 3. Scoring Table for the Qualitative Assessment of St. Sarkis Church

Mechanisms	Aseismic Measures	Vulnerability Indicators	Weight attributed to the Mechanism (ρ_k)	V_k	V_{ki}
Overturning of the Façade	1	1	1	2	1
Damage at the Top of the Façade	0	0	1	0	0
Shear Mechanisms in the Façade	0	0	1	0	0
Nartex	0	1	0.5	0	1
Transversal Vibration of the Nave	0	1	1	0	2
Shear Mechanisms in the Side Walls	1	0	1	1	0
Longitudinal Response of the Colonnade	0	0	1	0	0
Vaults of the Nave	0	1	1	0	2
Vaults of the Aisles	0	0	1	0	0
Overturning of the Transept Façade	1	0	1	1	0
Shear Mechanisms in the Transept Walls					
Vaults of the Transept	0	1	1	0	2
Triumphal Arches					
Dome, Drum, and Tiburio	0	1	1	0	1
Lantern					
Overturning of the Apse	0	1	1	0	1
Shear Mechanisms in the Presbytery and the Apse	0	0	0.5	0	0
Vaults in the Presbytery and the Apse	0	0	1	0	0
Roof Mechanisms: Side Walls of the Nave and Aisles					
Roof Mechanisms: Transept					
Roof Mechanisms: Apse and Presbytery					
Overturning of the Chapels					
Shear Mechanisms in the Chapel Walls					
Vaults of the Chapels					
Interactions with Adjacent Buildings					
Projections					
Bell Tower					
Belfry					

As mentioned, γi denotes the importance factor. Considering the historical nature of the church under study, this factor is high. The factor S considers the stratification profile of the soil beneath the foundation and any morphological effects and varies based on both soil type and the seismic acceleration of the area (NTC18). The regional acceleration was calculated based on the Seismic Code of Iran (Standard 2800). These parameters are crucial for calculating the seismic safety index, as detailed in Table 4.

Table 4. Effective Parameters in Calculating the Seismic Safety Index of St. Sarkis Church

Soil Type	Location	Regional Acceleration (g)	S	Category of Use	Category of Importance	γ_i
C	Flat Land	0.35	1.17	Very Frequently	Elevated	1.2

5.2. Quantitative Assessment of St. Sarkis Church

5.2.1. Mechanical Characteristics of Materials and Confidence Factor of St. Sarkis Church

In this building, stone materials were used for the construction of walls, while bricks were utilized to construct the domes. The mechanical properties of these materials were determined per the NTC18 code, as listed in Table 5.

Table 5. Mechanical Properties of the Materials used in St. Sarkis Church

Building Materials	f (N/mm2)	τ0 (N/mm2)	fv0 (N/mm2)	E (N/mm2)	G (N/mm2)	w (Kn/m3)
Smoothed Stone	3.2	0.065	-	1740	580	21
Brick and Lime Mortar	3.4	0.09	0.2	1200	500	18

After examining the building in terms of geometry, materials, structure, and foundation, a variable confidence factor was defined within the range of 1 to 1.35, in accordance with Tables 1 to 4 of the Italian guidelines. This factor is used to assess the level of confidence of the model in structural analysis and the seismic safety index (Akhoundi and Kheyrollahi 2023). The geometric assessment of the church included a comprehensive survey of the plan and the location of the openings, although no specific testing was carried out on the materials and the foundation. The typical method for constructing foundations in historical buildings involves the use of stone and sand-lime mortar. The width of the foundation was generally about 10 cm, and in some cases, it extended to 20 cm more than the width of the wall. The confidence factor of the church under study was estimated according to the data listed in Table 6.

Table 6. Confidence Factor of St. Sarkis Church

F_{C1}	F_{C2}	F_{C3}	F_{C4}	Confidence Factor (FC) $F_C=1+(F_{C1}+F_{C2}+F_{C3}+F_{C4})$
0.05	0.12	0.12	0.06	1.35

5.2.2. Modeling and Seismic Assessment of St.Sarkis Church in 3Muri Software

As discussed in the quantitative assessment section, modeling was carried out in 3Muri software using the equivalent frame method. Figure 4 displays the model created for St. Sarkis Church in this software.

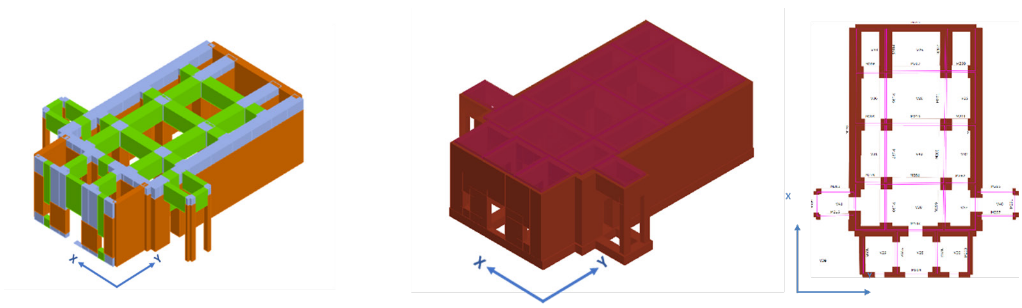


Fig. 4. Modeling (Right), and Meshing (Left) of St. Sarkis Church in 3Muri Software

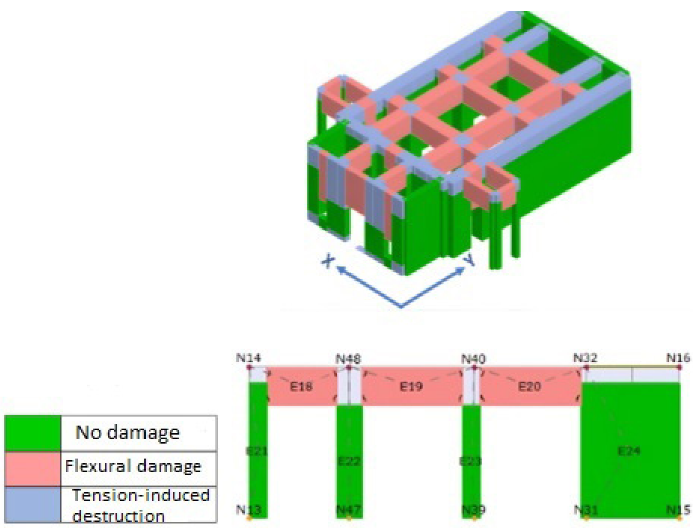


Fig. 5. Damage and Destruction; Pushover Analysis of St. Sarkis Church

Armanshahr Architecture & Urban Development
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As seen in Fig. 5, the side walls of the St. Sarkis Church remained undamaged under the influence of the pushover force in the -x direction. The primary damage to this building was identified as flexural damage occurring at the upper part of the ribs, which were equated with masonry beams.

- Capacity Curve

The capacity curve depicts the relationship between the total base shear and the displacement of a control node. This curve characterizes the structure's capacity in terms of maximum force, deformation, and deformation capacity. Fig. 6 illustrates the capacity curve of St. Sarkis Church, which was derived from the pushover analysis in the 3Muri software.

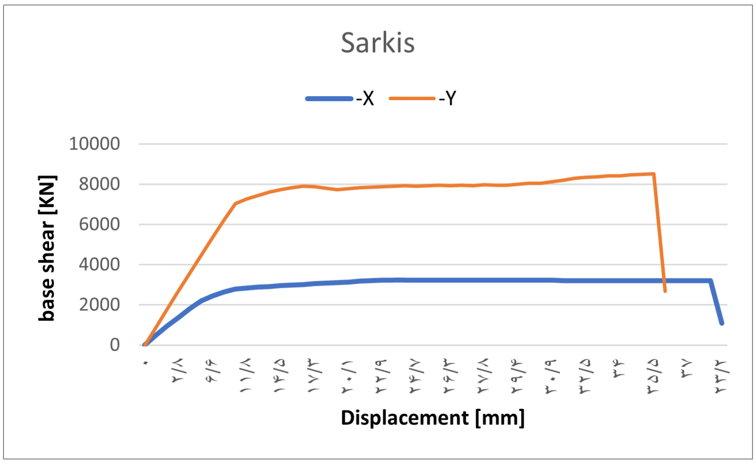

Fig. 6. Capacity Curve of St. Sarkis Church

5.3. Results of Qualitative and Quantitative Assessments

Tables 7 and 8 present the results of qualitative and quantitative assessments based on the calculations made according to Eqs. 1-4, and the modeling and pushover analysis of St.Sarkis Church in the 3Muri software, respectively.

Table 7. Results of the Qualitative Assessment of St. Sarkis Church

St. Sarkis Church	Results
Vulnerability Index	0.56
Acceleration Corresponding to Limit State of Damage ()	0.040 g
Acceleration Corresponding to the Ultimate Limit State ()	0.159 g
Safety Index (Damage Limitation State)	0.20
Sensitivity Analysis of the Safety Index (Damage Limitation State)	$0.22 > I_s > 0.17$
Safety Index (Near-Collapse State)	0.21
Sensitivity Analysis of Safety Index (Near-Collapse State)	$0.23 > I_s > 0.18$

Table 8. Results of the Quantitative Assessment of St. Sarkis Church

Limit State	Safety Index
Near Collapse	0.44
Damage Limitation	0.31

6. DISCUSSION

According to Table 7, the vulnerability index of St. Sarkis Church was calculated to be 0.56. This index does not consider the seismic characteristics of the area and the soil, which are factored into the seismic safety index. The results of the qualitative assessment indicated that the seismic safety index for the church studied was 0.21 in the near-collapse state and 0.20

in the damage limitation states, suggesting that this church is unsafe under the states studied.

The results of the sensitivity analysis showed that the safety index of this church ranges between 0.18 and 0.23 in the near-collapse state, while it varies between 0.17 and 0.22 in the damage limitation state. This process, which reduces the influence of individual judgments, provides more accurate insights into the safety status of the structure and shows that even in optimistic scenarios, the church remains unsafe in the event of an earthquake.

Comparing the results of qualitative and quantitative assessments (Table 9) indicated that the qualitative assessment method yielded a lower safety index than the quantitative assessment method. Specifically, in the qualitative assessment, the safety index for the near-collapse and damage limitation states was 47% and 65% of the indices obtained from the quantitative assessment, respectively. This discrepancy indicates that the qualitative assessment method identifies a higher level of vulnerability for the church, highlighting the importance of considering both approaches together.

Table 9. Comparison of Seismic Safety Index obtained in the Qualitative and Quantitative Assessments

Limit State	Safety Index(Qualitative Assessment)/Safety Index(Quantitative Assessment)
Near Collapse	0.47
Damage Limitation	0.65

These findings emphasize the importance of integrating quantitative and qualitative assessments in the seismic safety analysis of historic monuments. Such an approach not only leads to more accurate results but also serves as a basis for developing effective conservation strategies. In this context, comparison with international examples is crucial. Studies on churches and historical monuments in countries like Italy (Fazzi et al. 2021) and Romania (Onescu et al. 2024) reveal that even vulnerable structures in seismic zones rarely achieve very low seismic safety indices, such as 0.20 or 0.21. Consequently, the seismic safety of St. Sarkis Church becomes even more critical when compared to similar buildings in areas with a long history of earthquakes. Therefore, the results of this study underscore the urgent need for immediate intervention to strengthen and protect this church now more than ever.

7. CONCLUSION

Historical monuments often face challenging seismic conditions due to factors such as the low quality of their materials, susceptibility to landslides, excessive structural weight, damage sustained over time, and inadequate maintenance. Therefore, it is essential to develop appropriate methods for assessing and protecting these structures. The first step in conserving historic buildings is to assess their seismic performance, which plays a crucial role in ensuring their safety and developing effective conservation strategies. The seismic performance of buildings can be assessed qualitatively and quantitatively. In this study, St. Sarkis Church in Tabriz was assessed both qualitatively and quantitatively using the Italian guidelines and the 3Muri software, respectively. This church, dating back to 1821 AD, is one of the oldest Armenian churches in Tabriz and is located in a seismically active area. Thus, assessing its seismic performance is particularly important, given that it serves as an active religious place.

The qualitative and quantitative assessments yielded safety indices of 0.21 and 0.44 for this church in the near-collapse state, and 0.20 and 0.31 in the damage limitation state, respectively. Both assessments showed values below 1, implying that this church lacks adequate safety against earthquakes. Additionally, comparing qualitative and quantitative assessment results demonstrated that the qualitative approach, being more conservative, resulted in lower safety index values and proved to be an effective tool for quickly assessing the safety index before conservation interventions.

Given the risks associated with neglecting seismic safety, it is vital to conserve historical churches such as St. Sarkis in earthquake-prone areas. This preservation not only protects the cultural and historical identities of the region but also ensures the safety of users and visitors. Based on the findings of this study, several practical recommendations are proposed: installing simple sensors, such as LVDT, at the location of cracks to monitor seismic pulses; regularly monitoring the condition of the structure; reinforcing the connections between structural elements using materials compatible with the existing masonry; and using tie-rods in the vaults.

Finally, this study underscores the necessity of raising awareness about the seismic safety of historical monuments, carrying out specialized conservation measures, and paying attention to the living cultural heritage of Armenian churches in Iran to ensure that they remain a vital part of the cultural identity for future generations.

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CONFLICT OF INTEREST

The authors have no conflicts of interest to declare.

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The authors commit to observe all the ethical principles of the publication of the scientific work based on the ethical principles of COPE. In case of any violation of the ethical principles, even after the publication of the article, they give the journal the right to delete the article and follow up on the matter.

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The authors state that they have directly participated in the stages of conducting research and writing the article.

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