The Importance of Prevention and Emergency Planning in Cultural Buildings

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ABSTRACT: Fire risk is the leading hazard for the safety of buildings’, not only due to potential, but also concerning property/value losses. When it comes to cultural heritage, fire is by far the most destructive phenomena, and prevention is the most effective way of protection. Portugal’s current fire code published in 2008, establishes the need of self preservation procedures, embodied in Emergency Plans with five vectors: i) prevention procedures or plans; ii) safety records; iii) emergency procedures or plans; iv) appropriate training; v) fire drills. Each has its contribution upon providing the adequate fire safety. However, besides publishing safety laws it is the urgent to promote an intrinsic safety culture. Had previous generations done this and some of the cultural heritage now lost could still exist! Examples include the Alexandria Library fire or the 1755 Lisbon earthquake. It is our contemporary duty for generations to come, to provide safety means in order to ensure the safeness of our cultural heritage. The use of Serious Games to educate and train stakeholders is a possible way for creating and developing such an intrinsic safety culture. An on-going research on this matter at LIACC/FEUP is briefly described in this paper.

KEYWORDS: Cultural heritage; Emergency planning; Fire Drills; Serious Games.

1 INTRODUCTION

Fire risk is the leading hazard for the safety of buildings and, consequently, for other risk protections. The simple explanation is that fire consequences are often tragic, not only due to the potential casualties, but also in what concerns property/value losses. When it comes to cultural heritage, fire is by far the most destructive phenomena whatever are the causes in its origin. Moreover, prevention is the most effective way of protection against fire. Additionally, other hazards, such as earthquakes, terrorist attacks, explosion, are dealt with and consequently their risk is exponentially limited and, thereby reduced [4].

The risk of a tragedy due to a fire in a building increases significantly as the number of their occupants’ rises [42, 45]. Buildings nowadays may have hundreds or thousands of occupants. Many of them are not aware of the architectural layout or the safest and rapid exit from their standing point [15]. When facing an emergency situation, such as fire, explosion or other threats, having safe exits towards the outside is imperative. And in complex and large buildings the evacuation routes are sometimes not obvious for occupants [14]. Evacuees spend more time than expected in searching the right way, sometimes missing the evacuation signage and at other times not following the expected behaviour that architects and planners had in mind when designing the building [28].

For example, a large concert hall or a museum must have an adequate number of exits, well located, with sufficient width for quick egress of their occupants [18]. However, these exits and their location, required for the safety principles, collide with the security purposes, for which each one is a possible threat for burglars or vandals. Furthermore, there is the issue of the increased construction cost, so an adequate equilibrium must be achieved. This is a subject addressed by building safety codes with specific rules demanding a certain number of exits and their corresponding width for each set of people, for instance, multiples of hundred persons [29].

In Portugal, according to the current fire code [31], these aspects are properly addressed and regulated. Buildings’ architectural layout depends on the exits and egress paths positioning, among other factors. This aspect is of key importance due to the impact is has in the net area of the building that will be used by stairs and corridors, considering the construction costs. Building codes provide regulatory provisions on the number of exits and their widths as well as the stairs and corridors, for
almost every type of building use. However, the adequate size and number to provide safe conditions in case of emergency is not possible to assess easily.

![Figure 1. Baquet Theatre fire, Porto 1888 [12].](image)

When facing an emergency situation inside a building, safe exits are essential to ensure the adequate egress process. Hence, many times victims are due to the evacuation process instead of the situation that was in its origin. Historical cases such as the Station Nightclub in 2003, the Halloween party in Madrid 2012 or the Kiss discotheque in Brazil where over 230 died, are just recent examples [41]. The fire at the Baquet Theatre, Porto, in 1888 left over 120 people dead and many hundreds injured [12], perhaps the deadliest fire of its kind in the country at a leisure building (see Figure 1).

At Portugal, between 2009 and 2011, there were 59 registered fires in museums or libraries\(^1\). In Porto alone, between 2007 and 2012 there were 18 fire occurrences in cultural buildings\(^2\). As far as we know there are no records or statistics concerning the values related with cultural losses due to fire.

2 EMERGENCY PLANNING AND FIRE DRILLS

After the 1988 Chiado fire, that destroyed some historical buildings in Lisbon downtown, fire safety legislation that was commissioned to LNEC (Portuguese Civil Engineering Laboratory) and other institutions, under preparation for years, was finally published. But only in 2002 was it available legislation addressing the need of some sort of fire safety services at hospitals, schools and services buildings [4]. Later, a unified code was issued in Portugal [31, 32] covering all fire safety aspects including emergency management and planning, preventive maintenance, training and Fire Drills (FD).

According to [17], emergency management and evacuation planning became a sophisticated field of civil engineering science. The importance of fire drills to train occupants makes them mandatory in many countries [43]. Stress combined with lack of training and preparedness may lead to a phenomenon called “cognitive paralysis” [23, 24].

\(^1\) Data supplied by ANPC – Autoridade Nacional de Protecção Civil.
\(^2\) Data furnished by BSB Porto – Batalhão Sapadores Bombeiros do Porto
Fire drills are an important aspect of emergency planning. They are used to i) test and evaluate emergency plans; ii) train occupants; iii) and create routines for minimizing the consequences of an emergency if it occurs (see Figure 2). The ultimate goal is to reduce the number of casualties in case of possible hazards, ensuring that occupants take appropriate actions during the evacuation and reunite at the predefined meeting point for the given facility [7].

An effective fire drill starts with planning. First, possible hazards are identified and the adequate actions for each must be detailed. This is part of the risk assessment and emergency planning. Evacuation is one of the possible actions. It can be a total or partial site evacuation. For instance, in large facilities such as hospitals or tall buildings, the evacuation must be phased. It might be a horizontal evacuation, within the same floor or a vertical one, when people are moved to different floors, or even towards the outside. In hospitals, horizontal evacuation is the preferred method, from one ward to a safe area taking advantage of fire barriers. There are different kinds of evacuation exercises: i) small scale, with just some part of a building or campus is affected; ii) training staff in fire protection, where some tutorial is provided and real fire extinguishing using portable extinguishers or fire hoses and their use are evaluated; iii) large scale fire drills with the co-operation of fire fighters, police, ambulances and other emergency responders [16].

Evacuations are planned in levels. Some emergencies may require the evacuation of only a small area near the problem, others might require the entire building to be evacuated and larger emergencies might require the entire site to be evacuated as well. It is common to classify the emergencies into three levels:
1. Small emergency requiring a limited evacuation of only one or a few adjacent rooms;
2. Medium emergency demanding partial evacuation of an entire floor, or building section;
3. High emergency obliging to building total evacuation.

When establishing an Evacuation Planning, the following steps are typically used:
1. Vulnerability assessment and risk analysis;
2. Probability impact assessment, classifying each risk according to severity and probability as high, medium or low;
3. Identification of internal and external resources (safety equipment, rescue personnel, emergency responders).

Amongst the risks, they can be categorized according to the following list:
- Natural hazards: flooding, thunderstorm, earthquake, hurricane or cyclone, wildfire
- Technical: fire, gas leak, explosion, power failure, chemical leakage, radiation
- Human: terrorist attack, bomb threat, accidental or intended failure leading to fire, toxic or chemical leakage, social unrest or riots

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3 Photos in 2013 taken by the author.
Emergency plans have to address the following goals to be achieved: i) life safety; ii) assets protection including cultural heritage; iii) ensuring normal activities’ continuity. Evacuation plans must address the following aspects:

- For each location/compartment/floor define the egress route;
- If possible, identify alternate routes if the main one becomes blocked;
- Define staged evacuation phases in large facilities;
- Have an evacuation leader coordinating all evacuation groups;
- Assign one team leader to each evacuation group;
- Ensure good communication facilities for coordination purposes;
- Assign a liaison officer to receive and debrief the emergency responders (firemen, paramedics, police or civil protection personnel);
- Provide a “crisis room” adequately equipped with communication (telephones, mobiles, radios, CCTV, etc.) as well as plans with all facility floors and safety means;
- Define meeting point or points where evacuees must concentrate for people counting.

Emergency plans for cultural buildings with important and valuable heritage assets shall include additional measures in their evacuation plans to ensure that evacuation officers can carry goods, such as books, valuable documents, paintings, sculptures, jewellery and other artworks to safe places. Staff should be assigned to this procedure, and a priority list of goods to save must be previously prepared and ready to be used. This is of upmost importance for museums and other similar facilities irreplaceable possessions.

Fire drills should be performed regularly to train and validate these procedures. Any failures should be addressed and promptly emergency procedures must be revised. This if of utterly importance and should not be neglected.

3 USING DIGITAL GAMES FOR TRAINING AND SIMULATION

3.1 Using simulators for training

Training is an important activity; it is usually better to spend as much time as possible training an activity in order to master it, especially when the activities to be trained are expensive, dangerous, too time-consuming or just physically impossible to repeat at the desired rates [35].

According to Axelrod, simulation can be used to fulfil several purposes such as: prediction, performance, training, entertainment, education, proof and discovery [8].

Simulators for training are used for long in a lot of areas: from military to delicate situations (such as medical surgery training or flying and aircraft), including dangerous sports (e.g. formula 1), airspace and many more.

![Figure 3. ModP pedestrian simulator 3D viewer developed at LIACC][2]

There are dozens of evacuation simulators, some developed for academic purposes (e.g. Figure 3), and others for commercial ones. In literature we have some papers comparing existing models, their
features and even availability [19, 22, 30, 37]. However they are more focused in assessing risk safety and not for training.

The outcome of the simulation we are aiming for is primarily related with training and education of evacuees and emergency responders, and additionally the prediction or proof that one building is safe enough and the safety means available are sufficient.

### 3.2 Serious Games

The technological advances of the past decades in the digital games field, mainly in the recreation of virtual realities using 3D graphics has boosted an array of possibilities and applications [46]. These include the Serious Games (SG) concept in which virtual humans are inhabitants of artificial societies with social and cognitive intelligence, personality and emotions [26]. Although this concept was envisaged back in 1970 by Clack Abt [1], long before the spread that SGs have today, the idea of using games for serious purposes is older. Military use them for training strategic skills at least since 1812 when the Lieutenant Georg Leopold von Reiswitz and his son of the Prussian Army devised a set of “war games” [38]. They used the “riegsspiel” (German word for war games) system for training officers on tactical manoeuvres (http://kriegsspiel.org.uk/).

SG are used for training in diverse domains from military [9] to the industry, encompassing medicine, aerospace, advanced sports such as formula 1, among many others [20]. SGs are important for increasing motivation for learners, achieving high completion rates through engagement and enjoyment, as well as accomplishing higher efficacy of learning through “drill and practice” approaches [13].

Another important feature is that SGs can nowadays be easily developed by using commercial of-the-shelf (COTS) videogames [25] and 3D open source game engines for serious games modelling such as OGRE, JMonkey, Unreal, Cryengine, Panda or Unity [27].

![Figure 4 – EVAcuation Fire Drill prototype](image)

Our interest in SG consist on the possibility of using this technology for rapid prototyping a fire drill simulator (see Figure 4) that might be used for training as well as elicitation of human behaviour [34, 38, 40].

### 3.3 LIACC Research

At LIACC some research is undergoing for the past few years using SG and simulation to elicit human behaviour in emergency situations as well as for training subjects in buildings’ evacuations [2, 3, 5, 6, 10, 21, 33, 34, 36, 39, 40, 44].

In our approach, the aim is not to replace the traditional fire drills, but to help training occupants by creating immersive and more realistic simulated situations, using virtual environments. Another goal in our agenda is to compare the mixture of behaviours (human and computer agents) in the same simulation model and observe interactions between them, using the human-in-the-loop concept. This way we expect to be able to use results to analyze, validate and calibrate evacuation strategies and plans through simulation.
A possible way of validating behavioural models is by comparing the questionnaire answers such as used by [11] Cordeiro et. al., with a set of similar questionnaires to be answered by participants in the virtual fire drills, after being subjected to the gaming environment (see Figure 5).

4 CONCLUSION AND FUTURE WORK

Emergency planning and fire drills are the best way of preventing fire or other hazardous situations to destroy hopelessly valuable cultural heritage assets. With the Lisbon earthquake a great deal of historical books, paintings and many other artworks were utterly lost.

Besides the need of implementing the safety maintenance procedures as well as emergency plans, that are nowadays already mandatory by the Portuguese law, it is of paramount importance to train and educate all stakeholders concerned with the property maintenance of cultural buildings and heritage. This includes not only the staff and managers of such facilities but also the politicians and all persons that are somewhat responsible for them.

Fire drills are the ultimate training exercise to validate if emergency and contingency plans are up to date and adequate to the facilities, as well as assess the level of preparedness of all subjects involved. For this matter we present an ongoing research at University of Porto of using the concept of SG for training individuals and possibly detect vulnerabilities needing improvement.

We expect in the near future to see such technology being used for training as well as for assessing the safety risk level of buildings, either cultural ones or not. Our aim is to ultimately increase the safety level and implement a safety culture in all stakeholders responsible for cultural heritage safety as well as citizens’ safety.

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