

The Quito,

Ecuador

School Earthquake

Safety Project

Investing in Quito's Future



*Escuela Politécnica Nacional
GeoHazards International*

 A GeoHazards International Publication

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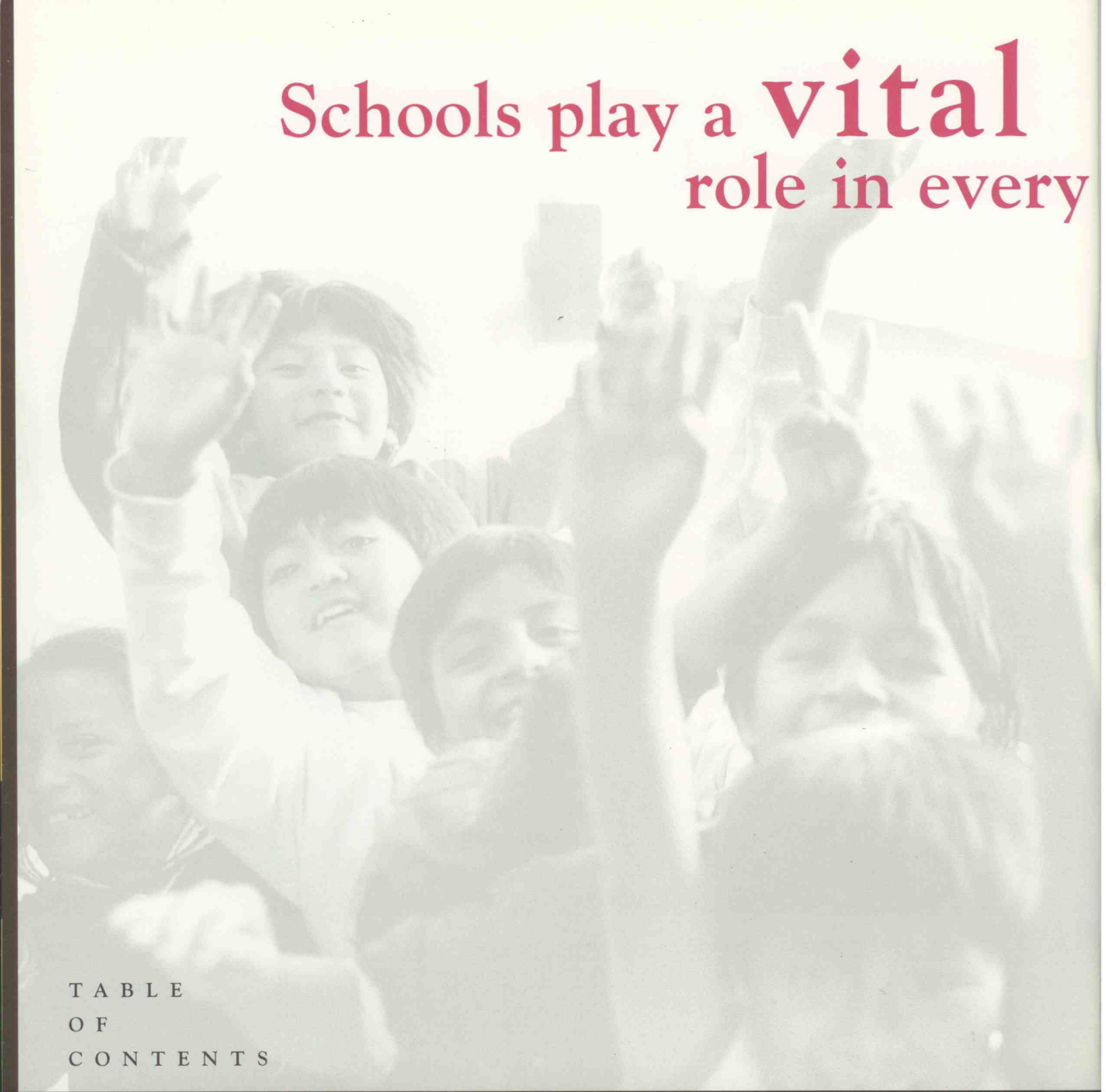
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Schools play a **vital** role in every

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community...

Schools teach civics, educating citizens of their rights and duties. They foster an appreciation of culture through the study of literature and the arts. In schools, students learn the lessons of history, the discoveries of science, and the rewards of public service. Schools benefit the economy by providing a skilled and literate work force. They are used for social gatherings, continuing education, theater and musical productions, and sports. Schools are a measure of community well-being.

Earthquake-threatened communities need earthquake-resistant schools. When schools are closed because of earthquake damage, education is delayed and community life disrupted. Repair and construction of school buildings are difficult and expensive after an earthquake, when government resources are strained. Where school attendance is compulsory, communities have a moral obligation to provide a safe study and work environment. But most important, earthquake-threatened communities need earthquake-resistant schools to protect their teachers and children.

A recent assessment of earthquake risk to Quito, the capital of Ecuador, concluded that many of its public schools are vulnerable to collapse during major earthquakes. That assessment was made over a period of two years, ending in May of 1994, by a team of Ecuadorian and international scientists and engineers. They found that while Quito has not been struck by a major earthquake recently, it has been in the past and will be in the future. They recommended that Quito's public school buildings be evaluated and, if found vulnerable, strengthened.

In response, GeoHazards International initiated the Quito School Earthquake Safety Project in December of 1994. GeoHazards International, a nonprofit corporation dedicated to improving earthquake safety worldwide, collaborated with Ecuador's National Polytechnic School and the University of British Columbia in defining the project. It had three objectives:

- Evaluate the vulnerability of Quito's public schools to earthquakes;
- Design affordable means of strengthening a sample of those schools that are vulnerable; and
- Strengthen the sample of vulnerable schools.

This report describes progress in meeting these objectives during the project's first year and concludes by offering recommendations for making Quito's schools safe.

Evaluating Quito's Schools

Quito

SOUTH AMERICA

Quito's public schools comprise a large and diverse collection of buildings. There are more than 700 schools, and many consist of several separate buildings. Some are converted warehouses or homes. Some are individually designed structures, and others are groups of modules. Today, all public schools are constructed by the National Directorate for School Construction, using reinforced concrete or steel modules. There are three prevalent school construction materials: reinforced concrete, steel, and, in older schools, unreinforced masonry. Unreinforced masonry includes cement block, adobe (handmade, sun-dried clay bricks), and ladrillo (handmade, fired clay bricks).

Home to 1.2 million Ecuadorians, Quito is 2,850 m above sea level in the Andes Mountains, and 22 km south of the equator.

"SOFT" FIRST STORY



Because of the number and diversity of school buildings, it was not practical to evaluate the vulnerability of them all. Instead, this project focused on a sample of schools that are in high use (a large number of students using the building per day per building area), highly vulnerable to earthquakes, and representative of the three prevalent construction materials. Schools that are both in high use and highly vulnerable are referred to as “high-risk” schools.

The process of choosing this sample and evaluating the vulnerability of its schools consisted of selecting Quito’s high-use schools, classifying them by construction material, and determining the most vulnerable within each group. Data provided by the City of Quito were used to select 340 high-use school buildings. Inspectors visited each, recording information including construction material and superficial condition of the structure. The buildings were then grouped according to construction material. Three steps were taken to determine the vulnerability of buildings in each group. First, project engineers selected a total of 60 buildings that appeared the most vulnerable. Next, each of these buildings was given a vulnerability ranking using the Applied Technology Council’s “rapid visual screening” method, adapted by project engineers to local seismicity and local construction materials. Finally, detailed structural analyses were performed for those buildings, a total of 20, with the highest vulnerability rankings within each group. The analyses included an investigation of the structural system (including that of the foundation) to evaluate the location, size, and connection details of all structural elements. Structural deterioration was also documented. Dynamic analyses were completed for each building, considering various levels of earthquake ground shaking. Soils engineers determined, based on a preliminary evaluation, that none of the buildings was situated on unstable soils.

As a result of this process, project engineers identified 15 individual high-risk school buildings. They also concluded that the two types of school modules constructed by the National Directorate for School Construction were at risk. The 15 individual school buildings and the thousands of modular schools located throughout Ecuador are the focus of the next section.

“SHORT” COLUMNS



Two common structural deficiencies are “soft” stories (such as stories without infill walls) and “short” columns (columns effectively shortened by partial infill walls). Shown are examples of each in Quito schools, and an earthquake-damaged building that had a “soft” first story.

Designing Retrofits

The 15 high-risk schools and the two types of school modules identified in this project (see the High-Risk Schools table on the facing page) were chosen to be “retrofit” so as to prevent injury to their occupants even during Quito’s largest earthquakes.

To retrofit a building is to improve its earthquake resistance. A retrofit design is a specification of the structural changes to a building required to achieve a desired level of earthquake resistance. The desired level of earthquake resistance is expressed in terms of design criteria — the levels of damage acceptable for various intensities of ground shaking.

The design criteria used in this project (see Retrofit Design Criteria table) state, for example, that retrofit schools should be able to withstand ground acceleration of 6% gravity (ground shaking strong enough to move heavy furniture) with no structural damage and with only minimal nonstructural damage. Based on historical records, earthquakes producing such ground shaking in Quito are expected every two decades.

Retrofit designs were created for each of the 15 high-risk school buildings and the two types of school modules. These designs are affordable and utilize local materials and local construction techniques. They are summarized in the following pages.

Strength of Ground Shaking	Historical Frequency of Occurrence	School Retrofit Criterion
Heavy furniture moves (6%g)	Every 2 decades	Minimal nonstructural damage, no structural damage
Difficult for some to stand (9%g)	Every century	Moderate nonstructural damage, no structural damage
Difficult for most to stand (26%g)	Every 5 centuries	Structural damage but no collapse

Retrofit Design Criteria



Project engineers from Ecuador's National Polytechnic School discuss school retrofit designs with a member of the Technical Advisory Committee.



Name of School	No. of Buildings	Construction Material	Year of Construction	Grade Level	Estimated Retrofit Cost (Sucre/US\$)
Ana Paredes de Alfaro	1	Reinforced concrete	1956	Kindergarten & elementary	S/ 34,333,000 \$14,000
Experimental Sucre	4	Reinforced concrete	1952-59	Elementary	S/ 144,098,000 \$57,000
José de Antepara	1	Adobe	Pre-1940	Kindergarten & elementary	S/ 27,452,000 \$11,000
República de Argentina	1	Unreinforced masonry	1953	Elementary	Not available
República de Chile	4	Reinforced concrete	1945/1994	Elementary & high school	S/ 618,698,000 \$244,000
Río Amazonas	3	Reinforced concrete	1978	High school	S/ 98,000,000 \$39,000
11 de Marzo	1	Steel	Unknown	High school	S/ 16,718,000 \$7,000
National Directorate for School Construction Module I	Numerous	Reinforced concrete	Various	Various	S/ 160,000/m ² \$6/ft ²
National Directorate for School Construction Module II	Numerous	Steel	Various	Various	S/ 33,000/m ² \$1.20/ft ²

High-Risk Schools

Location: Rocafuerte and Rodríguez de Quiroga streets

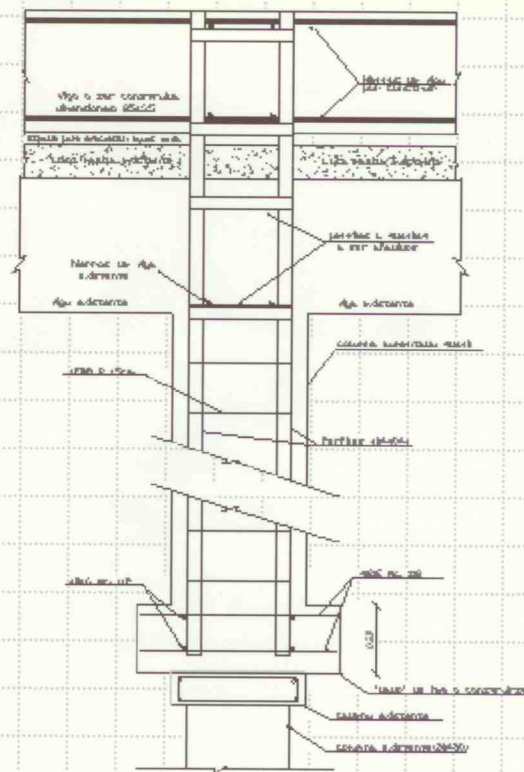
Year of Construction: 1956

Prevalent Materials: Reinforced concrete

Total Retrofit Area: 540 m² (5,810 ft²)

No. of Buildings Studied: 1

Estimated Cost: S/ 34,333,000 (US \$14,000)



Detail of Column and Roof Slab

BUILDING DESCRIPTION

The Ana Paredes de Alfaro kindergarten and elementary school consists of a one-story reinforced concrete main building and two steel school modules. The main building was considered in this project.

The main building is C-shaped; its spine and two wings are separated by construction joints. The structure's 15-cm-thick tile-covered concrete roof slab is supported by reinforced concrete columns and 20-cm-thick masonry walls. The foundation consists primarily of stone and reinforced concrete piers. Masonry walls provide support to some parts of the building where there is sloping terrain. The foundation has a 10-cm-thick concrete perimeter tie beam.

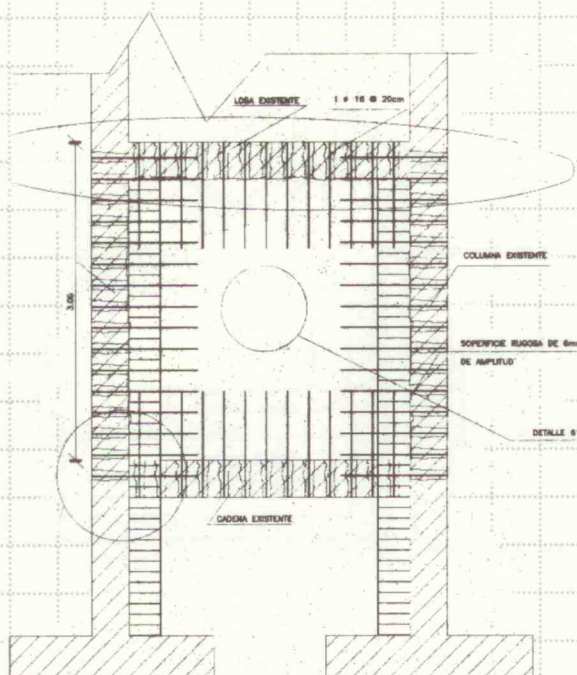
STRUCTURAL DEFICIENCIES

Weak concrete beams and columns put the structure's frame at risk of collapse during a major earthquake. Several columns are lacking sufficient reinforcing steel, and most beam-column joints are inadequate. The concrete roof slab is deflecting excessively in several places; cracks in the slab allow rainwater to leak into the building.

RETROFIT SOLUTION

The building will be strengthened by adding reinforced concrete beams above the roof slab and steel columns, and by strengthening the existing reinforced concrete columns and beam-column joints. This would create lateral-load-resisting frames for the building, increasing its ductility during earthquakes, diminishing stress on its structural elements, and halting the deflection of the roof slab. The roof will be sealed with a watertight coating.

A complete description of this structure, its analysis, and its retrofit design can be found in: G. Barahona and F. Vaca, *Seguridad Sísmica de los Establecimientos Escolares en la Ciudad de Quito: Jardín de Infantes "Ana Paredes de Alfaro."* (Quito: Escuela Politécnica Nacional, 1995.)



Retrofit Design Detail

Location: Sucre Street, Barrio La Loma

Year of Construction: 1952–1959

Prevalent Materials: Reinforced concrete

Total Retrofit Area: 3,080 m² (33,140 ft²)

No. of Buildings Studied: 4

Estimated Cost: S/ 144,098,000 (US \$57,000)



BUILDING DESCRIPTION

The Experimental Sucre elementary school consists of three- and four-story buildings of reinforced concrete frames with unreinforced masonry infill walls. Four buildings were studied in this project: a four-story structure serving as a longitudinal spine and its 3 three-story transverse blocks.

The 130-m-long spine consists of transverse portal frames with 7.5-m spans and 2.5-m overhangs, spaced every 3 m. Seismic separation spaces detach the 50-m-long central spine section from the rest of the structure. The floors are 35-cm-thick rigid slabs; the columns are connected to each other by dropped beams in the longitudinal direction only.

The three 18-m-long transverse blocks are 25 m apart and perpendicular to the spine, separated from the spine by seismic separation spaces. Each consists of seven portal frames spaced 3 m apart, with 6-m spans and 2.5-m cantilevers. A 35-cm-thick concrete beam embedded in the slab connects the two columns of each frame.

STRUCTURAL DEFICIENCIES

Experimental Sucre's beams and columns are not sufficiently strong to provide earthquake resistance to their structures. Door and window openings have created short columns. The first story of each transverse block lacks infill walls, creating a soft-story condition. The transverse buildings will likely pound against the main building during an earthquake.

RETROFIT SOLUTIONS

Shear walls will be added to the buildings in both the longitudinal and transverse directions. Two options have been proposed for constructing the shear walls. The first consists of adding reinforced masonry walls to the first floor (transverse buildings only) and replacing the walls of upper floors with properly connected reinforced masonry ones. The second design consists of adding unreinforced masonry walls to the first floor (transverse buildings only), and surface strengthening them and upper-floor walls with steel mesh and concrete. Shear walls will increase the stiffness of the portal frames and thereby mitigate soft-story and pounding hazards. Separation joints will be added between walls and columns to mitigate short-column hazards.

A complete description of these structures, their analysis, and their retrofit designs can be found in: S. Díaz and F. Ponce, *Seguridad Sísmica de los Establecimientos Escolares en la Ciudad de Quito: Escuela Sucre*. (Quito: Escuela Politécnica Nacional, 1995.)

Location: Corner of Húsares and Cabo Vinuesa streets

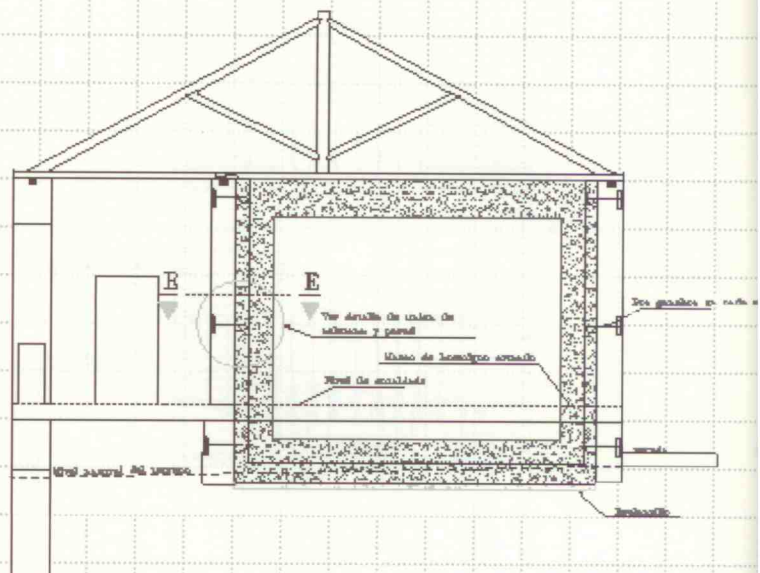
Year of Construction: Pre-1940

Prevalent Materials: Adobe, Spanish tile

Total Retrofit Area: 900 m² (9,680 ft²)

No. of Buildings Studied: 1

Estimated Cost: S/ 27,452,000 (US \$11,000)



Retrofit Design Detail

BUILDING DESCRIPTION

The José de Antepara kindergarten and elementary school comprises a one-story main building consisting of various materials and structural systems, and several steel and reinforced concrete modules. The original and largest section of the main building, an elongated adobe structure, was considered in this project. The L-shaped adobe structure has 40- to 60-cm-thick bearing walls supported on stone continuous spread footings. The walls show few signs of distress. The roof consists of wood trusses aligned in the transverse direction and is covered with Spanish tiles. The trusses are connected at the top and bottom chords by stringers. A false ceiling is attached to the bottom stringers.

STRUCTURAL DEFICIENCIES

The two major problems with this building are a weakness in its transverse direction and the hazardous roof. The longitudinal walls have long, unbraced spans between transverse walls. The extreme length of the spans makes them dangerously flexible in the out-of-plane direction.

The wood roof trusses are splitting in places. The truss joints and connections to the walls are not sufficient to transfer earthquake loads. The roof lacks bracing in the longitudinal direction. These deficiencies could cause the roof structure and overlying tiles to collapse into the classrooms below during an earthquake. The roof tiles, held in place by gravity alone, could slide off the roof in an earthquake and onto the playground and sidewalk below.

RETROFIT SOLUTIONS

Two options were suggested to reinforce the structure along its transverse axis. The first consists of building in the transverse direction a 40-cm-thick, continuous unreinforced masonry wall, confined by a reinforced concrete beam and columns. This would divide a large, multiple-use classroom. The second, a less invasive design, is to construct two reinforced concrete frames in the transverse direction of the building.

The roof trusses will be repaired and their joints and connections strengthened, and cross-bracing will be added in the plane of the roof. The roof tiles will be anchored to prevent them from moving in an earthquake.

A complete description of this structure, its analysis, and its retrofit designs can be found in: E. Márquez and P. Placencia, *Seguridad Sísmica de los Establecimientos Escolares en la Ciudad de Quito: Escuela Fiscal Mixta "José de Antepara."* (Quito: Escuela Politécnica Nacional, 1995.)

Location: Between Daule, Pita, and Pique streets,
Ciudadela México

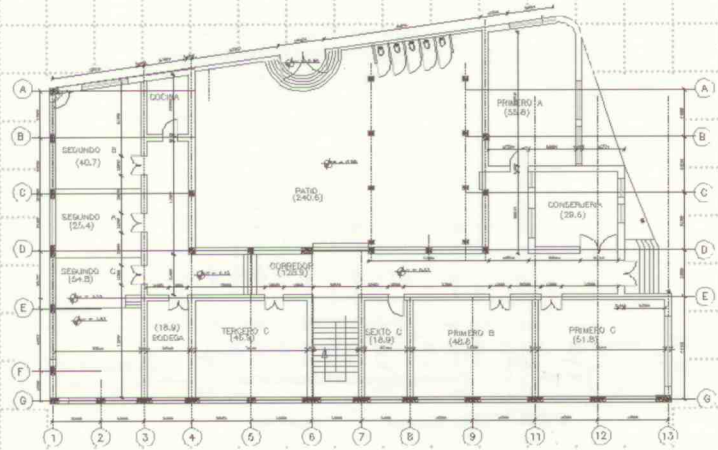
Year of Construction: 1953

Prevalent Materials: Unreinforced masonry

Total Retrofit Area: 700 m² (7,530 ft²)

No. of Buildings Studied: 1

Estimated Cost: Not available



Building Plan



BUILDING DESCRIPTION

The República de Argentina elementary school consists of two buildings: a recently constructed reinforced concrete structure and the original two-story brick main building. The main building was considered in this project.

The main building is C-shaped. Because of sloping topography, the first floor contains four levels, and the second floor contains two. The unreinforced brick walls are 40 cm thick. The wood floor of the second story is supported by reinforced concrete beams that, in turn, are supported by the first-floor walls. The roof is supported by wood beams. On the second floor there are several reinforced concrete additions with lightweight metal roofs.

STRUCTURAL DEFICIENCIES

The interior and exterior unreinforced masonry bearing walls have openings that create, in effect, a hazardous short-column condition. The beam-wall connections are deficient. Since the wood beams and roof structure are supported by the walls, failure of the beam-wall connections during an earthquake would result in building collapse.

RETROFIT SOLUTION

The wall openings will be modified to reduce the short-column effect. Better connections will be provided between intersecting walls. The in-plane rigidity of the floor and roof systems, as well as the connections with the supporting walls, will be improved.

A complete description of this structure, its analysis, and its retrofit design can be found in: G. Barahona and F. Vaca, *Seguridad Sísmica de los Establecimientos Escolares en la Ciudad de Quito: Escuela Fiscal Mixta "República de Argentina."* (Quito: Escuela Politécnica Nacional, 1995.)

Location: Rocafuerte and Cumandá streets

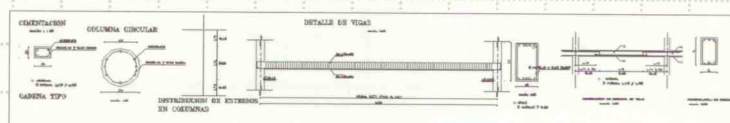
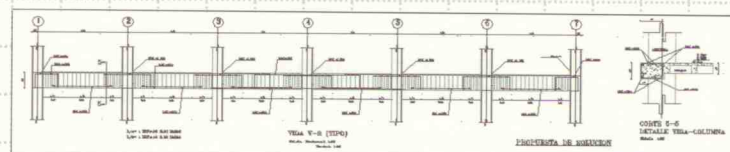
Years of Construction: 1945 and 1994

Prevalent Materials: Reinforced concrete

Total Retrofit Area: 2,130 m² (22,920 ft²)

No. of Buildings Studied: 4

Estimated Cost: S/ 618,698,000 (US \$244,000)



Retrofit Design Detail

BUILDING DESCRIPTION

The República de Chile elementary and high school consists of four reinforced concrete-frame buildings (Blocks 1 through 4) with unreinforced masonry infill walls. Blocks 1, 2, and 3, built in 1945, are two stories. Block 1 has a total floor area of 1,090 m² (11,730 ft²). Block 2, square-shaped in plan with a total floor area of 240 m² (2,580 ft²), is used for circulation between the other three blocks. Block 3 has an area of 600 m² (6,460 ft²) and is of construction similar to Block 1. Blocks 1, 2, and 3 have rectangular and cylindrical columns, some of which are dangerously slender. Piers of ciclópeo (large-aggregate) concrete support the columns, and stone footings support the walls. There are no tie beams between piers. Block 4, a one-story structure built in 1994, consists of concrete frames only in the transverse direction. It has a floor area of 200 m² (2,150 ft²).

STRUCTURAL DEFICIENCIES

The slab reinforcement and the reinforced concrete columns have deteriorated from exposure to water. In some areas the concrete contains soft aggregate or construction debris. The buildings contain short-column hazards, and the weak infill walls will likely crack and collapse during a strong earthquake. These buildings are not able to resist strong or long-duration earthquakes. Many ceilings contain unanchored clay tiles, which could fall during an earthquake.

The columns of Blocks 1, 2, and 3 contain smooth reinforcing steel. Slender cylindrical columns on the ground floor of Block 2 are not aligned with the corresponding columns on the second floor, resulting in a discontinuity between the columns and beams. Many beam spans are unusually long, and the beam distribution is inefficient. Block 4 lacks structural frames in the longitudinal direction, substantially diminishing the structure's ability to resist earthquake forces.

RETROFIT SOLUTION

Because the República de Chile school was built without an earthquake-resistant structural system, the frames of Blocks 1, 3, and 4 will be completely redesigned. Due to the extremely poor design and condition of Block 2, it will be demolished and rebuilt. The ceiling tiles in all classrooms will be removed and replaced with lightweight, secured panels.

A complete description of these structures, their analysis, and their retrofit design can be found in: R. Arellano and J. Espinoza, *Seguridad Sísmica de los Establecimientos Escolares en la Ciudad de Quito: Escuela República de Chile*. (Quito: Escuela Politécnica Nacional, 1995.)

Location: Avenue Alonso de Angulo, Barrio de la Villaflores

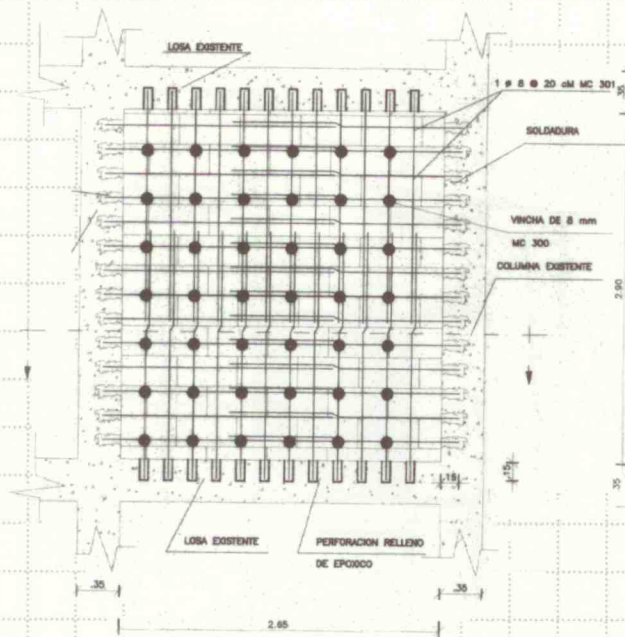
Year of Construction: 1978

Prevalent Materials: Reinforced concrete

Total Retrofit Area: 1,600 m² (17,220 ft²)

No. of Buildings Studied: 3

Estimated Cost: S/ 98,000,000 (US \$39,000)



Retrofit Design Detail



BUILDING DESCRIPTION

The Río Amazonas high school consists of 12 two- and three-story reinforced concrete buildings and one steel-frame building, all constructed between 1978 and 1985. This project considered three reinforced concrete buildings constructed in 1978: the two-story, C-shaped main building, and 2 three-story peripheral buildings.

The symmetric wings of the main building consist of a series of portal frames, each 3 m apart and with construction joints every 9 m. Beams embedded in the floor slab connect the frames in the longitudinal direction. The central part of this block contains a two-story passageway consisting of solid slabs supported every 3 m by columns. The staircase module is located in the middle of the main building.

The two peripheral buildings are of designs similar to the main building except that they have three stories and portal frames spaced every 4 m. Each building has a detached staircase module in the center, connected by 1.5-m construction joints.

STRUCTURAL DEFICIENCIES

The original building designs did not consider lateral forces. Inadequately connected portal frames in the longitudinal direction do not provide sufficient stiffness or strength to transfer properly lateral loads during an earthquake. Construction joint separations are too small and could permit pounding during an earthquake. Window and door openings and mid-height partition walls create short-column conditions. The staircase modules show excessive deflection.

RETROFIT SOLUTIONS

Additional structural elements will be added to the buildings in order to increase their longitudinal stiffness. Two options are recommended: strengthening the unreinforced masonry infill walls by replacing them with reinforced masonry walls with proper connections to the concrete frames, or surface strengthening the existing walls with steel mesh and reinforced concrete. Separation joints will be added between walls and columns to mitigate short-column hazards. Supporting elements will be added to control deflection of the staircase modules.

A complete description of these structures, their analysis, and their retrofit designs can be found in: S. Díaz and F. Ponce, *Seguridad Sísmica de los Establecimientos Escolares en la Ciudad de Quito: Escuela Río Amazonas*. (Quito: Escuela Politécnica Nacional, 1995.)

Location: Panamericana Sur, at La Internacional

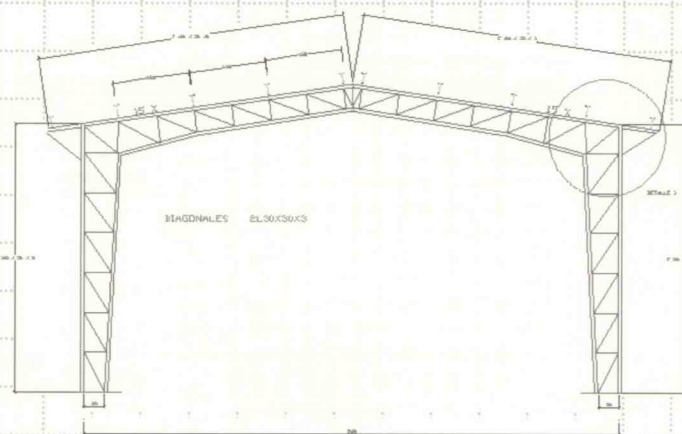
Year of Construction: Unknown

Prevalent Materials: Steel

Total Retrofit Area: 380 m² (4,090 ft²)

No. of Buildings Studied: 1

Estimated Cost: S/ 16,718,000 (US \$7,000)



Retrofit Design Detail

BUILDING DESCRIPTION

The 11 de Marzo high school, originally a warehouse, is a two-story steel-frame building with unreinforced masonry infill walls. It consists of eight rigid frames in the transverse direction and two braced frames in the longitudinal direction. The first floor uses wide-flange columns, the second uses tubular columns.

STRUCTURAL DEFICIENCIES

Because the unreinforced masonry infill walls are much stiffer than the steel frames, the wall-frame interaction could result in major damage to the frame during strong ground shaking. The bending capacity of the first-floor beams is low, and the beam-column connections in the longitudinal frames are not sufficiently rigid, potentially resulting in sudden collapse of the structure during an earthquake. Several steel members are corroded.

RETROFIT SOLUTION

Separation joints will be added between walls and columns. The bending capacity of the first-floor beams will be increased with proper reinforcement. Beam-column joints of the longitudinal frames will be reinforced to ensure continuity and proper frame action. Corrosion problems will be mitigated, and exposed steel members will be painted to prevent further corrosion.

A complete description of this structure, its analysis, and its retrofit design can be found in: J. Vintimilla, *Seguridad Sísmica de los Establecimientos Escolares en la Ciudad de Quito: 11 de Marzo*. (Quito: Escuela Politécnica Nacional, 1995.)

Location: Various locations throughout Ecuador

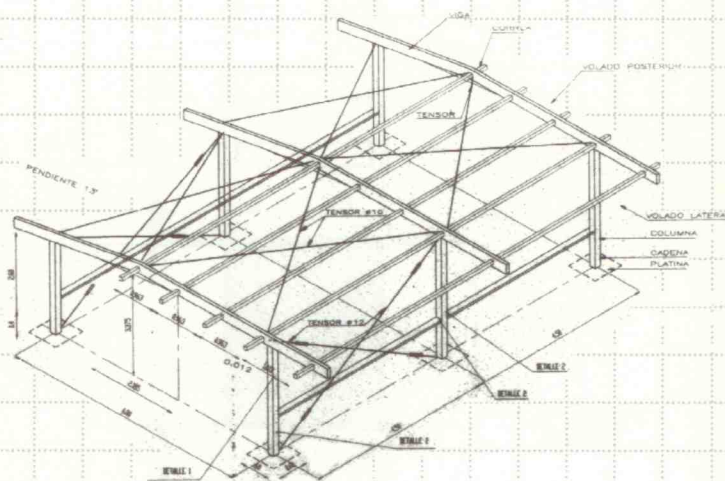
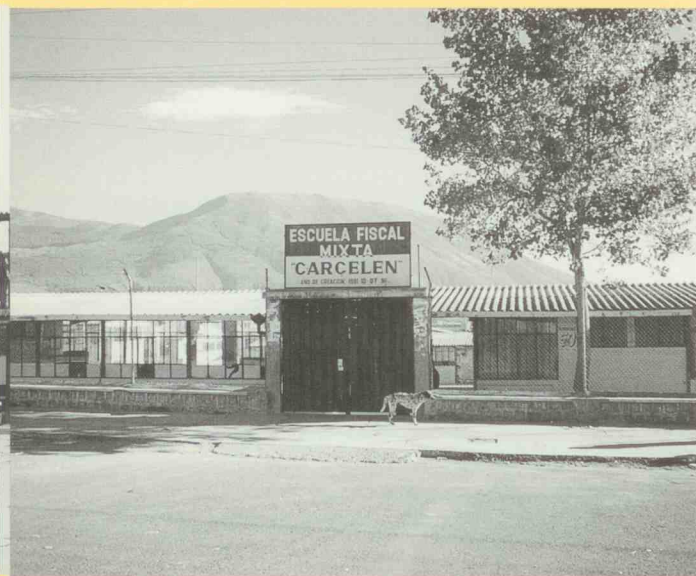
Year of Construction: Various

Prevalent Materials: Steel

Total Retrofit Area: Various

No. of Buildings Studied: Numerous

Estimated Cost: S/ 33,000 per m² (US \$1.20 per ft²)



Retrofit Design Detail

MODULE DESCRIPTION

The steel school module is a one-story structure with a lightweight gable roof. Several modules are connected in various configurations to form one school building. Lightweight steel tubular frame sections support the roof. The columns rest on individual reinforced concrete spread footings connected to tie beams and concrete slabs-on-grade. Infill walls are made of clay bricks or cement blocks with vertical and horizontal reinforcement. The walls are not separated from the steel columns. In some schools, exterior faces of steel members have been painted to prevent corrosion; interior faces of the members are usually unprotected.

STRUCTURAL DEFICIENCIES

The rigid, unreinforced masonry infill walls are much stiffer than are their flexible steel frames; the interaction of forces between the walls and frame could result in major damage to the frame during strong ground shaking. Window and door openings in the longitudinal walls create hazardous short columns. Corrosion of some steel members has reduced their strength and consequently their ability to resist earthquake loads. Modules are frequently altered after construction, sometimes creating additional hazards.

RETROFIT SOLUTIONS

Retrofit solutions for the most common deficiencies were developed. In general, the retrofit designs call for adding horizontal tensors at the roof level to increase earthquake resistance in the longitudinal direction; adding 2-cm joints between walls and columns to mitigate short-column effects; and mitigating the effects of corrosion by filling the tubular columns with concrete, and painting all steel members.

A complete description of this type of module, its analysis, and its retrofit designs can be found in: J. Fernández and P. Gachet, *Seguridad Sísmica de los Establecimientos Escolares en la Ciudad de Quito: Tipo DINACE*. (Quito: Escuela Politécnica Nacional, 1995.)

A Progress Report

Significant progress has been made in strengthening Quito's high-risk schools during even the first year of this project.

As of this writing, funding has been committed to retrofit 10 of this project's school buildings. The City of Quito has allocated funds to retrofit four buildings at its Experimental Sucre school. Ecuador's Project for Development, Efficiency, and Quality in Basic Education has agreed to retrofit six buildings at three schools: Ana Paredes de Alfaro, José de Antepara, and República de Chile. Retrofit construction for these three schools will commence shortly. Local philanthropic organizations and businesses have expressed interest in sponsoring additional school retrofits.

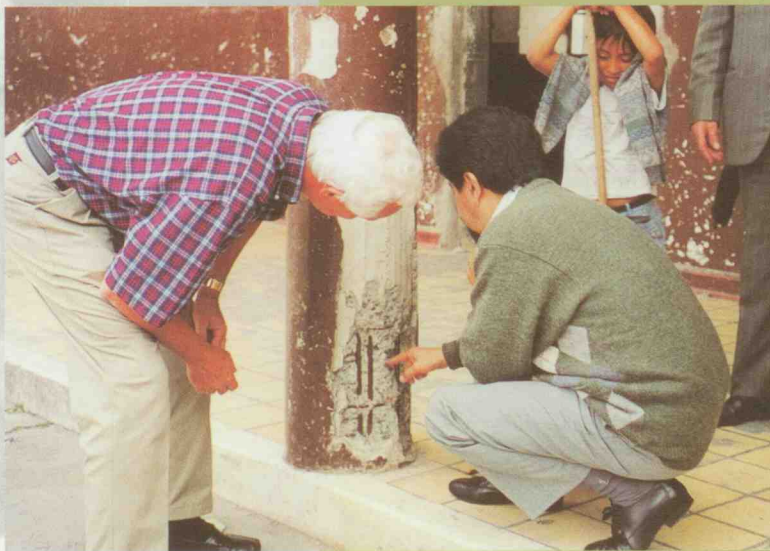
The City of Quito has agreed to fund the evaluation and retrofit of its Eugenio Espejo school, one identified by this project as vulnerable.

Most important for Ecuador's rapidly growing population, US AID-Ecuador has agreed to sponsor the design of new, earthquake-resistant school modules for the National Directorate for School Construction. These designs will be used for school construction throughout Ecuador.

Significant progress has also been made in learning how to identify and strengthen the remainder of Quito's vulnerable schools. Potentially vulnerable schools can readily be identified by experienced engineers with the methods used in this project. Based on the experience of this project, retrofitting schools to protect the lives of their occupants is affordable and inexpensive relative to a school's replacement cost.

The identification of high-risk schools and the design of their retrofits can generate local funding needed to strengthen the schools.

Engineers are shown here inspecting the República de Chile school, one for which retrofit funds have been committed.





THIS PROJECT IS ONLY THE FIRST STEP
TOWARD IMPROVING THE SAFETY OF QUITO'S SCHOOLS.

THE NEXT STEP CAN BE TAKEN BY
QUITO'S PARENTS, TEACHERS, AND COMMUNITY LEADERS.



Taking the Next Step

This project primarily involved Quito engineers, government officials, and education advocates. The engineers identified high-risk schools and designed retrofits. The government officials and education advocates provided guidance and raised funds for the retrofit construction. All have shown their commitment to school earthquake safety. They should be supported to continue this work until all of Quito's vulnerable schools are retrofit.

Parents and teachers were not directly involved in this project, yet they have the greatest personal interest in safe schools and can play an important role in making schools earthquake-resistant. Parents and teachers can:

- Raise awareness of the vulnerability of Quito's schools and the methods to make them safe.
- Request school inspections by structural engineers from, for example, Quito's universities and the Ecuadorian Structural Engineering Association.
- Identify and mitigate nonstructural hazards, such as unsecured bookshelves and heavy ceiling tiles, and develop earthquake preparedness and response plans for their schools. These activities are simple, inexpensive, and effective.

Earthquakes will be a part of Quito's future, as surely as they have been a part of its past. While it is not known when the next major earthquake will occur, it is certain that increasing earthquake safety in Quito's schools now will reduce future injuries and damage. This project is only the first step toward improving the safety of Quito's schools. The next step can be taken by Quito's parents, teachers, and community leaders.

Other GeoHazards International Publications:

Issues in Urban Earthquake Risk

The Quito, Ecuador, Earthquake Risk Management Project: An Overview

Uses of Earthquake Damage Scenarios

Escuela Politécnica Nacional, GeoHazards International, *The Quito, Ecuador, School Earthquake Safety Project: Investing in Quito's Future*. (Stanford: GeoHazards International, 1995.)

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