ISSN: 2395-5775

Available Online at http://www.journalijcir.com

International Journal of Current Innovation Research
Vol. 4, Issue, 1(A), pp. 966-968, January, 2018

International Journal of Current Innovation Research

DOI: 10.24327/IJCIR

Research Article

A RELATIONAL CONCEPT OF FIRE: AN INNOVATIVE STRATEGY FOR FIRE SAFETY DESIGN

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ARTICLE INFO

Article History:

Received 18th October, 2017
Received in revised form 10th November, 2017
Accepted 06th December, 2017
Published online 28th January, 2018

Key words:

Classical concept of fire, relational concept of fire, genetics of fire safety, prescriptive standards

ABSTRACT

The authors believe that there is a misguided concept regarding high risk fire in many countries. The classic concept of fire is that it is uncontrolled combustion. A new relational concept of fire is proposed herein, where fire is defined as the result of an interactive process between the fire, the building and the occupants. In addition, two design principles are proposed: the initial ignition is fully probabilistic, and the three elements of a fire may be fully designed. The authors discuss the role of design and the genetics of building safety. Conclusions point out that there has been a bad concept of fire during decades of prescriptive design practice. Authors emphasize that this relational concept of fire is a basis for an innovative design for fire safety.

INTRODUCTION

Concepts guide the practice in any technical field. In designing for fire safety, fire is a leading concept. In fact, the notion of a fire is as old as humanity and this fact leads us to underestimate the role of a fire concept. One of the most famous fire concepts is that given by ISO 8421-1:1987 [1] which states that a fire is uncontrolled combustion spreading in time and space. This concept is repeated in slightly different words in all known safety standards in the world.

Strange as it may seem, this formal concept is the keystone of fire safety in many societies. Even important people of Fire Sciences in the developed world think it is fully sufficient and abstain from discussing it. Recently a very prominent fire scientist expressed himself with a mixture of annoyance and surprise when we provoked him to think about the classical concept of fire; he said: "Combustion is the same in Albania as in Zambia!". Fire as just combustion, and fire as a set of multiple interacting phenomena, are the topics here. The aim of this article is to discuss this formal concept and its impact on the design for fire safety. It is our belief that an innovative strategy to improve fire safety design comes from it.

Fire as a combustion

The concept of a fire as being uncontrolled combustion is characterized by externality and inexorability. Externality means that a fire is thought to be a phenomenon whose physical characteristics are not determined by the building itself or by its occupants. Just as we think about earthquake waves reaching a building foundation, we may think about an external fire attacking a building. As a first and simple counter-argument, we may at least say that the building's materials and contents are the feed for the combustion. Thus, limiting fire load quantity and controlling its nature is a way of making buildings interact with the fire's production. But, this is much less than what is expected of a dynamically smart building facing a fire. Moreover, it is said that in most cases the occupants are directly or indirectly responsible for the initial ignition. Therefore, trained occupants reduce the risk of initial ignition caused by human failure. Externality is the basis for modeling fires by standard-test curves like that of BS 476-20:1987 [2]. This homogeneous temperature-time curve is imposed upon elements of the building's construction, independent of its physical and geometrical characteristics. It ignores the building's contents and ventilation.

All ancient and modern communities in some extension used to see fires as supernatural fatalities up to the beginning of XX century. This was a psychological expression of the externality then formally included in the classic concept of fire around 1936 [2]. In fact, fires escaped from the scientific Cartesian method that is basically based on repetition and observation to produce reliable data for investigation. This has made fire science a field of late scientific development. Inexorability means that there is nothing that can be done against fires except active combat and passive resistance. To bow down before the inexorability of fires is the closing of doors to a scientific approach to fire safety. One may argue that there is technique in fire combat and this is obvious. But, from the point of view of design, if a fire combat is needed in a building, its fire safety failed. Efficient fire combat is no more than a Pyrrich victory.

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There is a reflection of the inexorability imprinted on the standard-test curves which do not consider a decay phase in its fire model: fire load is unquenchable although mass burning rate is decreasing with time. Test curves increase temperature indefinitely to express the astonishing and unpredictable power of destruction of real fires. They are the anti-model of this inexorable fire because they fail in capturing the phenomenon they attempt to model. In fact they are a kind of an upper bound model: the greater the expected fire severity, the greater the required time of fire resistance in prescriptive standards all over the world. It follows from what we mentioned briefly above that we admit that no fires exist unless as a product of the dynamic interaction between combustion, building and occupants. Thus, combustion is the same in a laboratory in Albania or in Zambia but a fire is different in Australia and in Zimbabwe. It is easy to see that fire is not solely combustion. Moreover, the classic concept reduces the building under fire to a kind of inert punching bag passively resisting the fire attack. The fire safety system based on this concept is unaware of the variety of possible existing interactions between the building and the developing fire in it. These interactions are developed through a language-code which is truly the real subject of design. Before giving it attention, it is necessary to discuss whether fire safety exists or not.

The genetics of fire safety

Does fire safety exist? It would be wise to think first if safety exists? The simplest response is: not, if we think about absolute safety, and yes, if we think of a relative safety that is in fact, a binomial safety-risk. This is not the proper occasion to enter the fantastic epistemological world where discussions consider absolute safety as a human ideal and real safety-risk as a possible safety; everything framed by probability theories. In talking about design, the real world is the area of discussion. Thus, the first constraint of this discussion is that safety and risk are measured one by the other, that is, the greater the safety, the smaller the risk and vice versa [3]. Immediately a first conclusion follows: safety cannot be one hundred percent because risk cannot be zero. The second is that there are levels of safety which are acceptable and levels of risk which are unacceptable.

The basis of the design is the assumption that acceptable levels of fire safety can be reached by a rational work process, which in turn is based on the knowledge of the phenomenon of fire. Current knowledge of fire allows current acceptable levels of fire safety, if it is translated to real building through design. Thus, the design process has a pivotal role for fire safety.

Entering the world of design, we observe that frequently a parallel question moves to the center of discussions. It refers to the owner's obligation of design for fire safety. Some people argue that owners have been using several strategies to reduce fire safety costs, frequently not complying with the safety margins. Thus, enforcement of a minimum set of safety measures has surprisingly become a quality of the design process. Nowadays, this issue is being considered as an advantage of the prescriptive standards when compared with performance based ones. We want to put this matter aside because it is in the field of citizenship and social responsibility. Thus, prescriptive standards have to be considered herein not because of its character of obligation but only as a design philosophy for fire safety.

The genetics of fire safety concern the process of designing a safe building under the assumption that it may dynamically interact with the initial ignition and with the occupants, generating a fire that creates a given maximum fire risk. Additionally, this expression may be used to demark a design process which begins simultaneously with the beginning of the building's design. This is an idea opposed to that of a fire safety complimentary adhered to the building in the last phases of its design. The traditional process of design for fire safety had its origin in the reconstruction of London after the Great Fire of 1666. The King Charles II forced the adoption of some safety rules which were prescriptive in nature. Building owners resisted these rules at that time and this resistance is currently seen in different extensions in all societies. This method of design for fire safety became known as "prescriptive" in the sense that it is enforced in all its details by the official legislation. Thus, the specific building and its occupants are only considered through a very narrow vision of fire risk, measured indirectly by the building's top story height and purpose. The risk assessment on the basis of this method is made by technical consensus. In our point of view, its main characteristic is not prescriptiveness or enforcement but the fact that it does not admit the dynamic interactions of combustion, buildings and occupants and that fire risk assessment is empiric. It is evident that the so called prescriptive method departs from the genetic fire safety as previously conceptualized.

Would it appear boastful to claim that an optimum fire safety design of a given building for a given purpose exists? The scientific method is the guaranty of the best results of Engineering in all fields. Fire Science is a theoretical corpus on combustion, the fire behavior of materials, smoke movement, together with structural and human behavior during a fire, giving support to a scientific process of design for fire safety. Furthermore, scientific methods may be applied to evaluate the fire risk within a strategy for fire protection. The design method which includes Fire Engineering modeling of the building and occupant interactions with combustion is known as performance based design. Combustion is described through a set of likely scenarios of initial fire ignition. The word performance refers to the acceptance criteria used to distinguish proposed solutions. To remain on the prescriptive method just because of its enforceability is to waive the liberty of design. Therefore, a genetics or fire safety design team must be multidisciplinary. A common language must be developed. Common design values must be adopted. On this basis, a multidisciplinary platform is certainly a new concept for fire.

A relational concept of fire

Fire observation guides us to one conclusion: fires are the product of the interaction of a building and its occupants at the initial ignition. Once a stable initial ignition is set, a process of interactions begins like a puzzle where each player must take the correct action. The result of this puzzle, including asset loss, injuries and deaths, is what we call fire. Thus, fire may be conceptualized as the result of the interaction between the combustion, the building and the occupants, being this interaction developed through multiple chemical, physical, biologic, and psychic phenomena, mutually influenced and occurring within in a very short time [4]. This concept must be accompanied by two design principles that are: a) the beginning of an initial ignition is entirely probabilistic, and any design feature can´t reduce its probability to zero; b) all elements of the interaction process which define a fire, that is, combustion, buildings and occupants, may be designed. By the first principle, anyone or anything may be guilty of an initial natural ignition. But, if this initial ignition grows to a developed fire, this means that the fire safety design has failed. By the second principle, architects and engineers can design the fire expected in an ambient, controlling parameters like fire load, ventilation and reaction to fire of linings, ceilings and floors. Buildings can be designed to control fire growth and smoke movement. Occupants can be educated to act correctly at the beginning of a fire.

Fire safety design inspired by this relational concept of fire must go beyond the selection of a set of active and passive measures to be added to the building. It is possible go far designing the building's spaces, linings and contents to interact with the combustion's developing stages so as to minimize the resultant fire. This implies in adopting a flexible and integrated dynamic vision of the building's architecture. Of course, we must stop idealizing at this point and put these ideas into practice in order to be able to analyze the results.

CONCLUSIONS

Rethinking the concept of fire is proposed herein. The classic concept of fire as uncontrolled combustion supports the general belief that fires are fatalities that are external to the buildings and inexorable. In turn, externality supports the use of standard-test temperature-curves as the most used fire model design and inexorability makes fire resistance and fire combat the only effective weapons against fires. Taking the classic concept as the basis of fire design, all directions lead to the prescriptive method for which the building is completely inert in face of fire. The prescriptive method is well suited for enforcement of a set of fire safety measures. Nowadays, notably and regrettably this characteristic is being considered as the advantage of the prescriptive method in front of performance based design. We made an attempt to distinguish what really characterizes the prescriptive method and found that it is the fact that it ignores the dynamic interactions between combustion, buildings and occupants.

A new relational concept of a fire is proposed. Through this concept, fires are the product of the interaction of combustion, buildings and occupants. This interaction is truly the object of fire safety design, as we proposed herein. Thus, what we call fire is produced by this dynamic interaction between building, occupants and combustion. It is not external and design can turn it into a manageable phenomenon with minimum risk to people and asset loss. Two principles are set for design in the context of this new relational concept. Firstly, the non-deterministic beginning of a fire whose probability is not zeroed by any design measure. Secondly, the assertive that the fire, the building and the occupants may be designed as needed. This was what we called an innovative strategy for fire safety design.

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How to cite this article:

M. Claret-Gouveia *et al* (2018) 'A Relational Concept of Fire: An Innovative Strategy For Fire Safety Design', *International Journal of Current Innovation Research,* 4(1), pp. 966-968.

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