

# ARMENIAN MEDIEVAL ARCHITECTURE: EARTHQUAKES AND RESTORATION

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The territory of Armenia is a rugged land on the southern slopes of the Caucasus massif, at the junction of four tectonic plates: the Anatolian and Iranian in one direction, the Eurasian and Arabian plates in the other. Armenian situation has always been characterized by an high seismic risk. Along the course of history its territory and its historical monuments suffered the consequences of a large number of strong earthquakes. In this paper will be analyzed the reasons why, in spite of that difficult situation, most of the medieval religious monuments have been conserved until now in quite good conditions and will be presented two different kinds of work aimed to the safeguard of that heritage to allow the continuity of the transmission of it to future generations (the digital archive of Armenian Architecture and the restoration of Marmashen church).

In the field of the religious architecture Armenians achieved results of very high level just from the first realizations: architectural precedent classical tradition and the position of Armenia, bridge among the East and the West, allowed to create original and precocious synthesis, bringing to elaborate, among the IV<sup>th</sup> and the VII<sup>th</sup> century, almost all the constructive schemes that characterize the ecclesiastical Armenian architecture up to the modern times, advancing solutions often later adopted in Europe's medieval architecture.

Being the earthquakes motion a very complex mechanism, it could not have been fully accounted for in the past, nevertheless it is demonstrated that the evolution of Armenian Architecture form design was in the direction to reduce the seismic vulnerability of the monuments. As well as the spatial solutions, materials and construction techniques, partially derived from the roman ones, are tailored to offer good resistance to earthquakes.

As early as the middle of VII<sup>th</sup> c. where fixed a series of characteristics that together constitute the type of the Armenian church:

- limited and compact volumes;
- squat proportion of height to width of a building in order to keep the center of gravity low;
- thick walls and piers instead of columns;
- triple layered masonry, with tuff stones for the 2 external courses (squared outside and rough-hew inside) and lime mortar between them made hydraulic by the addition of pumice-stone. The lime concrete used to make the structure monolithic and more resistant to earthquake damage (the structure is able to react synergistically to earthquake movement);

- stones of the internal and external course placed on different layers and often also carved in a particular shape (e.g. swallow tile) to prevent horizontal sliding in case of earthquake;
- light material in higher parts and heavy material in lower parts of a wall, and/or sapient use of voids in the interior of the walls to keep the center of gravity low;
- in the great majority of cases lack of correspondence between internal spatial structure (generally vaulted and domed) and the simple external volume;
- one or two axes of symmetry (the double axis is ideal to resist P and S waves seismic motions);
- widespread use of the cupola for the spatial definition of the central part of the edifice, often covered by pyramidal roof;
- multiplication of the supports of the dome (typically squinches) and sometimes reinforcement of domes with ribs (Hripsimé, Mastara, etc.);
- few, small and narrow windows;
- niches that fold the walls at critical locations (i.e. where part of the roof load had to be shared with an interior column or where the length of the wall could render it vulnerable to earthquake cracks).

The above mentioned characteristics and the continuous maintenance work done in the course of history by the Armenians on their monuments, allowed the good conservation of the architectural heritage. In fact the Armenians, strongly attached to their traditions and their monuments, used, since ancient times, to repair and restore their monuments to their original shape.

So we see that Armenian architecture presents an other important characteristic that make it very interesting for the structural studies: thanks to that tradition and to the availability of ample material, it is possible to study the "structural history" of the buildings to understand weaknesses and strengths.

As them were deemed important, notices concerning these restoration works are given in Medieval literature and often also described in inscriptions carved on the churches themselves.

It is not difficult to interrelate the above mentioned notices with the ones kept from the study of the monument itself (i.e. through wall's stratigraphy).

Furthermore, in Armenia and in the *Centro Studi e Documentazione della Cultura Armena* (CSDCA)'s archives is available a good amount of documentation on historic monuments (elevations, photographs before and after the earthquakes, epigraphs, etc.) that, if studied, will allow to write a detailed history of decay and repair of nearly each monument of Armenia since last Century up to now.

This kind of qualitative study of the structural behavior of the monuments has proved to be an excellent enhancement of the numerical studies to identify the best solution for structural consolidation.

## The Digital Archive of Armenian Architecture

Near the University of Venice is now on the job a big effort of digitalization and filing of ample materials from the CSDCA's archives that will be soon published on the internet.

The aim of this work is to offer to the scholars new possibilities for the study of Armenian architecture and to create a tool that can be useful also to face the burden of monuments protection. The archive is designed to give the possibility to monitor the state of conservation of every monument of Armenia, to understand their weaknesses, to compare the problems pinpointed and asset priorities for intervention. The design of new interventions will certainly be facilitated by the possibility to study the effectiveness of different solutions adopted to solve similar problems on similar monuments.

According to that, the work of digitalization and filing is intended to be a starting point for further researches and studies on seismic behavior of Armenian monuments, as well as studies in the field of Art History. In fact all the data gathered from the *in situ* and archival research will be available through a search engine that will allow the visualization of any kind of synoptic tables upon request and the comparison of different data and/or images at every level (thanks to the refined software *ImageBase pro Orkis*).

The file is studied to classify images and drawings, providing information either on the drawing/image in itself, either on the subject of the image.


A part of the file concerns the general data about a monument that are repeated in all the files regarding that monument, an other part is more specifically concerning which part of the monument is illustrated in the image or drawing.

At every level there is room to signalize the contingent problems of conservation.

Every file contain, among numerous other information, notes about earthquakes and destruction suffered by the church during it's life and about all the restoration works realized in the past.

It is showed here underneath a sample of this work (a compiled file) that is realized both in Italian and English language.

All the work is conducted in collaboration between Italian and Armenian experts and undergraduate students from the Universities of Venice (*Ca' Foscari - Dipartimento di Studi Eurasiatici*) and Erevan (Faculty of Art History) with the support of CSDCA.

<b>description</b>	MARMASHEN MONASTIC COMPLEX	
<b>title (first three letters of the name of monument, serial number)</b>	Mar24	
<b>date of photo/design</b>	26/09/00	
<b>date of insertion (dd/mm/yy)</b>	02/10/2000	
<b>Name of the complex</b>	MARMASHEN	
<b>file maker (code number of the operator)</b>	6	
<b>File + directory</b>	mar24.jpg + Armenia/Shirak/Marmashen	
<b>name of building/dedication</b>	<i>hyussissi yegetzi</i> (chiesa nord), <i>Marmasheni kikhavor yegetzi</i> (chiesa madre di M.)/Surp Stepanòs, <i>pokr yegetzi</i> (chiesa piccola)	
<b>nation</b>	Republic of ARMENIA	

<b>actual/historical Region</b>	Shirak/Shirak
<b>city/village</b>	Vahramaberd
<b>date of construction</b>	988-1029
<b>designer/donor-builder (in the manuscripts the donor is often indicated as the "builder")</b>	architect Drtat (?)/prince Vahram Pahlavouni
<b>Internal/external view</b>	external view
<b>Type of view</b>	General view
<b>Location</b>	in a valley, near the river Axurian
<b>Orientation</b>	west
<b>Type of building</b>	Longitudinal plan, domed hall
<b>Building materials / construction techniques</b>	red-brown tufa, mortar of lime sand and pumice stone / sacco wall
<b>Earthquakes / distructions</b>	1064 destruction by the Seljuks, 1139 earthquake MSK 9-10, 1275 earth. MSK 9, 1668 earth. MSK 6-7, XIX c. destructions dued to the war and the robbery of the stones, 1920 the church was burnt, 1926 earth. MSK 9, 1988 earth. MSK 9, 1995 earth. MSK 5
<b>Reconstructions / restorations</b>	1225, XIX c. by Catholicos Khrimian Hayrig, 1903 first archaeological excavations, 1932-1948 excavations, surveys and studies, 1945 restoration of the "little church", 1950 renewed th roof os S. Stepanos, 1954-55 new restoration works on the complex, 1954-56 archaeological excavations, 1970 installed signs and engaged a keeper, 1995 installed anti-bird nets and extensimeters to monitor the micro movements of the cracks, 1999 archaeological excavations of the gavit, july 2000-nowaday structural consolidation works
<b>state of conservation (very sinthetic)</b>	several problems of conservation, urgent intervention needed
<b>problems of conservation (accurated description of the problems related to the monument or part of the monument represented in the picture)</b>	the north church has serious problems of stability and needs very urgent itervention, the archaeological remains need to be studied and preserved, the walls of the gavit must be strenghtened, the roof and, mostly, the paving of the little church are decayed, the little church presents problems related to humidity, there is everywhere the need of a cleaning from vegetation.
<b>Decoration settings</b>	blind column and arches, typical of the buildings of the "Ani school", the sculpted motifs of the frames, portal and windows are related to the classical tradition (e.g. ovuli, dentils, etc.)
<b>References</b>	in Armenia see the churches of Amberd (XI c.) and Ketcharis (XI-XIII c.), in Turkey see the churches and the cathedral of Ani (X-XI c.), in Italy see the romanic churches of Puglia and Tuscany (cfr. A. Alpago Novello, "L'architettura armena e l'Italia", in GLI ARMENI IN ITALIA, De luca, Roma, 1990)
<b>Observations</b>	The mother church S. Stepanos is now in restoration by a group co-ordinated by Centro Studi e Documentazione della Cultura Armena (see the panel beneath)
<b>drawing datas (to fill in case of filing of drawings)}</b>	<b>author:</b> <b>inscriptions: publications:</b> <b>dimensions:</b> <b>scale:</b> <b>state of conservation:</b> <b>graphic techniques:</b> <b>type of reproduction:</b> <b>type of support:</b> <b>subject:</b>
<b>image datas (to fill in case of filing of images)}</b>	<b>photographer:</b> Gaiane Casnati; <b>type of image:</b> digital picture JPG format, 470KB; <b>publications:</b> no publications; <b>state of conservation:</b> very good
<b>bibliography</b>	AA.VV., <i>Antiche iscrizioni dell'Armenia</i> , Venezia, 1882, (in armeno), pp.430-31; AA.VV., <i>Marmashen</i> , in <i>Enciclopedia Armena Sovietica</i> , Erevan, 1974, p.467; AA.VV., <i>Marmashen</i> , in <i>Documenti di architettura armena</i> n°16, Milano, 1986, p.51; AA.VV., <i>Armenia</i> , in <i>Atlante Storico Garzanti</i> , Milano, 1987, pp.92-93; ALISHAN, Padre, <i>Shirak</i> , Venezia, 1881, (in armeno), pp.147-154; BARCELLINI F., <i>Gli apporti degli studi tedeschi all'architettura armena</i> , tesi di laurea, Facoltà di lingue e letterature straniere moderne IULM, a.a. 1987-88, p.56; BASMADJAN K.J., <i>Les inscriptions arméniennes d'Ani</i> , in <i>Revue des Etudes Armeniennes</i> , 1929, pp.233-252; BROSET M., <i>Les ruines d'Ani, capitale arménienne sous les rois Bagratides aux X et XI siècle</i> , in <i>Voyages archeologiques III rapport</i> , S. Pietroburgo, 1860-61, pp.71-75; CUNEO P., <i>Marmashen</i> , in <i>Architettura armena</i> , Roma, 1988, pp.30, 32, 34, 35, 130, 260-264, 290, 323, 330, 725, 726, 728, 737, 742, 755, 757, 758, 763, 765, 782, 787, 789, 794, 799, 801, 815, 847; DER NERSESSIAN S., <i>L'art arménien</i> , a cura della Fondazione G. Gulbenkian, Parigi, 1977, p.107; DEZELUS R., <i>L'art de Transcaucasie</i> , Vienna, 1989, pp.192,193,198-200,204; DONABEDIAN P., THIERRY J.M., <i>Les arts arméniens</i> , Parigi, 1987, pp.167-168,553,123-124; EGHIAZARIAN, Padre, <i>Il monastero di Marmashen e le sue iscrizioni</i> , Etchmiadzin, 1957, pp.12-34; HAGOPIAN T., <i>I luoghi importanti</i>

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## Example of the file elaborated near the University of Venice

### The case study of Marmashen

In the Nineties the CSDCA started a program of study and safeguard of Armenian monuments located in the territory of the Republic of Armenia. After the indications of the Board for Conservation and Fruition of Historic and Architectural Monuments of Armenia was chosen as first subject of study the principal church of the architectural complex of the monastery of Marmashen (X<sup>th</sup>-XII<sup>th</sup> C.), a magnificent example of the top architectural value of the school of Ani and of the skill of the Armenian medieval architects. To this church was in fact given the first place in the list of the most important monuments damaged by the disastrous earthquake of December 1988.

The church has been deeply studied<sup>1</sup> carrying on

- bibliographic and archival research,
- a complete architectonic survey (conducted with the utilization and comparison of different modern technologies),
- study of the context (meteorology, geology, etch.),

<sup>1</sup> The implementation of scientific analyses and sketch project was ruled by a convention stipulated between the Polytechnic of Milan and the Committee for the Preservation and Fruition of Monuments of Armenia SSR and conducted by Gaiànè Casnati, and Maria Mimmo under the supervision of:

- Prof. Amedeo Bellini (Polytechnic of Milan - methodological organization of the project)
- Prof. Giorgio Bezoari, the Department of Topography of Milan Polytechnic and Galileo Siscam for topographic and photogrammetrical elevation;
- Prof. Luigia Binda (Polytechnic of Milan) for preliminary structural analysis;
- Prof. Koriun Ghafadarian and the Committee for the Preservation and Fruition of Monuments of Armenia SSR. for archival documentation and for the logistics;
- Prof. Adriano Alpago Novello (CSDCA - University of Venice) for historical study;
- Prof. Giovanna Alessandrini e dr. Marco Realini of CNR Center Gino Bozza for the diagnoses of the decay of stony materials and the sketch project for their conservation.

- physical and chemical analysis of stony materials (on more than 90 samples of stone, mortar, plaster and efflorescence),
- the stratigraphic study of the walls conducted with the interpolation of the results of the over-mentioned analysis.

It was possible to understand all the history of destruction/restorations of the church, distinguishing four main interventions for the restoration of the church:

1. XIII<sup>th</sup> c. interventions conducted after a strong earthquake and the invasion of Seljuks (stones with a particular treatment of the surface and renovated decoration settings that demonstrate that sometimes the necessity of repair was treated as an occasion to renew and embellish the church. The inscription carved on the northern wall tells about that restoration of the convent realized in 1225, giving exhaustive information about the authors and the sponsors of the restorations works. In that occasion where also donated to the church the complete furniture, sacred vessels and vestments, fields, vineyards and villages),
2. restoration works carried on in 1888 at the time of Catholicòs Khrimian Hairig (some stones have been replaced with other stones superficially worked on *herring-bone* pattern for distinguishing them from those pre-existent, according to a method that Nikolaj Marr and his collaborators, especially Orbeli and Tamanian must have known, given the fact that Marr himself was vice-president of the Institute of Fine Arts at the Sorbonne of Paris and that surely he was not in the dark about the European debate, (above all Italian and French) on architectural restoration theory,
3. restoration work campaign of the 50ties that included the complete renewal of the tuff tiles of the roof (with new tiles roughly carved) and the substitution of some cornices with new ones carved in the tuff with a simpler design compared with the original ones to be distinguished from them,
4. Recent repairs badly executed.

It was demonstrated that there were a continuity in the use of materials (stone from the same quarry, sand from the same river, etc.) so it was not possible to propose a dating of materials only by chemical-physical analysis.

The analysis of destruction/reconstruction revealed that the main weakness of the structure is located in correspondence of the connection between the West front and the Southern and Northern walls, where different restoration works were needed in the course of history.

## Restoration works

The church of Marmashen (X<sup>th</sup> century) is now in restoration thanks to the joined efforts of World Monuments Fund and Centro Studi e Documentazione della Cultura Armena (CSDCA).

The restoration project was designed<sup>2</sup> following the last theoretical Italian orientations, considering conservation like restitution of the monument to the fruition through

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<sup>2</sup> In this phase the work is co-ordinated by the Center for Study and Documentation of Armenian Culture (CSDCA) on the basis of an agreement signed with the Ministry of Culture of Armenia concerning the implementation of the conservation project of Marmashen church to be realized in collaboration with the aim to organize in-yards training courses for architects interested in restoration or for restorers of Armenian nationality.

Project management: arch. Gaiànè Casnati, CSDCA  
 Project design: arch. Gaiànè Casnati, arch. Maria Mimmo

interventions that maintain the authenticity most possible intact. The aspiration to the maintenance of the authenticity imply the choice of techniques and technologies (modern or traditional) that can guarantee their technological compatibility with the monument.

This larger consideration for the "matter" is translated in the necessity of availing themselves of the contributions of those scientific disciplines that allow achieving a most complete possible acquaintance of the building in examination as over described.

The structural damages suffered by the church where rather heavy: the seismic vulnerability was certainly increased for the repetition of strong stresses due by the different earthquakes.

The church is now interested by a strong crack pattern, in particular, the west front is badly connected to the south and north walls and a wide crack also appears in the dome along a meridian line. The loss of connections between the principal walls permits local movements of the different parts, without any mutual help among the various structural elements.

The crack pattern noticed confirm the information acquired from historical data.

Designing the restorative intervention, the main objective to be reached was the connection between the different structural parts. It was retained as a priority the preservation of original materials and structural authenticity. The interventions are concentrated on the parts where has been individuated a breaking mechanism.

The structure has been studied by prof. Jurina with the aid of a well known finite elements analysis program named SAP90, adopting "shell" elements to simulate the walls and "frame" elements to simulate the steel consolidation bars and cables. The numerical analysis demonstrated that the results of the qualitative study were very good and that the limited intervention foreseen was correct to produce the desired results.

The project is implemented<sup>3</sup> as a training yard for Armenian restorers and architects involved in the field of restoration and it is accompanied by the organization of seminars. All the equipment necessary for the work has been bestowed to the Board for Art and Historic Monuments Conservation to be used for further restoration works.

Small diameter steel bars where introduced in the walls by drilling the stone; steel cables will be used to pre-stress the dome and its cylindrical support at two levels. Grouting and selected demolition and reconstruction interventions ("*cuci-scuci*") where implemented in selected collapsing areas.

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Structural project: Prof. Lorenzo Jurina (Polytechnic of Milan)  
with :

- Armenian Ministry of Culture and the Armenian Board for the Preservation and Fruition of Monuments (Mr. Gagik Gurjyan) for consultancy and for the logistics;
- Arch. Mery Danielyan, Board for the Preservation and Fruition of Monuments
- Prof. Adriano Alpago Novello (University of Venice) CSDCA director;
- Stefano Volta, director of ARCHE' Restoration Company for the intervention on stony materials;
- Geom. Enrico Pasta, Luigi Recanati and Alberto Aresi from SICEM Monumental Strenghtening Company for the structural works.
- Carmen Pellizzi, Mario Mainetti, collaboration for the drawings

<sup>3</sup> **Project implementation:** *ARAGAZOTN Arvesdanoz*, a state company depending from the Armenian Board for Art and Historic Monuments Restoration, Director dr. Liohva Hugassian

The northern stylobathe was strongly damaged by the inclination that the earthquake provoked. Nearly all the stones were broken and out of their place, so it was necessary to take away all the stones damaged, clean and reposition them, reinforcing where necessary with the introduction of steel spines between the broken stones.

The roof covering of the church was rebuilt in 1954, which had considerably improved the protection of the construction against bad weather condition. However, it was damaged by the earthquake and by the presence of vegetation. So it was necessary to destroy and rebuild all the pitches to clean-up them from vegetation and roots. As they were in good conditions, it was decided to re-use the tiles although different in shape from the original ones to respect the history of monument. It has been necessary to substitute some tiles. All the new stones have been signed with a mason mark that will characterize the work done by the stone-carver Sanson in the year 2000.

The state of conservation of the stony materials has been carefully investigated *in situ* and in the Laboratories of the Polytechnic of Milan: pronounced zones have been interested by chipping of the stone, by the presence of efflorescence or crypto-efflorescence and by concretions and patina more or less solid. During the 2000 campaign were experimented all the cleaning and conservation techniques and materials that will be utilized in Spring 2001.

In general, during the implementation of works were checked all the materials and equipment available in Armenia to choose between them (when possible) the ones to be used for that and for future restoration works to give to Armenian experts the possibility to continue the work in the future with low costs and high quality. We found out the availability of excellent materials as pumice stone that can be used either to give pozzolanic effect to the lime mortar, either to clean the stone with micro-sand-blasting, either to be mixed with Hydraulic lime for the injections (in this case it is very good for its lightness).

To fix and point of the cracks on the façade it was used a mortar composed by hydraulic lime (bifluid XA, Tassullo), powdered pumice stone, crushed brick and tuff powder that proved to be excellent as compatibility with the original materials either from the aesthetic and from the physical point of view.

To work in Armenia with Armenian architects and bricklayers was a very enriching experience, the good results obtained with few means were possible thanks to the passionate work of every one. The restoration of Marmashen gave work to more than 20 unemployed people that in few time became surprisingly refined masons.

The works done in Armenia demonstrated the high value of the knowledge and respect of the traditional building and restoration techniques. In fact this knowledge allow to design and realize non-expensive interventions effective in terms of improvement of seismic resistance and compatibility with the old structures.

Furthermore the rediscovery and revitalization of ancient traditions is proved to be effective also from the social point of view. Its positive affect on every-day's life consists to give to people that live at the moment in a very difficult situation a sense of continuity and pride for their glorious past and so also hope for the future.

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### **CURRICULUM VITAE**

Gaiànè Casnati is a conservator architect now working on her own as well as in collaboration with other professionals and architecture firms, mainly concentrating her activity in the conservation field. Her interest is on ancient monuments conservation, in particular, she is now working with the role of project designer and site manager for the Lombardia's Archaeological Superintendency to the restoration of the roman amphitheatre in Milan and in Armenia to the restoration of Medieval churches and fortresses (Marmashen, Ererouk, Amberd).

- Since 2000 she hold a research on the Digital Archive of Armenian Architecture at the Department of Eurasian Studies near Venice University Ca' Foscari.
- In 1999-2000 she was invited professor at Venice University Ca' Foscari and teached "Conservation Problems of Medieval Architectures in Caucasian Area".
- Since 1987 she works for *Centro Studi e Documentazione della Cultura Armena* and *Oemme edizioni* and since May 1995, she is responsible for the activities of study and fund raising on Armenian monuments restoration and conservation.
- She held several lectures and wrote some articles on architectural restoration and Armenian architecture and collaborated with the Polytechnic of Milan for the Course of Restoration held by Professor Gionata Rizzi and for the Course of Architectural Technology held y prof. Alfredo Castiglioni.
- She organised and participated to several CSDCA missions in Armenia aimed to the study and restoration of Armenian monuments.
- From January 1994 to January 1997 she used to work for architect Castiglioni to important project of restoration in northern Italy.
- She attended courses and seminars of specialisation in the field of conservation of historic buildings.
- She achieved a degree in Architecture at the Milan Polytechnic with honours.
- Final dissertation was titled *Marmashen a conservation plan in Armenia. Hypotesis of intervention in an exceptional case.*