

# Managing the Consequences of Fire

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## Discussion Paper

Explicit definition of the stakeholders and their attributes is essential when addressing safety. Without these explicit definitions there is many times confusion of roles and misunderstanding of competence. Safety, under these circumstances, cannot be achieved. The definition of each stakeholder and their attributes will be explored in the context of fire safety and the events of September 11<sup>th</sup>, 2001.

Risk (R) is, in its simplest definition, the product of the probability of the event (P) and the Consequence potential (C).

$$R=P \times C$$

It is the basic formulation of risk that enables the definition of the main stakeholders in fire safety. The first stakeholder is the *"public."* The *"public"* is to be assumed as an ignorant and passive participant. The *"public"* is not required to understand the level of safety of the infrastructure he/she utilizes. It is clear that fire drills, information and induced behaviour are intended to mould the *"public's"* actions to enable fire safety. Nevertheless, the *"public"* is not expected to play an active part or to have an explicit understanding of its role in the implementation of fire safety. Thus the *"public"* is there to be protected. The role of the *"public"* in the events of September 11<sup>th</sup>, 2001 can be considered as exemplar. The *"pubic"* followed the ideal behaviour and was guided in as effective a manner as possible.

The role of the *"public"* is the only role that can be easily defined when dealing with fire safety. Other stakeholders can only be defined within the context of the regulatory framework. Therefore, the main features of the framework that regulates fire safety will be briefly defined.

Fire safety can be implemented in a prescriptive way or by means of engineering solutions (i.e. performance based design). Prescriptive definition of fire safety relies on code compliance while performance based design relies on competent utilization of engineering tools.

In a prescriptive environment, infrastructure is classified according to its characteristics. The classification will then impose a series of well-defined actions that are intended to mitigate the consequences of a fire. This is a very important point; prescriptive design does not address the probability of the event, but mitigates its consequence. It is safe to say that in prescriptive design it is assumed that the probability of a fire is one. The actions following the classification will then deliver an acceptable (but implicit) set of consequences in the event of any fire. The means by which prescriptive rules achieve acceptable consequences are many (testing, theory, calculations, common sense, individual interests, etc.) and in many cases are very controversial. These methods will not be discussed here and it will be assumed that prescription is acceptable management of consequences.

The design of infrastructure in a prescriptive environment requires two main stakeholders; the *"designers"* and the *"approvers."* The former is an individual or a group of individuals that will make use of the prescriptive rules to deliver a solution. The latter will evaluate the solution against the

rules and establish if the solution is consistent with prescription. The process of approval thus guarantees that the “*public*” will face acceptable consequences in the event of a fire. The “*client*” is a potential stakeholder in this process. In an ideal prescriptive environment the “*client*” should play a passive role, nevertheless, in practise most prescriptive requirements leave grey areas where “*client*” interventions can be accommodated by “*designers*” and “*approvers*” by interpreting prescription with some flexibility. This scenario transforms the “*designer*” into a “*code consultant*.”

The complexity of this process is not in its structure but in the definition of who are the “*designers*” and “*approvers*.” The development of infrastructure involves many disciplines and the boundaries between these disciplines are not always clear. These boundaries become even more unclear as “*designers*” move towards becoming “*code consultants*.” Furthermore, in a prescriptive environment, competencies remain undefined because what is regulated is the process (rules and approval). As “*designers*” move towards “*code consultants*” it is essential to define competency. The Society of Fire Protection Engineers has defined competency in this domain and it is implemented through an examination process that rigorously defines the Professional Engineer (PE). Nevertheless, given that the process is what is regulated, it is not compulsory to only involve Professional Engineers.

In the case of the World Trade Centre 1 & 2 the main “*designers*” were the architects, the structural engineers and the fire protection engineers. The fire safety obligations were shared by the architect and the fire protection engineer. The architect and fire protection engineer defined together the necessary means of egress, the fire protection engineer defined all active fire protection measures and the architect defined the structural fire resistance by following existing rules on thermal protection of the steel structure. The “*approver*” was in this case the Ports Authority of New York and New Jersey. While there is some controversy on this matter, here we will assume that all rules were deemed to satisfy the prescriptive requirements and that the “*approver*” established compliance in an adequate manner. The structural engineers had no role in delivering fire safety. It is important to note, that in this particular case, the uniqueness of the infrastructure extended the boundaries of applicability of prescription and had all stakeholders operating as “*code consultants*.” This particularity gave the “*client*” a significant influence on the outcome.

In the case of performance base design, engineering tools are to be used in a competent manner to deliver an outcome that provides an explicit level of safety. The “*designer*” and “*approver*” are now professionals whose competence needs to be defined and regulated. Like any other professional discipline, the “*professionals*” have the right to monopoly over their professions. The process, in this case, remains unregulated and is up to the “*professionals*” to agree on the methodologies to be used to explicitly define risk. The “*client*” in conjunction with the “*approver*” (could be an authority or an insurance company) will have to agree on what is an acceptable level of risk. The “*designer*” is there to inform the client and authority (in a convincing manner) of the probability of all potential events and to introduce mitigation techniques that reduce the consequences to a level that is acceptable to “*client*” and “*approver*.” It is not the role of the “*designer*” to define what is an acceptable level of risk or a negligible probability. The role of the designer is to provide in a competent and ethical manner the necessary information for “*client*” and “*approver*” to make a decision if the proposed solution provides an acceptable level of risk.

It is important to note that currently there is no clear definition of professional competence for Fire Safety Engineers that are to operate within the professional framework required for performance based design. Instead, fire safety still operates in a regulated prescriptive environment where “*code consultants*” have extended their role to cover this void. The right to professional monopoly is not exercised anywhere so drastic variances in competence can be observed among those who call themselves Fire Safety Engineers.

In the case of September 11<sup>th</sup>, 2001, much has been discussed about the nature of the event. An aircraft full of fuel impacted each building. The probability of such event happening is extremely low but the potential consequences are very high. Many will argue that due to its low probability it should not be required to design tall buildings for such an event. In a prescriptive environment this is a moot point because probabilities are not involved in the design process and the design outcome will be the same if these events were to be considered or not. If a performance based design approach is to be followed, the event should always be assessed because its probability is not zero (at least two of these events have been recorded in New York in the last 100 years). The consequences resulting from such an event might be deemed to be acceptable by “*client*” and “*approver*” but this conclusion needs to be made in an explicit manner on the basis of a consequence analysis. The “*designers*” play no role in this decision making process beyond that of providing the explicit assessment of consequences.

The events of September 11<sup>th</sup>, 2001 revealed the complexity of this process and how the poor definition of process and stakeholders can result in very negative unintended consequences. World Trade Centre 1 & 2 were designed for fire safety by “*code consultants*” that stretched the applicability of the codes on the basis of “*client*” influence. The design followed a prescriptive framework and it can be accepted that it was “*approved*” on the basis of satisfying the code requirements. Under this framework the architects defined all structural fire safety requirements (insulation) with no competence in structural engineering. Structural engineers and Fire Protection engineers had no responsibility for the design or performance of the structure under fire conditions. The “*code consultants*” in fire protection had no competence in structural engineering while the structural engineers had no competence in fire behaviour. The required competence was never established because the design (from the fire safety perspective) was deemed to follow an acceptable classification and therefore could be designed within a prescriptive framework. From a fire safety perspective, the scenario of an aircraft full of fuel impacting the buildings did not have to be considered.

In contrast, the structural design, given its uniqueness, could not be classified, thus was designed by competent professionals operating in a performance based design framework. The performance of the structure was evaluated explicitly, the scenario of an aircraft impacting the building was considered and the consequences were deemed acceptable by “*client*” and “*approver*.” From a structural perspective, the presence of fuel in the aircraft was irrelevant (because the building was insulated to prescriptive requirements) and the event of a fire following the impact did not have to be considered.

In summary, “*designers*” did not act as an ensemble, thus different disciplines operated in different frameworks and under different definitions of competence. The inappropriate definition of the stakeholders that resulted from this confusion disabled the approval’s process. A comprehensive consequence analysis was never done, and thus the approvals decision was made with insufficient information. The potential consequences of this fire were therefore not managed correctly and the result was a disaster.

While the weakness of the design process seems obvious, after more than a decade, discussions on WTC will remain around egress, code misinterpretations and poor construction practises. Furthermore, the low probability of a similar event is constantly evoked as justification to not consider an event of this nature for design. Consideration of the probability of such an event is only relevant if a performance based framework is used, in which case all the technical issues described above, while relevant, are secondary to that of structural behaviour. In a discipline that regularly evolves on the basis of forensic analysis of failures (design by disaster) this scenario seems paradoxical. What is it about WTC that disables the discipline from distilling from a forensic study sufficient knowledge to improve design, instead of simply using palliatives of minor relevance? There

are many reasons that drive this behaviour and range from logistics to politics. Nevertheless, the overwhelming reason is that the existing knowledge base of 2001 was not sufficient to deliver a quantitative assessment of the fire performance of a building of the complexity of WTC. Therefore, the information emerging from the forensic study was not robust enough, not conclusive enough and not clear enough to encourage the practise to enhance their understanding of the problem. In simple terms, we were not ready to design a building like the WTC and we were, most definitely not ready to conduct a forensic study of such a building.

## Questions

1. WTC can be seen as a missed opportunity to demonstrate that the gap between what we are building and what we know how to build has increase so much that we are in the process of constructing many future manmade disasters. What would it take to gain this explicit understanding?
2. How does society move from a practise that is ill-formulated to one consistent with the task at hand? How do we professionalize disciplines like fire safety engineering?
3. Our legal framework is disabled when “experts” cannot be defined. How can we use our legal framework to force an adequate definition of technical expertise?