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The collection and compilation of school evacuation data for model use

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ABSTRACT

Numerous evacuation models are now able to represent populations with different movement abilities. However, this representation is not always supported by empirical data; i.e. the functionality can occasionally overreach the empirical support for it. The goals of this work are: (1) to provide data that adds to the understanding and quantification of vulnerable population's evacuation performance, and (2) to provide sufficiently detailed and transparent data-sets for model configuration and validation.

Data was collected during five evacuations from the same school, conducted between 2011 and 2014. Children from 4 to 16 years old were involved in these drills. Four of the evacuations were unannounced, while one was semi-announced (i.e. staff were aware that the drill would be conducted on a particular day). In addition to the initial scenario conditions (e.g. the building geometry, population, procedures employed, etc.), a number of different performance data-sets were collected: pre-evacuation times, travel speeds, route use and evacuation arrival curves. Through the provision of detailed architectural diagrams and other initial conditions and raw data/analysis describing evacuee performance it is hoped that this data-set will be used in the development of evacuation models and their application. The limitations in the data collection and analysis process are outlined allowing the modeler to identify where issues might arise and take corrective actions where possible.

1. Introduction

As the use of evacuation models matures, the research questions associated with the use of these models also change. These questions have moved on from asking whether the models should be used at all to whether their accuracy, reliability and application are acceptable for the design of life safety systems. A key aspect in this change is the availability of sufficiently detailed, comprehensive and relevant data. These data-sets need to include data that can be readily understood and modeled by third parties, scenario conditions that reflect the context from which the data was collected and a description of the data collection method adopted such that the user can better understand the strengths, limitations and relevance of the data-set.

A new data-set needs to address an area of research interest for it to be relevant and to make a contribution. Of particular concern at the moment are vulnerable individuals who potentially have issues with understanding the nature of the incident, receiving sufficient information on the nature of the incident and/or who have issues with movement to a place of safety (Gwynne, 2007). One example of such a vulnerable population is children, who typically need assistance during the evacuation process.

A number of data-sets exist describing the performance of children and young adults during an evacuation. These populations are considered somewhat vulnerable given the potential for cognitive and mobility limitations that might impair their evacuation performance. These data-sets include results derived from surveys (e.g. Ono and Tatebe, 2004; Kholshevnikov and Samoshin, 2009); experiments (Larusdottir and Dederichs, 2010, 2011, 2012a); drills (Ono et al., 2012; Larusdottir and Dederichs, 2012b; Campanella et al., 2011; Kholshevnikov et al., 2012); and simulation work (Ono and Valentin, 2009; Campanella et al., 2011; Capote et al., 2012; Cuesta et al., 2013). The data-sets presented here add to this body of work by presenting evacuation drills repeated at the same location (enhancing confidence in the robustness of the data produced) and presenting the background information in some detail (allowing the reproduction of the drills described).

The data presented here relates to five evacuation drills involving pre-school, primary and secondary school children from Altamira School, in Camargo, Spain, conducted between 2011 and 2014. These drills were observed to compile data-sets that would (a) increase our understanding of the vulnerable populations in

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question, (b) quantify the nature of this vulnerability, and (c) provide a means by which the scenarios examined could aid model development, validation, or application (e.g. as part of an engineering project). The data collection includes the initial population distribution, the routes used, pre-evacuation times (and its constituent parts), walking speeds and overall evacuation times. It is expected that a sub-set of this data could be used for model configuration and validation.

As part of this work, additional material will be made available outlining the background conditions present during each of the trials and the outcome of each of the trials. This material includes:

- Architectural diagrams of the buildings involved
- Raw data collected from the trials describing
  - pre-evacuation times,
  - route use,
  - travel speeds,
  - exit use, and
  - arrival times.

Interested parties will be able to download this material and use it to configure or validate evacuation models.

The goals of this work are to provide a data-set that adds to the understanding and quantification of vulnerable population's performance and to provide a sufficiently detailed and transparent data-set for model configuration and validation when applied to scenarios involving such a population. The overall scenario examined may be specific to the school in question and the full data-sets may therefore be of primary use in testing where an attempt is made to recreate the drill scenario. However, breaking down the data associated with evacuee performance into its constituent parts provides more generally applicable insights and allows the data to be more widely used.

2. Context and methodology

The following sections address the nature of the buildings, the populations, the emergency procedure employed and the data collection methodology. This information will help the user assess the relevance of the data, the credibility of the observation process and determine how to employ the data presented.

2.1. Building information

The five drills observed all occurred in the Altamira School which is attended by children ranging from 3 to 16 years of age (e.g. pre-school, primary and secondary school children). The repeat drills were observed both to capture a representative set of drills from the same space and of the scenario examined. The school consists of two separate buildings referred to as the Small Building and the Main Building. The layout of the two buildings is shown in Fig. 1.

The Small Building is a two storey structure that has a single point of egress. It has a single, straight, 1.58 m wide stair (Stair 3) that spans the height of the structure. This stair is equipped with two handrails at the standard height and also has an additional handrail compatible with the children's height and use. Exit E (a double-leaf door that is 1.40 m wide) can be accessed directly or via Stair 3.

The Main Building is a four storey structure with three exit points (Exits D, F and G); however, Exit G was not observed during the trials and was used by a class (Class 1) that did not interact with the rest of the evacuees. Exit D is 1.14 m wide with a double-leaf door and is the main entrance to the structure. Exit F is a 0.8 m wide emergency exit and is located on the basement level. Two stairs service the Main Building: Stair 1 (a dog-leg stair, 1.23 m wide) and Stair 2 (a straight stair, 1.20 m wide).

2.2. Population demographics

Table 1 shows the population demographics and their respective classroom positions during the drills (refer to Fig. 1 for classroom locations). Table 2 shows the distribution of pupils and teachers when the alarm sounded in each of the trials and the exit that they used during each trial. Again reference should be made to Fig. 1 to locate each of the classrooms.

A small number of students with impairments attended the school including children with cognitive impairments who were physically capable (see Table 3). This small number of children were drilled and trained in the same manner as the rest of the population and also had a pupil or teacher assigned to them during an evacuation.

Typically, the school population did not include children with physical impairments. However, during Trial E5 two children had temporary movement impairments requiring them to use crutches. Both of these children were originally located in C7, used Exit D, and evacuated along with the cognitively impaired student in C7 and a teacher (see Table 3).

2.3. Drill scenarios

The trials were part of the routine evacuation drills conducted each year at the school (see Table 4). Students had no prior warning during any of the trials, while the teaching staff had some prior warning in one of the trials (E1). These two scenario types are indicated by *'semi-announced'* in the Table 4 (i.e. in Exercise E1 where staff knew the date of the evacuation exercise in advance, but not the time); and *'unannounced'* (i.e. in Exercises E2–5 where neither staff nor students had warning of the evacuation exercise with the exception of the teacher in charge of safety and the secretariat of the school).

The precise conditions on each day of the trials differed. For instance, children were absent, different staff were allocated, etc. More significantly, Exercise E3 was conducted on the eve of the Christmas holidays and although teachers/students were still located in their respective classrooms they were involved in Christmas activities, as opposed to routine lessons. This may be representative of a number of situations where pupils are engaged in activities as opposed to observing the teacher present material; however, the conditions may lead to different pre-evacuation activities.

2.4. Procedure

The school conducts at least one evacuation exercise every year in compliance with the local regulatory requirements (Ministerio del Interior, Gobierno de España, 2007). The building was subjected to two false alarms in 2012. The first one was due a student pressing the emergency button. The second was due to an electric failure during a storm that caused a power loss and smoke in a classroom (without fire). The building was totally evacuated in both cases. However, these false alarms were not counted as evacuation drills. The school has no automatic fire detection. During the drills, an alarm bell was activated manually by a secretary on the ground floor of the Main Building. This sounded throughout all occupied areas. This alarm was activated at 10:00 AM in all five of the evacuation exercises. Once the alarm was sounded, the classes evacuated separately in a phased approach to reduce congestion. In the Main Building, the evacuation strategy consisted of using two separate evacuation routes ending at either Exits D