CASE STUDY

Rapid visual assessment for retrofitting

Country: El Salvador

Organisation: UNESCO, University of El Salvador, University of Udine, Italy

Hazards: Earthquakes

Keywords: VISUS, rapid visual assessment, information communication technology, government, retrofit, triage, training

Summary: Before school retrofitting or reconstruction programs can begin, weak buildings need to be identified and prioritised, and retrofit or replacement designs calculated. Rapid visual assessment is typically the first step in this process. In El Salvador, UNESCO and two universities piloted a tablet-based rapid visual assessment tool. The project assessed 100 school buildings in 10 days and built the capacity of government officials, professionals and engineering and architecture students along the way. For many, the pilot was their introduction to building assessments and the fundamental principles of seismic-resistant design.

Country and hazard overview

El Salvador is both populous and seismically active. In 2001, two earthquakes struck, causing landslides and damaging 1,700 schools – more than one in three in the country. Ten years later, many school buildings remain in disrepair, in sites that leave them vulnerable to earthquakes and other natural hazards, or they do not comply with seismic building codes.

School buildings in El Salvador are mostly one story of confined or reinforced masonry. Although some buildings were traditionally constructed from adobe (mud brick), it has not been used for schools after many children and a teacher died during an earthquake in 2001.

When existing school facilities have not been built to withstand hazards, they need to be identified and strengthened. In contexts like El Salvador, where resources are insufficient for a full detailed assessment of every school, a rapid visual assessment can quickly collect proxy data from a brief site visit. From these assessments, the MoE can develop school retrofitting programs based on a triage action plan that prioritises the weakest buildings and those with the most students first. Detailed assessments can then determine whether school facilities should be retrofitted or replaced.

Using rapid visual assessment

Rapid visual assessment approaches have been developed in many countries. These assessments do not empirically determine the structural integrity of a building. Instead they rely on proxy data to determine fragility.

Originally, the proxy data was collected by engineers after earthquakes or other hazards. Noting the intensity of the hazard, they recorded the damage to buildings and organised the results by the building typology and other defining characteristics. Over time, enough data was collected to be able to predict damage based on a visual assessment of a building's characteristics and the expected strength of the hazard.

Rapid visual assessment only provides a general prediction of damage. After the rapid visual assessment is conducted, engineers still need to perform in-depth assessments to develop appropriate retrofit designs, but only for those identified during the rapid assessment for an in-depth analysis. This strategy reduces the cost of doing in-depth assessments for every school.

Planning school retrofits through rapid visual assessment

Faculty and students of a Salvadoran engineering program, along with researchers from the University of Udine in Italy, pilot-tested the VISUS tool as a rapid visual assessment methodology in 2014. VISUS is an expert-based methodology that organises and collects rapid visual assessment information for school facilities through a tablet-based application. It then uses collected data to judge the overall safety of school facilities. VISUS has been designed to quickly aggregate data through photographic evidence and prioritise the most appropriate action for achieving school safety based on risk and cost. These actions are listed as nothing, repair, retrofit or replacement.

Even though El Salvador has a relatively robust university system, civil engineering students are not required to take courses in evaluating existing buildings for seismic safety. For one month, VISUS developers from the University of Udine in Italy, together with UNESCO personnel, communicated with a Salvadoran professor who spearheaded the pilot project. He provided pictures from previous earthquakes and information detailing the technical aspects of typical school construction in El Salvador. Over time, this initial contact snowballed into a steering group, which maintained the project throughout its lifespan.

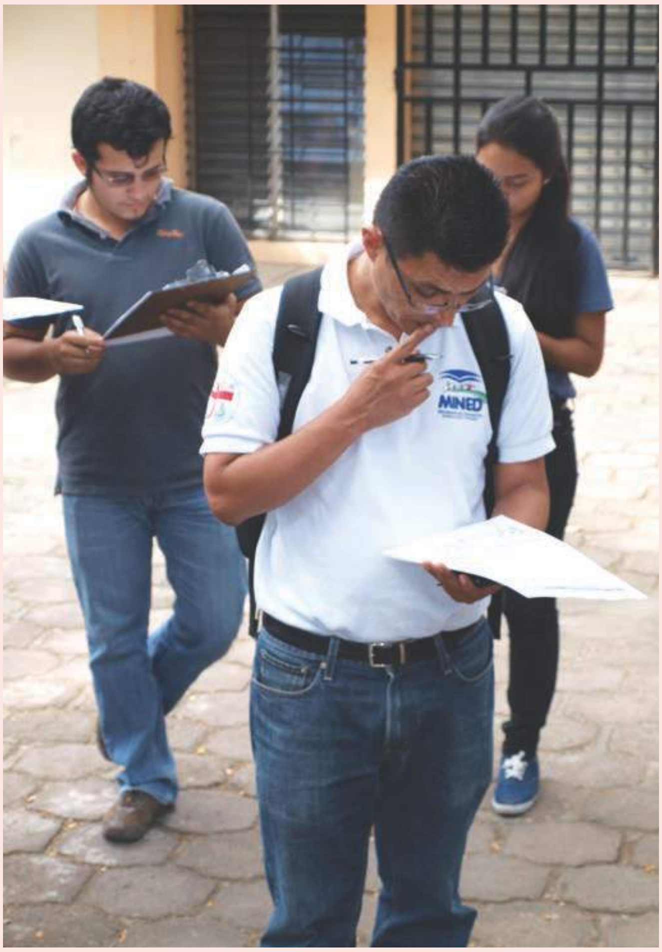
After establishing a base of operations at the University of El Salvador, the VISUS developers trained more than 60 people to perform the assessment, including personnel from the MoE, Engineers Associations and a small team of 15 students and 8 professors. The first half of the three-day training was in the classroom learning the concepts of rapid visual assessment and the VISUS tablet application for collecting data. In the latter half of the training, the trainees got hands-on experience in the field. A day was added for evidence-based photography so experts could verify the team's assessments after the fact.

The VISUS pilot project assessed school buildings in the departments of San Salvador, La Libertad and La Paz. Ultimately five groups of three university students and a professor visually assessed 100 buildings in 10 days. The VISUS evaluation of the school took as little as a half an hour and occasionally as long as three hours. When school staff were available to guide the team, the evaluation process was much faster.

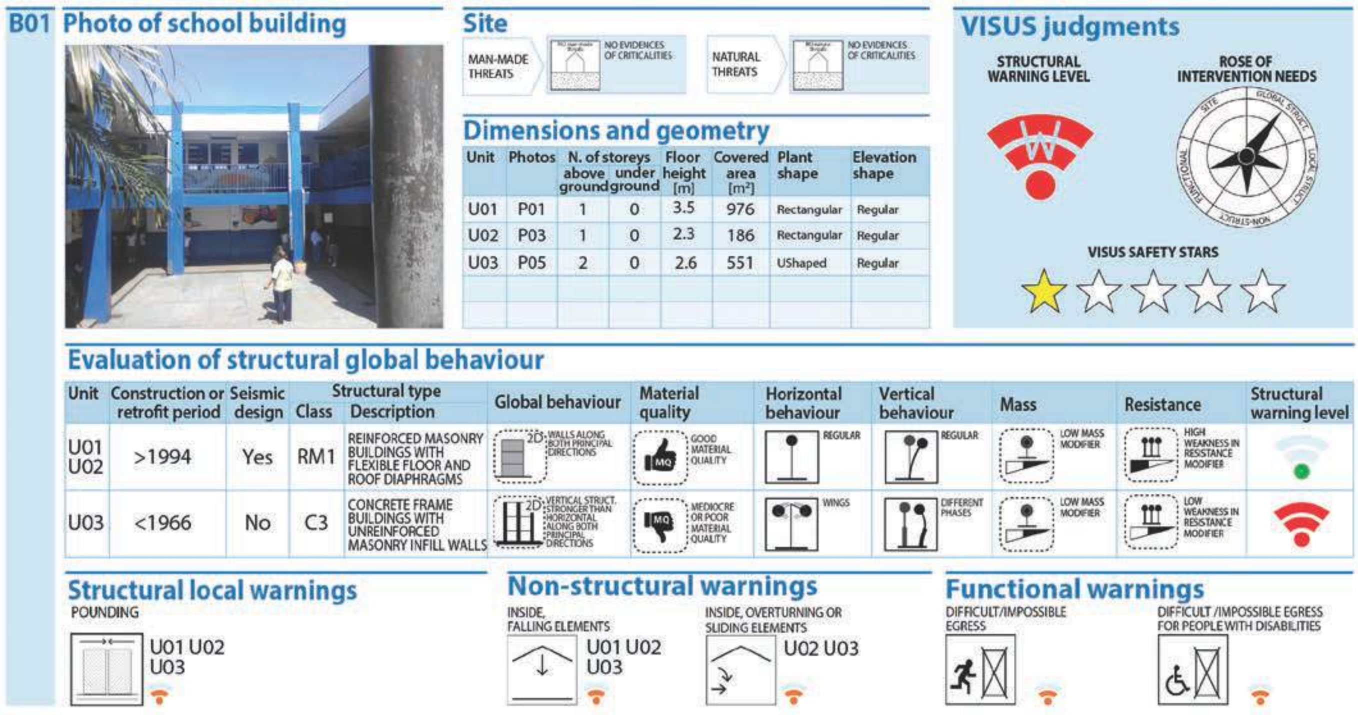
The VISUS methodology could be divided into three broad chronological sections: characterisation, evaluation and prescription for school safety upgrades. Teams used tablets to photograph structural and non-structural characteristics of schools and then match what they saw to a set of pre-defined alternatives. The methodology related each alternative to different damage levels the school would likely experience in an earthquake.

The newly trained surveying team did not always have sufficient expertise to correctly perform the matching. However, the photo documentation was sent to a scientific committee who vetted on-the-ground data, filling in any gaps in experience. This double-checking helped verify the congruence of the collected data. An algorithm then rated school building on a 1-5 star system ranked by risk and retrofit cost.

VISUS was able to effectively train and immediately rely on local students and professors for site visits because of its rigorous review protocol. By producing detailed and functional pictorial evidence, the oversight could be exported off-site, increasing speed and reducing costs.



Personnel from the MoE, engineering associations, students and professors of civil engineering practice rapid visual assessment of school buildings to determine which are most vulnerable to earthquakes. Photo: Jair Torres/UNESCO



Unit	Photos	N. of storeys above ground	N. of storeys under ground	Floor height [m]	Covered area [m²]	Plant shape	Elevation shape
U01	P01	1	0	3.5	976	Rectangular	Regular
U02	P03	1	0	2.3	186	Rectangular	Regular
U03	P05	2	0	2.6	551	UShaped	Regular

Unit	Construction or retrofit period	Seismic design	Structural type Class	Structural type Description	Global behaviour	Material quality	Horizontal behaviour	Vertical behaviour	Mass	Resistance	Structural warning level
U01 U02	>1994	Yes	RM1	REINFORCED MASONRY BUILDINGS WITH FLEXIBLE FLOOR AND ROOF DIAPHRAGMS	3D: WALLS ALONG BOTH PRINCIPAL DIRECTIONS	GOOD MATERIAL QUALITY	REGULAR	REGULAR	LOW MASS MODIFIER	HIGH WEAKNESS IN RESISTANCE MODIFIER	
U03	<1966	No	C3	CONCRETE FRAME BUILDINGS WITH UNREINFORCED MASONRY INFILL WALLS	2D: VERTICAL STRUCT. STRONGER THAN HORIZONTAL ALONG BOTH PRINCIPAL DIRECTIONS	MEDIOCRE OR POOR MATERIAL QUALITY	WINGS	DIFFERENT PHASES	LOW MASS MODIFIER	LOW WEAKNESS IN RESISTANCE MODIFIER	

A summary view of the rapid visual assessment of a school building with three blocks – Unit 1, 2 and 3. Using a series of screens to compare the unit to photos of different building typologies and characteristics, the team has categorised the units, considering global building behaviour, material quality, horizontal and vertical behaviour, building mass and lateral resistance. The tool also asks teams to assess non-structural and functional issues. Following a rapid visual assessment, VISUS engineering experts review field assessments and the accompanying photographs to ensure accuracy.

Challenges to this approach

In the pilot stages, the tablet was not fully functional in the field. Rather than allowing the users to assess the safety of the facility as issues were discovered, the tablet-application forced the user into a rigid linear progression of the five sections of the VISUS method. Realising this problem, teams quickly began recording the information on paper and enter the data once they returned to university. The pictorial comparisons provided in the application were still essential, but the tablet application needed modification to be fully functional in the field.

Rapid visual assessment is only the first step. The work in El Salvador identified school buildings that were likely to be the weakest, and because the VISUS tool was used, it provided initial estimates for retrofitting or replacing them. Yet even though the results of the pilot study are promising, the long-term impacts to Salvadoran schools are still unknown. The MoE and other actors still need to fund retrofitting and replacement. Engineers still need to complete detailed assessments, including sampling materials from the schools and testing their strength, before creating retrofit or replacement designs. And of course, the work then needs to be carried out.

Designed in Italy, VISUS focuses on structural typologies common in southern Europe. Applying this technology to other contexts requires adaptation. The tool needs to be expanded to include traditional building materials like adobe. It also needs to respond to a broader range of hazards to be applicable in other contexts. Currently, the team is conducting other pilot applications in Laos and Indonesia. This requires adapting the tool to entirely new building types and hazards – including floods, tsunamis and high winds.

Key takeaways

- Retrofitting programs can improve the hazard resistance of existing unsafe school buildings.
- When resources are limited, rapid visual assessment tools help quickly identify the weakest schools and the schools with the most vulnerable students.
- Local engineers may have little formal training in methods for assessing existing structures for vulnerability to hazards.
- Partnering assessment experts with local universities can build the capacity of engineering students, faculty and government officials.