Architecture and the Safety and Vulnerability of Buildings in Earthquake Zones

Chairman – Tony Gibbs

Panellists:

Robert Woodstock, Gary Turton, Jenifer Smith
Buildings are designed by architects and engineers. In reality, in most cases, buildings principally for human occupancy are designed conceptually by architects. That is to say that architects are the ones principally responsible for the configuration of buildings for human occupancy.
D. UNUSUAL OR NOVEL STRUCTURAL FEATURES

- Cable-supported structures
- Shells
- Staggered trusses
- Buildings on hillsides

C Arnold
Configuration has to do with the shape and size of the building. Inevitably shape and size to a large extent determines (or greatly influences) the type, shape, arrangement, size, location and most other aspects of the structural concept.
"IRREGULAR STRUCTURES OR FRAMING SYSTEMS" (SEAOC)

A. BUILDINGS WITH IRREGULAR CONFIGURATION

- T-shaped plan
- L-shaped plan
- U-shaped plan
- Cruciform plan
- Other complex shapes
- Setbacks
- Multiple towers
- Split levels
- Unusually high story
- Unusually low story

Outwardly uniform appearance but nonuniform mass distribution, or converse

C. Arnold
In the words of Geoffrey Wood (one of the five founding partners of Ove Arup & Partners):

“Earthquake-resistant design is really a problem for architects.”
Either the architect has a better-than-usual knowledge of the basic principles of the conceptual design of earthquake resisting systems

or

The architect should involve the structural engineer in the initial discussions and development of the building concept.
Architectural Considerations
(GEM launch in the Caribbean)

04 May 2011

Tony Gibbs
The Tri-services Manual of the USA Army, Navy and Air Force states:

"A great deal of a building's inherent resistance to lateral forces is determined by its basic plan layout. . .

"Engineers are learning that a building's shape, symmetry and its general layout developed in the conceptual stage are more important than the accurate determination of the code-prescribed forces. . . ."
Irregularities in the floor plan
Structural engineer William Holmes, writing in 1976, states:

"It has long been acknowledged that the configuration, and the simplicity and directness of the seismic resistance system of a structure, is just as important as the actual lateral design forces."
Examples of structures with irregularities in elevation

(a) ABRUPT CHANGES IN GEOMETRY
(b) LARGE DIFFERENCES IN THE MASS OF STORIES
(c) LARGE DIFFERENCES IN THE STIFFNESS OF THE STORIES
Discontinuity in the elements and the flow of forces
Henry Degenkolb is emphatic in stressing the importance of configuration:

"If we have a poor configuration to start with, all the engineer can do is to improve a basically poor solution as best he can. Conversely, if we start off with a good configuration and a reasonable framing scheme, even a poor engineer can't harm its ultimate performance too much.

"This last statement is only slightly exaggerated."
Those quotations above warrant discussion among the various disciplines involved in the design and building processes. Terán (Nicaraguan architect) recommends that buildings be "simple, continuous, symmetrical, straightforward, and repetitive". This advice is given not as an absolute, but as a qualitative factor that influences the reliability of the structure. Terán asks for understanding and knowledge among the disciplines, not the imposition of mandatory constraints.
Use of seismic joints for structural designs of buildings with complex floor plans

(A) CONCENTRATION OF STRESSES IN STRUCTURES WITH COMPLEX GEOMETRY

CONCENTRATION OF STRESSES

(SEISMIC JOINTS

(B) SEISMIC JOINTS RECOMMENDED FOR COMPLEX FLOOR PLANS

PAHO/WHO - Disaster Mitigation in Health Facilities: Structural Issues
Asymmetry (false symmetry) due to the location of rigid elements
Architectural Considerations
(GEM launch in the Caribbean)

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Irregularities in elevation

PAHO/WHO - Disaster Mitigation in Health Facilities: Structural Issues
Soft stories
Damage caused by shearing force on ground-floor columns
Architectural Considerations
(GEM launch in the Caribbean)

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Structural damage mechanisms

(a) BEAM DAMAGE MECHANISM (RECOMMENDED)

(b) COLUMN-CONCENTRATED DAMAGE MECHANISM (NOT RECOMMENDED)
Interaction between structural and nonstructural elements

Story where the partition walls do not interact with the structure

Story with interactions between structural and nonstructural elements that modify the behavior of the structure

PAHO/WHO - Disaster Mitigation in Health Facilities: Structural Issues
Nonstructural Components

- Lighting System
- Roof
- Electrical and Communications System
- Air Conditioning, Heating and Ventilation
- Pipes, Medical Gases, Industrial Gases, Vacuum, Steam, etc.
- Parapets, Ornaments, Railings and Attachments
- Doors
- Ceiling
- Facades, Windows, Plastering
- Furniture and Equipment
- Divisions / Partitions

PAHO/WHO - Disaster Mitigation in Health Facilities: Nonstructural Issues
Response of different components and contents of a building during an earthquake

T. Guevara, 1999
Architectural components that run across seismic joints must be correctly detailed.
Basic services may be interrupted due to failures associated with the inappropriate crossing of seismic joints.
Horizontal seismic isolation
(case of High Damping Rubber Bearings – HDRB)
Base-isolation technique

Center of Information on Natural Disaster Research

Architectural Considerations
(GEM launch in the Caribbean)

Tony Gibbs
Energy dissipation

Tests with electroinductive dampers on the ENEA shake table.

Source: Alessandro Martelli
Method of “strengthening”: dissipation of energy used in the central offices of Instituto Mexicano del Seguro Social-México (PAHO)
The panel will examine the problems for the architectural designer when confronted by the earthquake hazard and some of the possible solutions to those problems.

It is also hoped that the GEM regional programme would have a measurably positive influence on reducing the vulnerability of future buildings.