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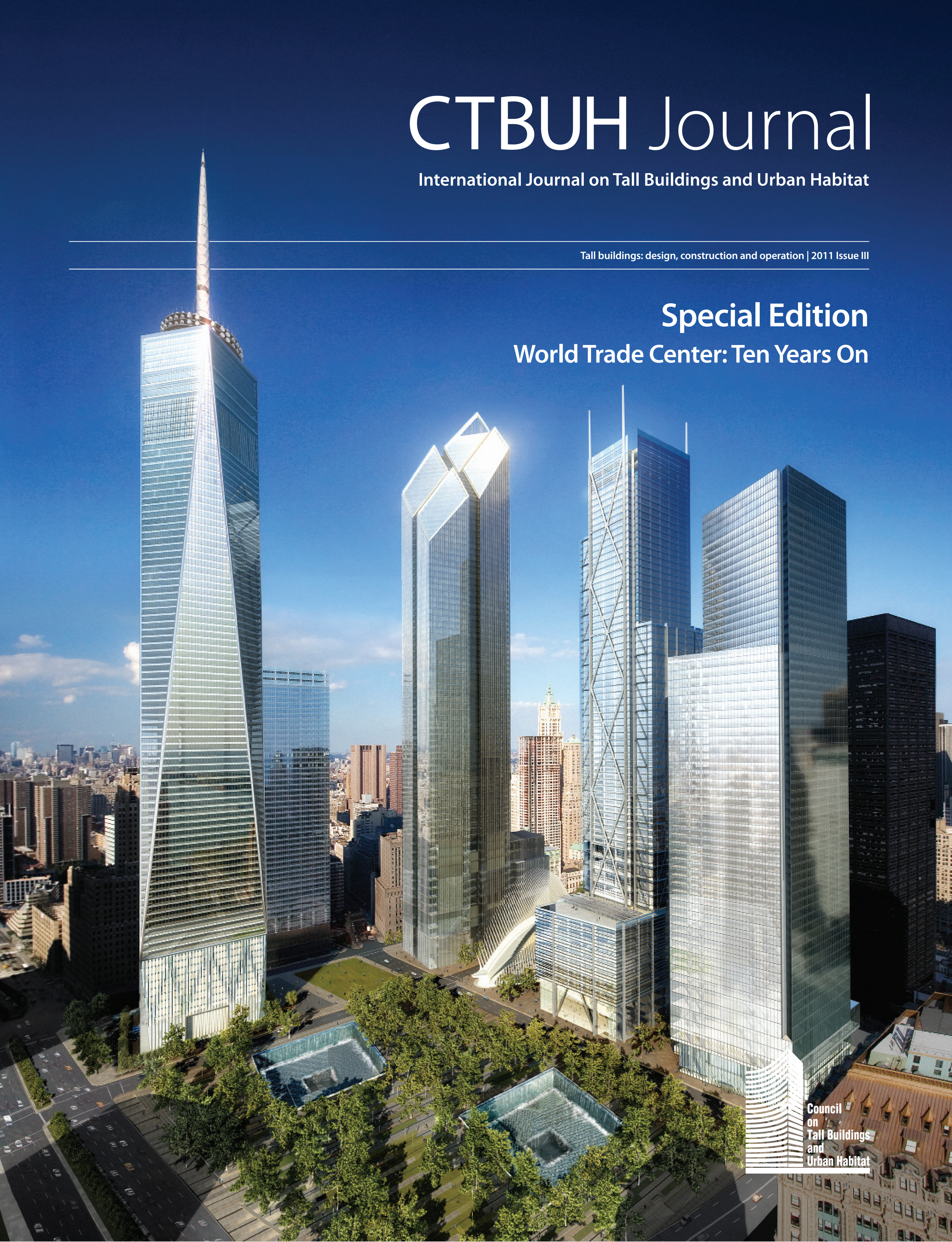
World Trade Center: Ten Years On



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Case Study: One World Trade Center, New York

"While, in an era of supertall buildings, big numbers are the norm, the numbers at One World Trade are truly staggering. But the real story of One World Trade Center is the innovative solutions sought for the unprecedented challenges faced in building a project of this size on such a difficult site."

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Revitalizing Lower Manhattan: World Trade Center in Context

"It is nearly impossible to predict when the World Trade Center site will be fully rebuilt and occupied. As it is already gradually becoming part of the New York urban context, it can be argued that there will never be one definitive moment of completion."

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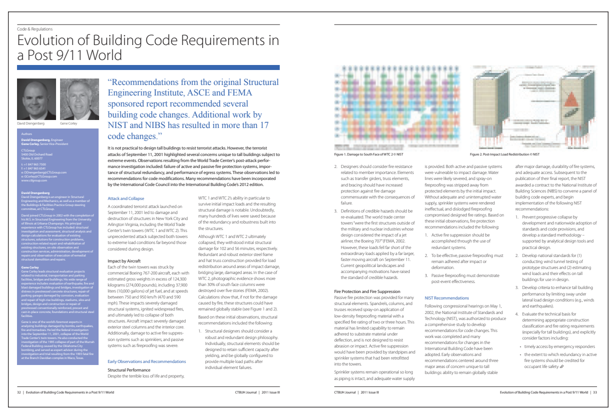
Evolution of Building Code Requirements in a Post 9/11 World

"Recommendations from the original Structural Engineering Institute, ASCE and FEMA sponsored report recommended several building code changes. Additional work by NIST and NIBS has resulted in more than 17 code changes."

"The WTC showed that we lack an adequate definition of competence… What we truly need is to legislate competence, not standardized solutions."

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Challenging Attitudes on Codes and Safety

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José was elected fellow of the Royal Society of Edinburgh in 2008 and the Royal Academy of Engineering in 2010. He was awarded the Arthur B. Guise Medal by the Society of Fire Protection Engineers (USA) and the Rasbash Medal by the Institution of Fire Engineers (UK) in recognition of eminent achievement in advancing the Education, Science and Engineering of Fire Protection. He has participated in landmark projects like the NASA Space Shuttle Hangars in Florida, the 80 story Heron Tower in London, the Clyde and Dartford Tunnel fire safety design, the investigations of the WTC 1, 2 and 7 collapses, the Madrid Windsor Tower Fire, the Texas City and Buncefield Explosions as well as the Ycua Bolanos supermarket fire.

José is co-chair of the CTBUH Fire and Life Safety Working Group.

The history of technological evolution is filled with failures and the lessons learned from them. Many will even claim that "design by disaster" is one of the most effective methods for progress. The World Trade Center is no exception. The collapse of the World Trade Center buildings created the potential to question the mere nature of tall buildings and examine tall building design in ways that we could never have anticipated. Nevertheless, tall building design in the last decade was not primarily driven by September 11, 2001 but by a strong impetus towards sustainability and a thriving real estate market. The result has been unprecedented growth in the number of tall buildings and unprecedented innovation driven by sustainability.

While sustainability is a managed life cycle where proactive decisions are made to reduce consumption and negative impact from the inception of a project to the disposal of the infrastructure, fire safety is the social responsibility that requires adequate measures to be taken to mitigate foreseeable risks associated with fire. Thus, while the fire safety questions raised after the WTC event are an integral part of sustainable building design, they do not reflect the definition of sustainability and therefore cannot be construed as the driving evolutionary force in tall building design over the last decade. Although the World Trade Center failures have not driven the evolution of tall buildings, a series of more subtle, but not less important, lessons were raised after the event.

Engineered Solutions

The social responsibility associated to fire safety has been historically translated into codes and standards that establish prescriptive requirements for buildings. These prescriptive requirements, if followed carefully, provide the minimum level of safety required by society. There have been periods in which codes and standards had enough embedded knowledge that they could respond to all variants of construction innovation. In these periods all aspects of infrastructure could be comprehensively classified into some group that is fully addressed by a specific set of rules. Few exceptions appear outside the codes and standards and require individualized solutions. In periods of great urban or technological development codes and standards cannot cope with the evolution imposed by the drivers of the construction industry. In these periods codes and standards fall behind, standard solutions only concern a select number of buildings and in most cases individualized solutions are necessary. Explicit definitions of safety produced using engineering tools need to complement codes and standards to provide individualized solutions. The WTC epitomized innovation and most of the technical solutions involved were evaluated using the most sophisticated engineering tools of the time . Fire Safety was established in a purely prescriptive manner. WTC emphasized the need for engineered solutions. Given that the last decade has been a period of great innovation for tall buildings, Fire Safety Engineering has felt the need for a systematic move from prescriptive to performance-based analyses.

The tall buildings community turned towards the investigation of the WTC to derive the necessary lessons that would enable adequate performance-based analysis. Nevertheless, extracting lessons from a failure to enable professionals not to make the same mistakes requires a minimum level of prior understanding. The most successful investigations are those conducted in an atmosphere where all those involved have sufficient knowledge to make the most of the investigation and to transfer that new knowledge into the design process. In the past, fire investigations had been conducted in such an atmosphere. The unprecedented magnitude and novelty of the WTC failures caught the fire safety and structural communities unprepared for the investigation. Thus, these professional communities have managed to produce, over the last decade, the science necessary to unveil many of the phenomena, but have not been able to transform the knowledge into design methodologies and tools. As a consequence, many new requirements have emerged, not always because they were needed, or because we were ready to define them, but mainly because something had to be done. These gaps of knowledge are now evident. The future of tall building design depends on our capability to continue filling these knowledge gaps and transforming the knowledge into design methods at a pace faster than the transformation of tall buildings driven by other forces such as sustainability or cost.

Problems need to be understood and resolved by means of the most adequate methodologies. The WTC demonstrated that for tall buildings, egress and structural performance are the pillars on which fire safety stands. Only for tall buildings is egress on a similar time scale to the deterioration of the structure by fire. Thus both components of the fire safety strategy are coupled. Egress times can be reduced, but for tall buildings, they can never be made much smaller than structural failure times. Improvements in egress have therefore been legislated through code requirements. Innovative structures thus need a proper engineering analysis because they do not conform to standard practices and the integrity of the structural system is the guarantee for safe egress. In the absence of an adequately durable structural design, enhanced egress capabilities cannot be used as compensation. The safety of tall buildings requires an explicit structural analysis conducted using state of the art engineering tools. The WTC did not introduce fire safety within the structural design process, thus it was not optimized correctly. The failure to understand the structural behavior in fire resulted in disproportionate and unpredictable consequences. Tall buildings are by nature optimized structures, thus their design has seen the need to incorporate fire safety as an integral component. The last decade in particular has seen the development of novel tools for the design of structures for adequate fire performance.

Professional Competence

WTC showed that the responsibility for integrating structural integrity to the fire safety strategy was undefined. While in a prescriptive environment the architect is responsible for the definition of thermal protection to the structure, no one was responsible for the assurance that the structure will perform adequately. The implicit assumption that thermal protection is sufficient to guarantee safety was proven inadequate. For tall buildings, it has become clear that the structural engineer needs to assume responsibility for the adequate performance of the structure in fire. Nevertheless, the drive for sustainable tall buildings is introducing fundamental changes in structural design, material selection and potential fire conditions. Questions of competence emerged when the analyses of professionals were put into question. What does a structural engineer need to know to be able to design a tall building that will be safe in a fire? What does a Fire Safety Engineer need to know to be able to design a proper fire safety strategy for tall buildings? Sustainable tall buildings now require the involvement of professionals competent in the design of a complex and comprehensive fire safety strategy.

Throughout the WTC investigation it became very clear that the framework educating fire safety engineering professionals is designed to operate within a prescriptive environment and does not incorporate the knowledge base necessary for engineering based safety. If we are to continue to strive for sustainable infrastructure and innovation, then we need to support the development of an educational framework that will enable our professionals to deliver safe infrastructure. The current framework is not suitable. Furthermore, the WTC showed that we lack an adequate definition of competence. When addressing tall buildings, our current definition of competence not only leaves enormous knowledge gaps, but is also structured around incorrect objectives.

The WTC showed that if we want sustainable tall buildings we need to develop the knowledge base and the technological tools that can adequately assess the performance of a fire safety strategy. We need to incorporate this knowledge, not by legislating new rules, but through adequate professionals and a relevant definition of competence. What we truly need is to legislate competence, not standardized solutions. ■

Figure 1. Photo luminescent stripes in the stair cases of 7 WTC as extra safety measure © Jan Klerks