Drilling for safety

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1. Abstract

This article explores how egress drills are currently employed, their impact, and the insights gained from them. By investigating their strengths and limitations, this article suggests enhancements to future egress drills including the use of *other* egress models to support and expand upon the benefits provided.

2. Introduction: What is an egress drill and what are its benefits?

An egress drill is a pre-planned simulation of an emergency evacuation for a specific incident scenario.[1] This is typically performed in relation to expected *fire* scenarios, given regulatory requirements. Given projected demographics, social and environmental developments, there are new threats faced and vulnerabilities present. This means there are an increasing variety of incident scenarios to be investigated by drills[2] and that more preparation and resources might be required to adequately address these future conditions [1].

Egress drills are a model of an emergency evacuation from a particular building. Ideally, the occupant population, the safety staff[3] and the procedures expected during a real incident should be present during the drill, allowing more confidence in the similarity between the drill and reality.[4] The potential for this similarity is one of the strengths of the egress drill model. An egress drill is one of the most important tools available to the safety manager and provides an ongoing means of influencing performance. Typically the drill is seen as:

- a means to familiarize the evacuating population with the emergency procedure and the safety staff with their roles in the procedure during a representative scenario;
- and/or as a means to assess the performance of the population, procedure and staff under the same scenario.

Egress drills are assumed to benefit evacuee familiarity with the emergency procedure and practitioner understanding of the achieved evacuation performance. It is suggested here that the strengths and limitations of the egress drill are not widely appreciated and that, as a consequence, we are not fully exploiting the benefits of the egress drill. On the other hand, we may be overestimating the benefits provided given the way in which they are currently employed. The subsequent discussion is an attempt to assess the merits of egress drills.

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[1] The NFPA Guidance on All Hazard Emergencies defines an All-Hazard Drill as follows: 'A training exercise in which building occupants are familiarized with and/or practice the procedures for remain-in-place, in-building relocation, partial building evacuation, and total building evacuation, in accordance with an Emergency Action Plan. From NFPA Guidelines.'

[2] Or other methods of assessment.

[3] Safety staff are occupants in charge of managing or directing the evacuation of other building occupants, and/or emergency service personnel.

[4] Procedures might include total/partial evacuations, staged/simultaneous approaches and may require the deployment of a range of different human and technological resources.

3. What do we know about egress drills?

A great deal of research has been conducted using egress drills as a tool to provide insight into evacuee performance [2,3]. This work was conducted to collect data on specific elements of evacuee performance (e.g. pre-evacuation times [4-6], travel speeds [7-10], etc.), to assess the evacuation of different occupancy types (e.g. apartment blocks [11-12], hospitals [13], schools/universities [5,14], etc.) and to examine the impact of different procedural elements (notification type [15], actions of staff [13,16], etc.), amongst many other factors that might influence performance (e.g. culture [14,17], fire-fighter activities [8,18], etc.). Research into human behaviour in fire has therefore used egress drills as a resource to collect data and develop concepts. Egress drills have provided a convenient field laboratory for evacuation researchers.

Researchers must understand the egress drill scenario (e.g. the population, the building, the procedure, etc.) - to ensure that the data produced is relevant to their particular interests. It is also important for researchers to maintain control over the observation process (so as not to unduly influence the drill) and ensure that the data collected is sufficiently comprehensive and refined so that factors of interest can be explored rigorously. The researcher needs to document the context of the event and the outcome of the event. In recent years, there has been considerable effort to enhance the methodology for collecting egress drill data - to address researcher requirements [2,3,15]. This has maximized the value of the data collected and meant that we better understand the information to be collected, and the methods and technologies currently available to collect it. However, it is not clear whether the data collected during routine egress drills is gathered using these research approaches and whether the data collected has the accuracy and granularity required.

4. What is required of an egress drill?

Several regulatory codes require that egress drills be performed. For instance, NFPA 101 Life Safety Code [19] specifies the number of times that a drill has to be performed, who should be involved, the prior knowledge of those involved and the nature of the scenario examined, given the type of occupancy involved. NFPA 101 2015 provides the following general guidance on the performance of drills:

> 4.7.2* Drill Frequency. Emergency egress and relocation drills...shall be held with sufficient frequency to familiarize occupants with the drill procedure and to establish conduct of the drill as a matter of routine. Drills shall include suitable procedures to ensure that all persons subject to the drill participate.
> 4.7.3 Orderly Evacuation. When conducting drills, emphasis shall be placed on orderly evacuation rather than on speed.
> 4.7.4* Simulated Conditions. Drills shall be held at expected and unexpected times and under varying conditions to simulate the unusual conditions that can occur in an actual emergency.
> 4.7.5 Relocation Area. Drill participants shall relocate to a predetermined location and remain at such location until a recall or dismissal signal is given.
> 4.7.6* A written record of each drill shall be completed by the person responsible for conducting the drill and maintained in an approved manner.

NFPA 101 2015 goes on to provide more detailed guidance for specific occupancy types. For instance, the following additional information is provided for performance of drills in new health care facilities:

> 18.7.1.4* Fire drills in health care occupancies shall include the transmission of a fire alarm signal and simulation of emergency fire conditions.
> 18.7.1.5 Infirm or bedridden patients shall not be required to be moved during drills to safe areas or to the exterior of the building.

18.7.1.6 Drills shall be conducted quarterly on each shift to familiarize facility personnel (nurses, interns, maintenance engineers, and administrative staff) with the signals and emergency action required under varied conditions.
18.7.1.7 When drills are conducted between 9:00 p.m. and 6:00 am. (2100 hours and 0600 hours), a coded announcement shall be permitted to be used instead of audible alarms.
18.7.1.8 Employees of health care occupancies shall be instructed in life safety procedures and devices.

This refines the information provided regarding who should be involved in the drill, how frequently it should be performed and when it might be performed.

The International Fire Code (IFC) [20] also requires that drills are performed, that the frequency of performance be dependent on the occupancy type, and that conditions and drill times should be varied [Section 405,3]. The IFC makes specific reference to the twin objectives of an egress drill highlighted above:

> 405.1 Commentary: 'Just as emergency operations and hazardous material response plans require operational drills to verify their continued viability and effectiveness, so too do *evacuation plans require periodic implementation to gauge effectiveness in achieving their objectives*.'

and

> 405.2 Commentary: "To utilize fire drills and the lessons that they teach to the best of their advantage, *drills should be conducted on a regular basis to familiarize both staff and residents with the evacuation plan*.'

It goes on to provide more guidance on the type of information that needs to be collected when an egress drill is performed. In Section 405.5 on Record Keeping, the IFC identifies that information should be collected on those conducting the drill, the date/time of the drill, the notification method involved, the participating staff, the number of evacuees, the conditions simulated, the problems encountered during the drill, weather conditions and the time required to complete the evacuation.

Division B of the National Fire Code of Canada (2010) [21] addresses similar concerns in two key clauses:

> NFC Div B 2.8.3.1 Fire Drill Procedures: 1) The procedure for conducting fire drills shall be determined by the person in responsible charge of the building, taking into consideration a) the building occupancy and its fire hazards, b) the safety features provided in the building, c) the desirable degree of participation of occupants other than supervisory staff, d) the number and degree of experience of participating supervisory staff, e) the features of fire emergency systems installed in buildings within the scope of SubSection 3.2.6 of Division B of the NBC, and f) the requirements of the fire department.

The clause stipulates that the drill will be sensitive to the building, the population, the potential hazards, the procedural resources available and the fire service. These issues are discussed further in associated explanatory material, which addresses the objectives of the drill and how the design of the drill influences meeting these objectives and the operational status of the building:

> NFC Div B A-2.8.3.1.(1) A fire safety plan is of little value if it is not reviewed periodically so that all supervisory staff remain familiar with their responsibilities. A fire drill, then, is at least a review of the fire safety plan by supervisory staff. The extent to which non-supervisory staff participate in a fire drill should be worked out in cooperation with the fire department. The decision as to whether all occupants should leave the building during a fire drill should be based on the nature of the occupancy. It may be necessary to hold additional fire drills outside normal working hours for the benefit of employees on afternoon or night shifts, who should be as familiar with fire drill procedures as those who work during the day. If full scale fire drills are not possible during non-regular working hours, arrangements should be made so that night-shift staff can participate in fire drills conducted during the day-time.

The second clause addresses the frequency that the drill should be performed, which is again sensitive to the building type:

> NFC Div B 2.8.3.2 Fire Drill Frequency: 1) Fire drills as described in Sentence 2.8.3.1 (1) shall be held at intervals not greater than 12 months for the supervisory staff, except that a) in day-care centres and in Group B major occupancies, such drills shall be held at intervals not greater than one month, b) in schools attended by children, total evacuation fire drills shall be held at least 3 times in each of the fall and spring school terms, and c) in buildings with the scope of Subsection 3.2.6 of Division B of the NBC, such drills shall be held at intervals not greater than 2 months.

It is apparent that these regulations do not specify drill requirements in detail. Although a degree of flexibility is warranted, the absence of detail does allow safety managers a great deal of scope - particularly in the scenario examined, the data collected and how the data is used. Close third party scrutiny might allow for these choices to be checked for consistency and credibility.

For both familiarization and performance assessment, egress drills need to be as representative of real-world conditions as practicable; i.e. a comparable population, building type and configuration, procedure and resources available. The closer the approximation between the egress drill and real-world conditions, the more indicative the performance will be and the more valuable the training and assessment will be. The regulatory structures mentioned above attempt to ensure that drills are performed in a reasonable manner given the occupancy in question. However, the codes grapple (to varying degrees of success) with a number of key questions related to egress drills:

- What scenarios should be examined as part of an egress drill?
- Who should be involved?
- What procedures should be tested?
- How realistic can/should the drill be?
- Who can/should know about the egress drill in advance?
- What proportion of egress drills should be used for training and/or assessment?
- How often should drills be performed to enhance performance without desensitizing the occupants and causing undue disruption?
- What data should be collected from the drill and how should it be reported?
- How should the data be collected?
- What constitutes a successful outcome for a drill?
- Who should monitor the drill?

All of these questions should be considered when designing and implementing a drill; however, the responses to many of these questions are not well understood and may be compromised by issues that do not relate to the objectives of the drill itself. For instance, issues of cost, safety, convenience and practicality. These issues will affect any attempt to approximate a real evacuation – an approximation that might be used to assess or influence evacuation performance. This poses another question: How good an indication of a real evacuation is provided by an egress drill?[5]
The issues are now discussed in the context of such approximations – or models – of reality.

5. What is an egress model?

Fioretti defines a model in the following terms: "Models are simplified reproductions of portions of reality that, if validated, are still able to capture a few of its essential properties." [22]. Models are then a simplification that provides a limited insight - in terms of scope and refinement - into the

[5] For instance, where a real fire has occurred in a building, how representative was the scenario examined during egress drills performed prior to the incident and how representative was the evacuee performance of that exhibited during the real incident?

target entity. The use of model results requires qualification and justification to ensure that the model limitations are understood. Models are employed to help describe, understand or predict elements of a real-world entity. As such, they are a potentially useful tool for the investigation of real-world conditions, especially when the direct observation of such conditions is difficult; for instance, if a fire occurs in a high-rise building. Models provide useful insight on the basis that the conditions represented and the results produced are deemed to credibly represent the real-world entity of interest. However, as noted by Fioretti [22], any model is a simplification, a partial and limited representation of reality. The model will not be suitable for all scenarios and cannot represent any one scenario perfectly. Factors will be excluded as part of the simplification. Model use then needs to be clearly understood and justified given the application at hand; this applies to all models.

In this context, an egress drill is a *model* of a real-world evacuation. This fact can be obscured given that the building and population can often be the same as those present during a real event[6]; however, key factors are often deliberately omitted by design. Where prescriptive regulations are employed (e.g. NFPA or IFC), the egress drill may be one of the few opportunities to quantify egress performance. However, as with other egress models, any egress drill model will exclude a number of factors that might be present during a real incident; e.g. a lack of warning, presence of active emergency personnel, presence of fire effluent (to which some individuals might have been exposed leading to psychological, physiological or behavioural developments), etc. It is unlikely that all of these factors would be adequately simulated during a drill. The impact of these omissions may not be immediately apparent or easy to quantify.

The egress drill is one of several egress models available. Other models include computational, physical, scale, engineering, conceptual, real-world, prescriptive, experimental, and table-top models [23-25]. Each of these models has their strengths and weaknesses. All of them make assumptions regarding evacuee behaviour and the scenario to which evacuees might be exposed. These enable the models to either quantify evacuation performance or aid in the planning for future evacuations. For instance, a number of computational simulation tools allow the relationship between underlying evacuee actions (e.g. the routes adopted by simulated agents) and overall evacuation performance (e.g. time to clear a floor, congestion on a stair, the building, etc.) to be explored. A detailed description of these models can be found in the reviews developed by Kuligowski et al. [25] and Gwynne et al. [23].

In order to understand the value and appropriateness of the output produced by an egress model, it is critical to assess the distance between the model and reality; between the assumptions made in the model and the underlying factors that would be present in the real-world. The proximity between real-world and egress model (simuland and simulation [26]) is limited by a number of considerations that preclude the representation of key influential factors. Given the involvement of human participants, the following considerations are particularly relevant to the egress drill model:[7]

- **Financial /Organizational:** Resources are needed to design, organize, execute and analyse an egress drill. Attempting to generate realistic evacuation conditions may be disruptive to the routine operation of the building – before, during and after the drill - which will incur costs due to the services lost. In addition, organizational resources may need to be diverted to the performance of the drill; for instance, staff, equipment, etc. External resources may also need to be applied in order to help organize, manage and examine the evacuation. The

[6] Similar to the way that the sophistication of computer model can be obscured by the quality of its graphical user interface.

[7] Although here being applied to egress drills, these considerations could and should also be applied to the other types of models.

performance of frequent and representative drills may then be too costly in terms of the disruption in building services, preparation and analysis. Authority is required to organize and perform egress drills - especially drills that might cause significant disruption. Depending on the organization, authority for the design and execution of drills may not entirely reside with safety planners. This might then require them to negotiate the timing and nature of the drill performance with other interested parties, leading to the drill being less disruptive, costly, etc.

- **Ethical:** Attempting to reproduce credible real-world conditions may place those involved in the drill at undue risk of injury. For instance, if a sense of evacuee urgency and route loss leading to stair congestion is represented during a drill, then these conditions might expose the evacuating population to trips, falls or even crush conditions. This concern might also limit the involvement of those that might be exposed to injury or discomfort simply by taking part in the drill; e.g. the movement of vulnerable populations from a place of safety during the drill that exposes them to fatigue, trips/falls, or discomfort related to their vulnerability. This is especially important as these sub-populations may have an important influence on overall evacuation performance and also require additional training given their vulnerable nature.[8] Ethical concerns may prevent the performance of a drill at a certain time (e.g., in winter, during the night, etc.). Safety concerns may also preclude the adoption of certain emergency procedures given concerns over their 'side effects' (e.g. using evacuation devices, descending numerous flights of stairs), or the involvement of people who might more effectively be used elsewhere during real incidents (e.g. fire service who might reasonably address real incidents).
- **Methodological**: It may not be possible to sufficiently instrument the building to collect the data needed to assess overall performance (e.g. route use, travel speed, local congestion, etc.) and the underlying factors that influence it (e.g. congestion on stairs, performance of those with movement impairments, individual actions, etc.). It may also be difficult to collect data without influencing the outcome of the incident (e.g. people seeing the cameras, staff, etc.). It may not be possible to deliberately manipulate key underlying factors in a controlled manner. For instance, enforcing the initial location of the population, ensuring route use, etc. This might limit the potential to recreate real-world scenarios of interest. Instead of examining challenging scenarios reflecting credible incidents, the drill might instead represent the most convenient scenario to arrange; for instance, with all routes available, the vulnerable population excluded, staff pre-warned, etc. This might dilute the representativeness of the scenario and reduce the insight gained from the data produced.
- **Supervisory:** In many cases, the drill is not monitored or the results scrutinized by authorized third parties. Little control is then exerted over the manner in which drills are executed, the scenario examined, the data collected, the manner in which the data is analysed and the use made of the data collected. In 2009, the Auditor General of Canada reported on whether government departments complied with regulations on egress drill performance [27]. [9] They found that although departments were required to perform yearly drills, 33% could not show that they had done so. They also noted that there was no government-wide means of observing and documenting the performance of these drills. Drills were then potentially not being performed according to the requirements and were not being consistently monitored. If representative of wide practice, such issues mean that any shortfalls in the methodology adopted or compromises needed given financial, organizational, or ethical concerns may not be consistently identified or documented, preventing assessment.

[8] However, vulnerability is not static. For instance, evacuating a fit, unimpaired population down the stairs from the 75th floor of a high-rise building may make them relatively vulnerable in comparison to the evacuation of a similar population from the 3rd floor of the same building.

[9] The Treasury Board Standard for Fire Safety Planning and Fire Emergency Organization [27].

- **Statistical** - Drills are performed periodically (given the concerns highlighted above). Each drill represents an instance of a scenario – a single data-point from within a distribution of outcomes that might reasonably be expected for a particular scenario given minor perturbations in the initial conditions. A scenario may possibly be repeated a number of times over a period of time. For instance, a mid-rise office block may be completely evacuated using all of the stair cases available several times over several years. Given the appropriate controls, this set of results may eventually provide some statistical foundation for any conclusions made. However, if this is the case, then many other possible scenarios would likely not be drilled; for instance, where a particular stair is not available, where the population is distributed differently, etc. Given the current number of drills performed, emergency managers are then torn between producing a reliable understanding of a single scenario, or limited understanding of several scenarios.

These concerns limit the accuracy and credibility of egress drills in a number of ways. Firstly, the results produced may not be a good indicator of real-world performance given the limited number of data-points collected. This is especially the case if the drill is not performed or not documented as mentioned above. A drill produces only one overall evacuation time. It cannot be assumed that this time is representative of the range of different times that might be produced during a real evacuation involving the same scenario. Secondly, the scenarios examined may not be representative of those that might actually occur. A relatively narrow range of scenarios will typically be examined, providing little insight into other emergency scenarios. In addition, the scenarios selected may be biased to favour simple planning and execution, further skewing the insight provided. Thirdly, only a limited amount of data are routinely collected; for instance, focusing on the overall clearance time of the building. It may not be sufficient to provide insight of the underlying factors that lead to this performance. The diagnostic value of the drill (i.e. understanding what led to the overall performance) is then limited given the type and accuracy of data collected. Fourthly, it is unlikely that the accuracy and credibility of the drill is independently assessed. All of these limit the usefulness of the insight into evacuation performance that an egress drill provides.

In addition, if addressed simultaneously, the competing objectives of an egress drill can undermine its value. As mentioned in the IFC requirements, drills are typically performed for two distinct reasons: to assess the performance of a procedure and to train the population and staff of the procedure in place. These are both enormously important objectives. Egress drills are a useful model in addressing each of these objectives. However, it is challenging (if not impossible) to achieve these objectives during the same drill. For instance, where staff members (whose influence might otherwise not be present during a real evacuation) intervene to assist training and familiarization, then the overall performance may be unduly optimistic. Where there is no staff intervention of this type, then the training objective might not be met.

Given the limited number of times that drills are performed (due to the considerations mentioned above), it is often assumed that a drill addresses both objectives simultaneously. This is a mistake. This may encourage a false sense of safety[10] promoting overconfidence in the robustness and performance levels achieved when applying an emergency procedure; for instance, where performance has been enhanced by intervention or instruction, and where relatively unchallenging scenarios have been examined. Training allows the improvement of performance through the provision of information and the familiarization of the target audience with the procedure in place. Assessment requires an unpolluted measurement of the current performance levels achieved given current practice: the procedure in place, population distribution, population training levels, the nature of the incident, etc. A clear distinction has to be made; otherwise both objectives might be compromised.

[10] It may also provide a false sense of security.

6. So what?

It is suggested that egress drills are not currently used to their full potential. That is not to say that egress drills are unnecessary - far from it, they are vital. However, there is insufficient scrutiny and guidance on how drills should be performed, what can be expected from a drill, the data that should be collected, those that should be involved and the scenarios that should be examined. This undermines the value of what might otherwise be a sophisticated and important model of evacuation performance. Egress drills need to be fully exploited given both the value of their results and the cost of performing them.

Just as undermining is the frequent attempt to assess performance and train staff at the same time. The value of the drill can be further diluted by the examination of relatively benign scenarios; often required by issues of cost, potential disruption and behavioural impact (e.g. the threshold at which familiarity breeds occupant contempt of false alarms).

Where possible, a population needs to be trained, to ensure that they are familiar with the general procedure and their role within it. It is just as important to assess the effectiveness of this training and the robustness of the procedural resources in place - to determine the performance levels that can be expected during a real incident. Other approaches should therefore be sought to support and complement the essential value of egress drills. One example of this is presented below.

Egress models cope with assessment and training challenges in different ways and with different levels of success. A comparison between the relative merits and vulnerabilities of egress drill and computational models is shown in Table 1.

Table 1: Impact of considerations on model performance.

	Model	
Considerations	***Egress Drill***	***Egress Simulation Tool***
Financial / Organizational	*Disruption to building services likely. Internal / external costs dependent on resources required.*	*No disruption. Cost dependent on licensing, technology and expertise requirements.*
Ethical	*Participants may be put at risk during drill. Either they are excluded (compromising drill) or included (potentially compromising safety). Restrictions may exist; e.g. timing and scenarios represented.*	*No risk to participants. Participants (agents) can be exposed to a range of different fire scenarios.*
Methodological	*Perceived similarity between model and real-world entity. Challenges in manipulating scenario factors and collecting sufficiently refined data without compromising event.*	*Scepticism of similarity between model and real-world entity. If model has sufficient functionality, manipulating scenario should be simple. If model has sufficient refinement, data collection at required granularity should be possible.*
	Limited number of scenarios examined and repetitions. Conducted periodically.	*Ability to examine multiple scenarios and produce multiple instances of each scenario. Can be conducted as required.*
Regulatory Scrutiny	*Quality of both models highly dependent on third party scrutiny*	
Training Benefit	*Able to familiarize and contribute to training of target population.*	*May be used to demonstrate impact of evacuee/staff actions as part of training.*

In both instances, a range of model approaches and capabilities exist [23-25]. In this discussion it is assumed that the computer egress model is able to simulate accurately

- the movement of individual agents during an evacuation
- the physical space (e.g. based on an engineering diagram)
- and the required emergency procedure (e.g. specifying route use, pre-evacuation times, etc.).

This outlines the potential for the application of egress drill and computer models to address the considerations listed. It is apparent that drills have a high degree of credibility and can directly enhance performance through training, whereas computational tools have a high degree of flexibility and are able to generate multiple repetitions of numerous scenarios.

These two approaches could be used to produce a more robust, informative and representative training and assessment program. An outline of such a program is shown in Table 2. Obviously, this is one of many approaches that might be adopted - others might specify different tests, population sizes, schedules, etc.

Table 2: Training and assessment program using multiple models.

Step	Event	Frequency	Impact
1	Small-Scale Training: Individual training / familiarization of the procedure and their role within a given range of different scenarios.	Frequent (e.g. bi-monthly)	Low disruption. Enhance performance level.
2	Small-Scale Test: Individuals / groups asked to enact role in procedure; e.g. go to nearest exit, operate device, identify alarm, etc.	Frequent (e.g. bi-monthly)	Low disruption. Test benefit of training on local performance levels.
3	Large-Scale Test: Full-scale Drill	Rare (e.g. yearly)	High disruption. Test overall performance level.
4	Validation: Full-scale Simulation	Rare (e.g. yearly)	Compare results from Step 3 with simulation of equivalent scenario. Increase confidence in simulation by demonstrating reproduction of full-scale drill result. Enhance understanding of scenario examined in Step 3 by producing multiple repetitions. Use output to enhance Step 1 - by gaining insight into important underlying factors and the ability to demonstrate the impact that individual training has on the overall outcome.
5	Scenario Simulation	Rare (e.g. yearly, following changes to building/ procedure)	Examine array of different scenarios to quantify robustness of procedure in place. Feedback suggested enhancements (e.g. procedural modifications) into procedural design and Step 1.

Such an approach exploits the respective strengths of the two models in order to compensate for the vulnerabilities present in each and to address both training and assessment objectives. Initially, small-scale training exercises are performed to provide a basis for occupant understanding. This is followed my ‘micro-drills': local drills that involve individuals/groups. This then establishes the performance level given prior training, without disrupting the whole building or exposing them to undue risk. Periodically, the full emergency procedure will be tested. This will only involve instructions typically provided as part of the emergency procedure - a 'clean' test. The data collected from this event will have enormous value in and of itself and will also be used as a validation case for the computer simulation. This validation will demonstrate that the model is able to reproduce the

original conditions, but also allow the same scenario to be repeated multiple times to see how representative the original result was, how sensitive it was to minor local variations in the initial conditions (e.g. the population distribution within the building) and help provide insight into key factors. Finally, the computer simulation can be applied to different scenarios that would otherwise not be examined, given issues of time, cost and ethical concerns. These might examine the outcome of fire scenarios given current building operations (e.g. different use scenarios - during holidays, at night, peak conditions, etc.), or estimate the outcome of the fire scenarios given proposed changes to the building (e.g. structural, procedural, demographic, etc.) before the changes are implemented. These would provide critical insights into the effectiveness of a procedure given different incident scenarios, and allow safety managers to assess performance, modify procedures and enhance training programmes in an informed, evidence-based manner. This simple approach would address many of the challenges posed earlier, while potentially reducing cost and occupant exposure.

This approach does not address the issue of third party supervision – the monitoring of the training and assessment approach adopted. Irrespective of the models employed, third party scrutiny is key to ensure that the right models are employed and that they are employed responsibly. This has to be done consistently and expertly – to ensure models are applied and are applied such that they produce valuable results. The absence of such scrutiny in any approach undermines the credibility of results produced. Similarly, clear regulatory guidance should be provided on the models to be employed (drill, computer or otherwise), how such models should be employed (configuration, execution, data collection, etc.) and how the results should be compiled and reported. This, along with third party scrutiny, would enhance the consistency between model applications and increase the credibility and value of the entire process.

7. Conclusion

The egress drill model is a critical tool for both enhancing and assessing evacuation performance. Drills have often been used to provide insight into evacuation performance and to aid in the training process with great effect. However, a number of issues limit the realism of these drills, the representativeness of the data collected and the eventual impact of this data. Current practice would be enhanced through a greater appreciation of the strengths and limitations of egress drills – so that they can be conducted in a more informed manner. It is hoped that this article has contributed to this understanding. We must (a) exploit the drills to their full potential, especially given their cost and the important insight gained from their performance and (b) avoid issues that might be caused by drills, such as occupant complacency through over-drilling and drilling to unrealistically benign scenarios providing a false sense of security. It is also suggested that other models (e.g. computer models) could be used to complement the performance of egress drills - to provide additional insight and confidence in the results produced and also expand the scenarios examined without increasing the number of drills required. This could be achieved without compromising the twin objects of egress drills: training and assessment.

Egress performance needs to be assessed. This assessment provides key insights into the effectiveness of the emergency planning and procedure in place. However, irrespective of the model used (drill or otherwise), model application should be informed by clear guidance and be monitored to ensure consistency and credibility.

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