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By Jocelyne Hébert, Roger Cyr, Eng., Louis Crépeau, Eng., Luc Laliberté, Eng., Louise Lecompte, Eng., Guy Vachon, Eng.

BUILDING STRUCTURES

A vast field worth mastering!

We are continuing with our presentation of the six competency profiles published by the Ordre in its Guide to professional practice (www.gpp.oiq.qc.ca, "Professional development" section). This month: building structures.

Building structures is a field that is as wide as it is complex and is fraught with specific challenges.

Engineers specialized in building structures must comply with various standards and codes, deal with many types of stakeholders, work with ever changing materials and conditions … In short, they must master a great number of competencies which, to say the least, cannot be acquired through books; the committee responsible for developing the competency profile estimates that, in order to consider himself or herself autonomous, the engineer must have five to ten years of experience in the field. Five to ten years during which engineers will agree to having their plans and designs reviewed, consulting with those who have more experience, in short, to being supervised. Even then, and after having gained the required experience, it is always advisable to have one's projects reviewed by one's peers.

This long learning period may be surprising, even disheartening for young engineers who are excited to begin practising independently once they've obtained their title and seal. Still, it remains absolutely necessary since practising engineering and dealing with framing and foundations come with great responsibility. In this field, where every plan is based on a number of calculations and an incomplete or erroneous design can lead to serious consequences, quality is a must.

Experience is thus acquired by working alongside seasoned colleagues and through teamwork, where ideas and opinions can be shared. In that respect, the competency profile provides an overview of the skills engineers must possess and keep up to date in the field of building structures. Even experienced engineers will find this tool useful to detect possible shortcomings they may have relating to their competencies, whether technical or general.

TECHNICAL COMPETENCIES

As the saying goes, "The devil is in the details". In the building structures field, no calculation is useless, no research, superfluous. For each technical step, engineers must rely on sound know-how and be fully aware of the basis and effects of their undertakings. Here are some examples of technical competencies which must never be neglected or underestimated.

When elaborating design parameters (section A1 of the detailed description of required competencies in the competency profile), engineers must, among other things, determine which regulatory framework applies. They must find the competent authority for a given project and determine which standards and codes are applicable. Although this step may be a relatively simple one, it still requires experience and judgement. In cases where the standards and codes are imprecise or if they are simply not required (for example, in certain municipalities or for certain types of structures), the engineer's work must nevertheless be based on principles and theories which serve as the basis for recent standards.

Furthermore, aseismic calculations, which are relatively new, are becoming more and more complex given that they are subject to the fast paced evolution of applicable codes and notions. A few years ago, dynamic analysis and soil liquefaction were topics that weren't discussed by many. As such, small engineering offices are at a disadvantage compared to large firms since the latter often have engineers specialized in seismic calculations on staff.

In this field, it is clear that a good basic education coupled with continuing education and a working knowledge of worksite construction methods are paramount. More than once, the competency profile highlights the competencies related to seismic issues. Thus, in order to evaluate the architectural design's compliance with the regulatory framework applicable to the structure (A3), engineers must be able to:

- validate the proposed project's compliance with aseismic requirements;
- with respect to existing buildings, validate the proposed transformation's compliance with aseismic requirements;
- if needed, propose appropriate modifications, as early as the initial design stage.

Charge calculations A6) are also becoming more and more complex and are based upon a number of standards which need to be interpreted. In order to develop the structural system, one must calculate gravitational, lateral (wind and earthquake) and other charges, such as earth pressure and hydrostatic uplift. This type of work is introduced in university but requires much more in-depth training.

Another task that requires a more particular thought process is determining the forces diagram (A4). Engineers who design a building's structure must determine the path of gravitational and lateral forces down to the foundations. However, the importance of this aspect is often underestimated, and this ripples through the calculations

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and drawings. We must pay special attention to joints or junctions between various systems (slabs, columns, building envelope, architectural devices, diaphragms, bracings, foundations…) or between various materials.

Beyond the calculations and the software that carries them out, designing engineers must be able to understand the constructability of a structure. How will the structure be assembled? What are the construction methods usually used on the worksite? What difficulties can be foreseen given the conditions of the site (access, site dimension, winter conditions…)? Will the interface between materials (wood, steel, concrete) happen harmoniously and according to the engineer's design? This notion can only be learned through working with experienced peers and is essential to obtaining satisfactory results that will stand the test of time (A5, "Analyzing different structural systems scenarios").

One of the main lessons that designing engineers must learn is to avoid undertaking calculations on numerical models too quickly (A6). For example, the rigidity hypotheses that were selected in extremis can have a great impact on analysis results. Much like a sculptor tries to imagine his or her work in the crude stone, building structure engineers start by visualizing their design in three dimensions so as to understand all of its elements.

Building structure engineers, even those who plan on doing on-site work, must be able to design as well. In fact, field engineers will not only have to interpret drawings, they will need to pinpoint possible problems, understand why an element is placed a certain way, why this or that type of welding or joint is required, why a particular material was chosen, etc.

GENERAL COMPETENCIES

Building structure engineers must work in a difficult context. Each project can include a tight deadline, a specific construction method (accelerated, turn-key, per lot), limited budgets and many other factors which could impact the work's progress. For instance, with an accelerated construction, plans are often presented as they are prepared during the building's construction. Modifications can also arise during the course of the project; they can come from various sources and can sometimes have repercussions on the building as a whole.

In addition to these technical contingencies, engineers must deal with the pressures coming from stakeholders, clients and employers. For example, designing a school, which took a year in the 1960s, must now be completed within a few months. Admittedly, today's work and communication tools are much faster and more efficient, but they often serve as pretence to set tight deadlines, which leave engineers unable to take a much needed step back.

However, all these stressful conditions should not prevent engineers from practising their profession in accordance with good practices. In order to achieve this, they should develop skills in communication, negotiation and coordination. How can we convince our employers that time gained by presenting incomplete plans will be caught up and sometimes extended on site? What words can we use to help clients understand that a correction that costs $1 at the drawing stage can cost $10 at the shop drawing stage and $100 on site? How can we maintain our authority on the work site and develop a trusting relationship with the client?

Each one of these elements is taken into account with respect to the general competencies building structure engineers must acquire and maintain.

As a whole, the competency profile is linked to a sweeping notion which must guide engineers in all of their actions: professional responsibility. When they sign a drawing, engineers must be fully aware of their professional responsibility, that is to say they must have confidence in the work they put in to produce the drawing. It bears reminding that such self-assurance can only be acquired after many years of supervised work. Given that building structure engineering is an ever changing field, the competencies relating to it will always have to be updated through continuing education. Quite a task!

Members of the drafting committee
Competency profile in building structures

Roger Cyr, Eng.
Vice President of Development,
Leroux, Beaudoin, Hurens and Associates Inc.

Louis Crépeau, Eng.
Director, Structures, exp.

Robert De Gols, Eng.
Consulting engineer

Luc Laliberté, Eng.
Consulting engineer
Member of the Professional Inspection Committee at the Ordre des ingénieurs du Québec

Louise Leconte, Eng.
Senior partner, SDK

Guy Vachon, Eng.
Building engineer

Serge Vézina, Eng.
Vice President, Engineering, Major and special projects, Montreal Structure Department, Dessau Inc.

Sources of information

Here are some useful sources of information for engineers working in building structures:

Canadian Standards Association (CSA):
http://www.csa.ca/cm/ca/en/home

Canadian Wood Council (CWC):
http://www.cwc.ca/index.php

Canadian Institute of Steel Construction (CISC) / Québec section: http://quebec.cisc-icca.ca/

Montreal Structural Engineers (MSE):
www.ism-mse.ca

Canadian Society for Civil Engineering (CSCE):
http://www.csce.ca/Accueil

American Concrete Institute (ACI): www.concrete.org

American Institute of Steel Construction (AISC):
www.aisc.org

American Society of Civil Engineers (ASCE):
http://www.asce.org