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Case Report

Using Computational Fluid Dynamics in the forensic analysis of a prison fire

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ABSTRACT

On the 8th of December of 2010 a fire killed 81 inmates in a Chilean prison. While the collected evidence (including eye witness' accounts) indicated an intentional fire, started by a group of inmates who were fighting against another group and who ignited a mattress and threw it over a bunk bed inside the cell, it could not be established how fast the fire grew and whether the prison guards acted promptly enough to prevent the tragedy. In this context, the public defender office in charge of the case requested an independent investigation in order to determine the approximated time the fire started, and the temperature evolution of the padlocks at the cell doors during the initial stage, based on the construction characteristics of the prison, the existing materials and the evidence collected during the investigation. Computational Fluid Dynamics (CFD) were used to analyse the movement of the smoke and to match the first appearance of smoke on CCTV recordings at locations away from the fire, allowing for the estimation of the time-line of events. The padlock temperatures as a result of hot gases from the fire was also simulated. It was shown that the fire grew quickly and became uncontrollable before the guards could intervene. By the time the guards arrived at the cells' door, the padlocks were shown to be too hot to be handled without protection.

1. Introduction

There have been several fires in Latin-American prison facilities in the last decades, many of them accompanied by important loss of life. Among the most important events range the fire occurred in Honduran Comayagua prison in February of 2012, which killed 361 people, the fire in Higey prison, Dominican Republic, where 136 people died on the 7th of March 2005, and the fire in San Pedro Sula prison, also in Honduras, with 101 dead inmates in early 2004 [1]. A common factor in all these events is overcrowding and critical living conditions existing in the prisons. In Chile the most important prison fire took place on the 8th of December 2010 at San Miguel prison in the country's capital, Santiago, where 81 inmates were killed. In the present document it is illustrated how experimental tests together with Computational Fluid Dynamics modelling were used to correlate evidence from the beginning of the fire to the appearance of smoke in the CCTV recording at the other side of the building, thus re-creating the time-line of critical events.

San Miguel prison has a somewhat different layout from what is used in most developed countries; instead of having cells shared by two or three inmates, distributed along a corridor, this prison consists of five four-storey blocks, each having a central staircase with large open plan floors (see Fig. 1). The floors are divided into two equal (mirrored) rooms, separated from the staircase by bars. Each room has a smaller cell attached, which is accessed from within the room through a barred door. Across from the room the common sanitary facilities are located. Fig. 2 shows an external view of the prison block affected by the fire. The three windows to the right correspond to the sanitary facilities on each floor, while the six windows correspond to the large common room. All windows are covered with metallic louvres (but no glass). On the top floor the soot marks from the smoke are still visible.

Inmates use their bunk beds, sheets and blankets to create semi-closed spaces shared by six to nine people (see Fig. 3(a)). In order to prevent air currents entering the cell, they hang blankets on the barred walls and across the open doors of the sanitary facilities. Personal belongings are stored in self-made over-head compartments between the concrete beams, as shown in Fig. 3(b).

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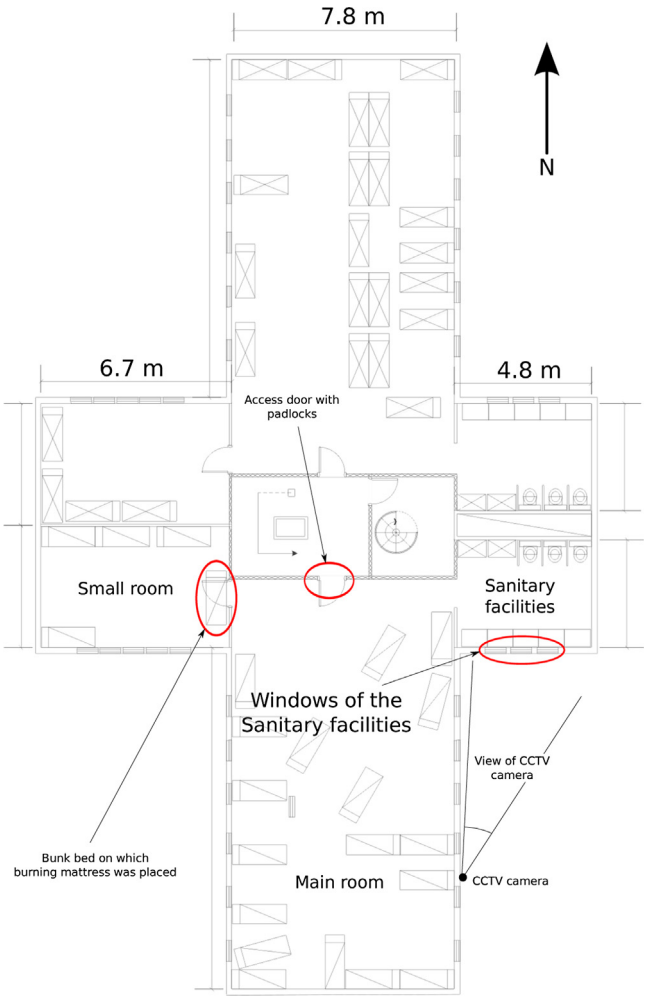

Fig. 1. Layout of the prison floor.

Fig. 2. External view from north-east of Block 5 of San Miguel's prison. This photograph was taken a few days after the fire. The CCTV camera that captured the smoke coming out of the windows of the sanitary facilities on the day of the incident can be seen in the upper part of the image.

In those compartments they keep clothes, magazines, newspapers and other items, most of them made of combustible materials.

The prison of San Miguel is used for remand detention, and as such allows its inmates certain level of autonomy. Among other things they are allowed to brew their own tea, for which they are provided gas burners and LPG.

At the time of the incident, the room where the fire started—which is located on the fourth floor—housed 71 inmates on a total surface area of about 160 m^2 including the bathrooms. The mirror room located across the staircase has the same area and housed 75 inmates. The little cell attached to the main room usually is occupied by the more influential inmates (of higher hierarchy), as it provides certain level of privacy. The barred doors communicating the main rooms to the staircase are locked by two padlocks, one at 0.5 m above the floor and another one at about 2 m above the floor. The prison block is made of reinforced concrete and is four floors high, each one having the same layout described, and is accessed through an underground tunnel. During nights no guards are placed within the prison block. Therefore, in order to access the cells on the fourth level, the guards had to walk across the tunnel, opening several doors before climbing the stairs and finally opening the two padlocks placed on each cell door.

The accusation against the guards on duty, that led to prosecution, was that they acted negligently by ignoring the fire for a prolonged period of time (over half an hour), allowing it to grow out of control.

(a) Bunk beds with hanging sheets and blankets.

(b) Over-head compartments.

Fig. 3. Internal view of a typical cell at San Miguel's prison.