Check List for Earthquake-Resistant Design

1 Seismicity

1.1 Earthquake History

1.2 Geology

1.3 Tectonics

1.4 The design earthquake characteristics

2 Site Conditions

2.1 Soils
- 2.1.1 Liquefaction
- 2.1.2 Seismic characteristics

2.2 Topography
- 2.2.1 Land slide
- 2.2.2 Building on slopes

3 The Clients Brief

3.1 Function

3.2 Cost

3.3 Reliability
- 3.3.1 Serviceability
- 3.3.2 Safety

4 Design Philosophy

4.1 Performance in moderate, frequent earthquakes
4.1.1 Protecting property
4.1.1.1 cost of repairs

4.2 Performance in strong, rare earthquakes
4.2.1 Saving lives

4.3 Critical facilities

4.4 Elastic behaviour

4.5 Post-yield behaviour
4.5.1 Ductility
4.5.2 Energy absorption
4.5.3 Deformations

5 Choice of Form or Configuration

Poor design concepts cannot be made to perform well in strong earthquakes

5.1 Failure modes
5.1.1 Redundancy
5.1.2 Accidental strength
5.1.3 Column capacities (and those of other vertical load-carrying elements) - New Zealands's "capacity design"
5.1.4 Brittle failures
5.1.5 Buckling failures
5.1.6 Designing for failure
5.1.6.1 avoiding failure in vertical, shear and compression elements

5.2 Geometric issues

5.2.1 Simplicity and symmetry
5.2.2 Length
5.2.3 Elevational shape
5.2.3.1 sudden steps and setbacks
5.2.4 Uniformity
5.2.4.1 distribution of structural elements
5.2.4.2 prismatic principal members
5.2.5 Continuity
5.2.5.1 columns and walls from roof to foundation (without offsets)
5.2.5.2 beams free of offsets
5.2.5.3 coaxial columns and beams
5.2.5.4 similar widths for columns and beams
5.2.5.5 monolithic construction
5.2.6 Stiffness and slenderness ($h > 4b$)
5.2.6.1 stiffness versus flexibility - table of pros and cons
5.2.6.2 maintaining the functioning of equipment
5.2.6.3 protecting structure, cladding, partitions, services
5.2.6.4 resonance
5.2.7 Diagrams of favourable and unfavourable shapes
5.2.7.1 square
5.2.7.2 round and regular polygons
5.2.7.3 rectangular
5.2.7.3.1 aspect ratios
5.2.7.4 **Ts** and **Us**
5.2.7.4.1 aspect ratios
5.2.7.4.2 deep re-entrant angles
5.2.7.5 **Hs** and **Ys**
5.2.7.5.1 aspect ratios
5.2.7.5.2 deep re-entrant angles
5.2.7.6 external access stairs
5.2.7.7 false symmetry - regular perimeter masking irregular positioning of internal elements
5.2.8 Soft storey
5.2.9 Cantilevers

5.3 Distribution of horizontal load-carrying functions in proportion to vertical load-carrying functions (avoiding the overturning problem)

5.4 Structural forms

5.4.1 Moment-resisting frames
5.4.2 Framed tubes
5.4.3 Shear walls and braced frames
5.4.4 Mixed systems

6 Choice of Materials

6.1 Local availability

6.2 Local construction skills

6.3 Costs

6.4 Politics

6.5 The ideal properties
- 6.5.1 High ductility
- 6.5.2 High strength-to-weight ratio
- 6.5.3 Homogeneity
- 6.5.4 Ease of making connections

6.6 Pecking order for low-rise buildings
- 6.6.1 Timber
- 6.6.2 In-situ reinforced concrete
- 6.6.3 Steel
- 6.6.4 Prestressed concrete
- 6.6.5 Reinforced masonry
- 6.6.6 Precast concrete
- 6.6.7 Unreinforced masonry

7 Construction Methods

7.1 Workmanship

7.2 Buildability

8 Components

8.1 Base isolators and energy-absorbing devices

8.2 Rocking foundations

8.3 Foundations
8.3.1 Continuous
8.3.2 Isolated
8.3.3 Piled

8.4 Movement joints

8.5 Diaphragms

8.6 Precast concrete

8.7 Welded beam-column joints for moment-resisting steel frames

8.8 Shear walls and cross bracing

9 Elements

9.1 Structure

9.2 Architecture

9.3 Equipment

9.4 Contents

10 Cost considerations

11 Analysis

11.1 Understanding the structural model

11.2 Torsional effects

11.3 Geometric changes
11.3.1 The P-delta effect

11.4 3-D analysis

11.5 Dynamic analysis

11.6 Stress concentrations

11.7 Complexity of earthquake effects and inadequacies of sophisticated analytical methods

11.8 Effects of non-structural elements

11.8.1 Change in the natural period of the overall structure

11.8.2 Redistribution of lateral stiffness and, therefore, forces and stresses (this could lead to premature shear or pounding failures of the main structures and also to excessive damage to the said non-structural elements due to shear or pounding)

11.9 Soil-structure interaction

12 Detailing

12.1 Compression members

12.2 Beam-column joints

12.2.1 Reinforced concrete

12.2.2 Structural steel :- all-welded construction

12.3 Reinforced-concrete frames

12.4 Non-structural walls and partitions

12.5 Shelving

12.6 Mechanical and electrical plant and equipment

12.6.1 Pipework

13 Construction Quality

14 Maintenance