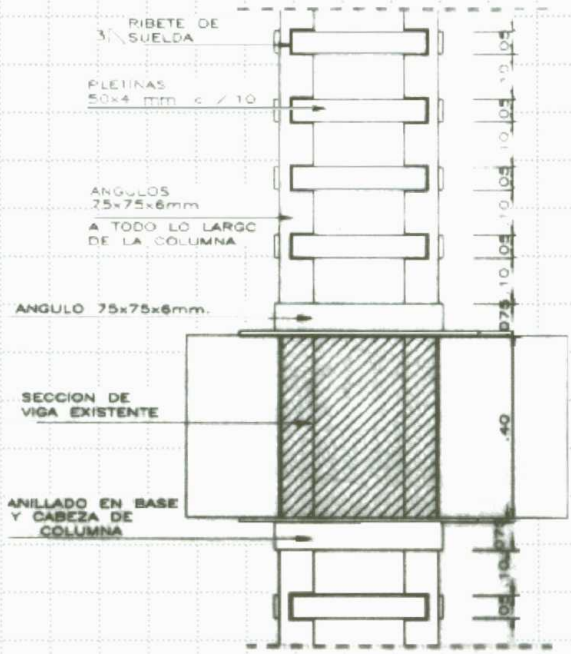


Retrofit Design Detail

Location: Various locations throughout Ecuador

Year of Construction: Various

Prevalent Materials: Reinforced concrete

Total Retrofit Area: Various

No. of Buildings Studied: Numerous

Estimated Cost: S/ 160,000 per m² (US $6 per ft²)

MODULE DESCRIPTION

These reinforced concrete school modules are connected in various configurations to form one school building. Rectangular columns are used to form longitudinal and transverse frames. Infill walls are made up of clay bricks or cement blocks with vertical reinforcing columns. Depending on soil characteristics, the foundations are made of reinforced concrete individual or continuous spread footings. Stair shafts are usually located at the corners of adjacent modules.

STRUCTURAL DEFICIENCIES

Because of the modular method of construction, these buildings lack stiffness in the longitudinal direction. Window and door openings in the longitudinal direction create short columns. Design details are inadequate. For example, improper construction joint details between blocks often result in rainwater leakage. In regions of the country with high humidity or frequent rain, the first floor is typically built with large openings in the walls, creating a potentially dangerous soft-story condition. 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 increasing the stiffness of the longitudinal walls and reducing the number of short columns by filling in some of the window openings, providing separation between columns and infill walls, and improving construction details.

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.)

Location: Various locations throughout Ecuador

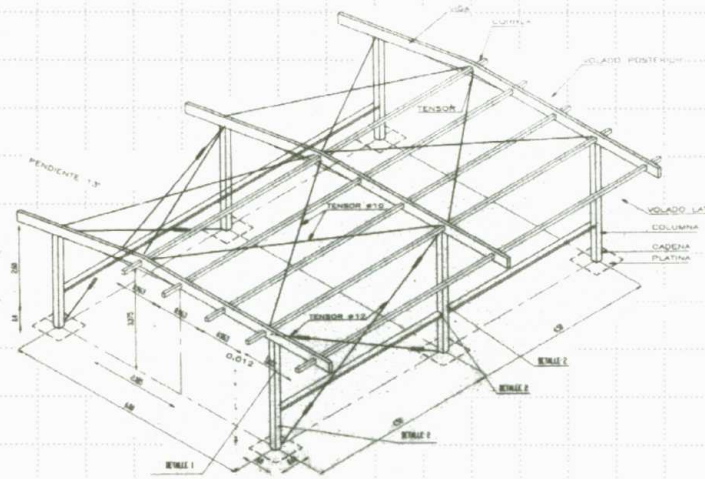
Year of Construction: Various

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.)