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The Role of the Structural Engineer

History
For as long as humankind has walked the earth, we have sought to improve and adapt our environment, although often great structures were understandably built in early history by trial and error. The Roman builders were perhaps the first to adopt an analytical approach to building geometry and record those methods for practical use. Following the decline of the Roman age, much of that recorded knowledge fell into disuse, great cathedrals were built, often by empirical methods. In the 17th century some thinkers turned their attention to the physical sciences. As the first industrial revolution became established, new materials became available that advanced the boundaries of established knowledge.

At the beginning of the 20th Century, new forms of construction were emerging with the use of reinforced concrete and steel frames. There was a plethora of proprietary systems and patentees, but no regulating body to advise upon acceptable practices.

A ruling body that would provide design guidance to support parties planning to deploy reinforced concrete and steel frames, was required. Such guidance was not catered for by engineering institutions then in place, nor was there any provision as to how to use these materials within the London Buildings Act.

In 1908 a group of practitioners congregated in London's Ritz Hotel and collectively agreed to the establishment of The Concrete Institute. Interestingly, the hotel in which they met had recently been completed using a steel frame within its construction; a reflection of the rapidly evolving construction industry of the time.

Four years later, it became clear that the growth in construction necessitated the establishment of a more broadly based body to advise on good practice in all aspects of structural engineering, particularly steel frames. This duly gave rise to the Institute of Structural Engineers, itself developed from the Concrete Institute.

The formation of this new Institute brought about the definition of specific relevant terms as follows:

- "Structural Engineering": "a branch of engineering which deals with the scientific design, the construction and erection of structures of all kinds of material"[1]; and
- "Structures": "those constructions which are subject principally to the laws of statics as opposed to those which are subject to the laws of dynamics and kinetics, such as engines and machines".[1]

The Role of the Structural Engineer
The role of the structural engineer is an essential element in the construction process. Structural engineering is a specialised discipline within the broader discipline of civil engineering, where structural engineering is concerned with the design and integrity of structures such as, buildings, bridges, and monuments.

[1] https://www.istructe.org/about-us/our-history/

Structural engineers must have a sound understanding of maths and physics, and the ability to apply those skills in creative problem solving. Being able to understand the theoretical principles of mechanics, mathematics and physics is not enough, however, to define an engineer. Those skills must be developed by applying them to the design of safe and sustainable structures. Structural engineers often take a sophisticated concept design and develop a solution that is capable of being executed practically, safely and within commercial parameters.

The roles and responsibilities of structural engineers can be diverse and varied but typically include:

Design
For many structural engineers, the primary focus is the technical structural analysis in the design of structures. Typically, this covers deriving the loads and assessing stresses the construction will be subjected to in service. Structural engineers also need to have an in-depth knowledge of the properties of a range of building materials, and understand structural form to provide support beams, columns and foundations.

Investigation
Before design work can begin, structural engineers are involved in preliminary investigation and survey of proposed building sites to determine the ground conditions to assess foundation options, and often to assess existing structures for planned modification.

Communication
One of the fundamental abilities sometimes overlooked is communication. As structural engineers often work as part of teams comprising multiple construction professionals, their ability to communicate ideas and solutions to provide co-ordinated responses to a problem is vital to the success of a project. Such communication and collaboration skills are also of importance in the instance that structural engineers are called upon to assist government bodies with investigations relating to their specialist field.

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Due Diligence
In modern society the term "Engineer" is overused, perhaps sometimes abused. However, in the United Kingdom, not only is a designated title of 'Chartered Engineer' highly respected, but '...it is also protected by Civil law'[2].

In order for this title to be bestowed on an individual, they will have to hold either a relevant degree (such as mathematics, engineering or science) or a Higher National Certificate or Diploma. A further stipulation, in place since 1997, means that candidates are required to demonstrate additional learning and knowledge by gaining a relevant Masters' degree.

[2] The Engineering Council - http://www.engc.org.uk

With this training and associated assessment completed by a sponsoring institution, an individual can then apply for Chartership registration with the Engineering Council in its capacity as the regulatory body for engineers

As this registration is required, this means that due diligence as to the qualification and relevant experience of individuals can be checked readily.

In addition, there are also professional bodies that maintain membership directories as follows: The Institution of Structural Engineers Institution of Civil Engineers

It is perhaps worth noting that, by contrast, the contracted term 'Engineer' – interpreted often to denote someone engaged in the design, manufacture, operation and maintenance of a system – is not a protected title in the UK. This is the case, as the terms 'engineering' and 'engineer' having been used in common parlance for many centuries.

Responding to the Environment
A significant factor in drawing up design is to use the environment in which the structure is to be built, operated and maintained. Accordingly, parameters for designs are based upon statistical analysis of historic data to ascertain the likelihood of an event impacting a given structure.

For example, the impact of wind loading, and rainfall associated with a 1 in 100-year (or 1%) storm – are assessed to ascertain how they will affect the life of the building. As a greater volume of more detailed information is recorded, fundamental design parameters are continuously evolving, not least because intense storms are occurring with increasing frequency.

In addition, building gravity loading comprising of permanent (dead) loading and variable occupancy (imposed) loading are also considered. Those occupancy loadings set out in standards are related to statistical probability that they will not be exceeded.

A Continuously Evolving Profession
On May 16th 1968 in Canning Town, London, a gas explosion caused Ronan Point, a 22-storey block of flats to partially collapse.

Although, fortunately, there were few casualties, subsequent investigations identified deficiencies in both design and construction as factors that had given rise to the failure. Inevitably, public confidence in high-rise residential buildings sank, but as a result of the investigations, major changes in UK building regulations were implemented. Those findings influence how we design buildings today:

"The building shall be constructed so that in the event of an accident the building will not suffer collapse to an extent disproportionate to the cause.[3]"

Disproportionate Collapse
To assess whether a collapse is disproportionate, the following factors are considered:

- The collapse, proportionate to the size of initial event; and

[3] HM Government – The Building Regulations, *A3 Disproportionate Collapse,* Page 41 For Use in England, incorporating 2004, 2010 and 2013 amendments

- The degree to which the damage extended, which has given rise to gradual collapse, may be deemed to have brought about disproportionate collapse.

There are, however, instances where complete collapse is accepted. In other cases, partial collapse, without collapse spreading unduly, or indeed a significant distortion or alteration to the structure can be regarded as manageable. That is, the structure must be stable as opposed to serviceable as, ultimately, the imperative is for the structure not to put lives at risk.

Once occupants are evacuated to a place of safety, it may be necessary to demolish the building. The structural requirement states that the primary frame and floors must provide for emergency evacuation, but does not extend to the stipulations regarding the protection of façade, finishes etc. That is, the requirement has a simple aim of saving lives. It is not required to attenuate all outcomes, rather, just avoid collapse becoming disproportionate.

Continual Development

On June 14th 2017 the 24-storey Grenfell Tower block in North Kensington, London caught fire. The fire, which engulfed the building caused at least 72 deaths, and over 70 injuries.

As with Ronan Point, public confidence in such structures has dropped. This and the subsequent Hackett report which identified shortfalls in current building regulations, mean changes in UK building regulations are expected to be implemented.

Looking to the Future

It has been said that were it not for engineers, we would all still be living in caves. We sometimes allow ourselves grandiose mission statements, “to divert natural resources for the benefit of humankind”. Perhaps more pertinent to our engineering role is we are at the forefront of assessing the natural environmental influences on our designs, wind, rain and flood. Over the course of my 30+ year career, what might have been considered an exceptional event a few years ago is now becoming common place. I am confident, however, our profession will continue to manage new emerging challenges

If you require any further information, please contact Philip Ebbatson at philipebbatson@hka.com.