# EcoSmart™ High-Rise Early Design Study
## Terms of Reference

## Scope
The scope of the proposed study is to identify the relationship between various existing high-rise construction systems and the principles of the EcoSmart™ Project.

## Background

### Principles
The goal of the EcoSmart™ Project is to minimize the greenhouse gas (GHG) signature of concrete by maximizing the replacement of Portland cement in the concrete mix with supplementary cementing materials (SCM) within the parameters of cost, performance, and constructability.

### Rationale
The rationale for this study includes the apparent challenges of schedule-driven high-rise construction, particularly for the tower portion of a structure. As demonstrated by a previous EcoSmart case study, the Bayview Building High-Rise Construction[1, 2], the main challenge exists with introducing EcoSmart concrete into the vertical/column and slab elements of the tower. The Fast and Epp, November 2000 report for EcoSmart, indicates that under the current construction practices, without some modification to construction procedure, it is not cost effective to use EcoSmart concrete in slabs, for example.

Therefore, there is a need to re-evaluate the current high-rise designs, construction methods, and use of materials in order to minimize the greenhouse gas emissions associated with the construction of high-rise structures.

### Context and Original EcoSmart Project TOR
The study is related to the original terms of reference of the EcoSmart Project in that it addresses the three desired outcomes:

**Early stage**

Develop design methodologies that take EcoSmart concrete properties into consideration at the time the structure is designed.

**Dematerialization**

Identify material reduction opportunities by using a smaller amount of better performing concrete or by using precast elements when possible.

**High-Rise construction**

The fast-setting requirements associated with high-rise construction make it very challenging to apply EcoSmart concrete to this important market. The project will search solutions to this issue both by looking at traditional cast-in-place methods and by investigating novel approaches such as a hybrid steel/concrete system. The project will invest in the additional research and design work necessary to produce a real case study using these innovative building design methods.

## Objective
The objective of the study is to produce the required knowledge for understanding the relationship between the selection of a high-rise building structural system and its environmental performance, cost and constructability.

The goal of this study is not to design new systems for high-rise construction; instead it is to compare available proven technology based on the principles of EcoSmart.

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[1] Fast and Epp Structural Engineers, November 2000, High Volume Fly ash Concrete Usage for High Rise Construction. www.ecosmart.ca.

[2] Busby & Associates Architects, November 2002. Use of EcoSmart™ Concrete in the Bayview High Rise Apartment, Vancouver, B.C. www.ecosmart.ca.

## Study Description

The study will examine current high-rise design options, construction methods, and materials usage, and identify how various solutions rate according to the following criteria:

1. maximizing
    a. cost effectiveness,
    b. performance, and
    c. constructability,
2. while reducing greenhouse gas emissions
3. during the entire life-cycle of the building.

The study will evaluate at least three design options for the structural system (i.e., at least one system from each of the three categories) indicated below.

### Building Systems

The subject of the building study is a typical residential high-rise condominium located in downtown Vancouver. It is 22 stories high with a typical floor plate dimensions of 23.1 x 24.7 meters and the corresponding area of 465 $m^2$ per floor as shown on the enclosed sketch on Figure 1. The building height is specified in terms of floor-to-floor clear height of 2400 mm only.

The exterior envelope is assumed to comprise of a full height double glazed window wall cladding system, commonly used in this type of building construction in Vancouver. Alternate comparable cladding can be suggested for the building in order to ensure compatibility with the structural system under evaluation.

### Floor Construction Criteria

Architectural:

- Floor finish: top–screeded concrete
- Floor soffit: painted concrete or suspended gypsum wallboard

Structural

At least three flooring systems (i.e., at least one from each of the following three categories) will be evaluated:

1. Traditional cast in place concrete
2. Conventional precast or Hybrid concrete-precast (e.g., Precast Seismic Structural System (PRESSS))
3. Steel, or Hybrid concrete-steel, or other system as proposed by the consultant

The total depth of the floor plus service space is not fixed but should be optimized to minimize the total height of the building.

Mechanical and Electrical Services

The services need to be contained in the floor system itself or in the ceiling space provided. Mechanical duct size, if it is to be contained in the floor, should be on average 8000 $mm^2$ in cross section.

Acoustical

52 STC sound transmission class rating minimum.

Fire rating

2 hours

While the study will focus on the structural design and selection of primary construction materials, the effect of the other elements of the building system: Envelope, Mechanical and Interior and the degree of integration between these different elements and the structure need to be consider in the final assessment.

**Environmental Performance**

Environmental performance and impact will focus on GHG emissions only.

The study will refer to existing emission and impact factors readily available and accepted by industry, such as Athena, BEES, IISI, or factors proposed by standards, industry associations, or federal, provincial or local governments.

The calculations should be parametric. The end results should be linked to emission factors to allow future updates or "what if" scenarios.

**Economics**

The economics will take into account costs incurred during the entire life-cycle of the building (see life-cycle below).

It will include direct and indirect costs such as financial cost, bank interests or extra-design cost.

**Constructability**

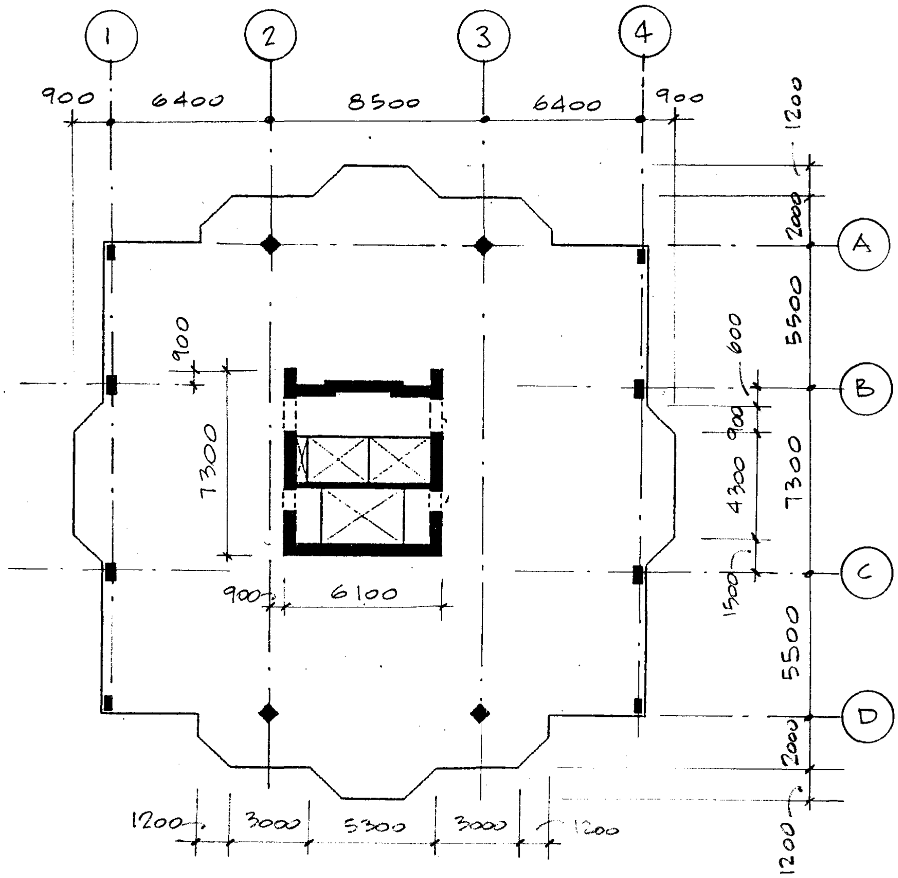
The assessment of "constructability" will use proxy data such as:

- Time for construction
- Cost of construction equipment
- Trade and labour availability
- Financing
- And other

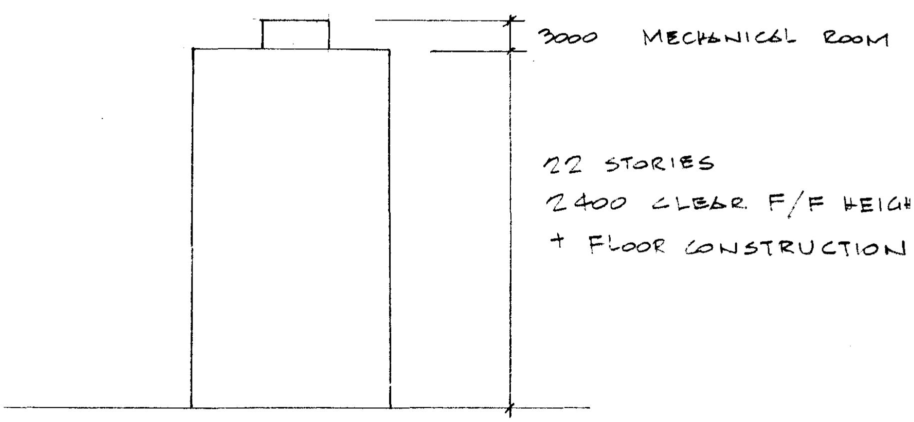
**Life-Cycle**

The study will cover the entire life-cycle of the elements of the building:

- Extraction and process of primary materials (e.g., limestone and iron ore)
- Manufacturing of material (e.g., cement, steel, plastic, drywall, etc.)
- Design
- Construction
- Operation (e.g., HVAC, maintenance, remodeling, refurbishing)
- Demolition or disassembly (e.g., elements reuse, recycling, "downcycling")
- Transportation of materials for each life-cycle phase
- And other, as applicable




**Typical Floor Plan**




**Building Envelope**

**Figure 1: Typical Floor Plan**