

## **Analysis of Fire Evacuation Behavior in a Primary School Environment**

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Fire Safety in Primary School: Korea

### **Abstract**

*The paper compares the statutory requirements for the design and construction of primary schools in Korea and Scotland with respect to fire safety and examines the attitudes to, and the behavior in, evacuation scenarios of primary school pupils in both countries. The key behavioral issues examined are the effectiveness of fire safety training, the level of teacher dependency, the effect of spatial organization and gender differences both within and between Korea and Scotland.*

### **Introduction**

Research on evacuation behavior in emergency situations has established the importance of psychological factors in determining the effectiveness of escape route design and evacuation management strategies <sup>1,2,7,9</sup>. However there has been comparatively little research into the differences in behavioral response between adults and children, and of variations in response between children of different age groups.

Building regulations and design guidance for school environments tend to assume a uniform population with respect to both physical ability and behavioral response <sup>3,4,5,6</sup>. However as primary school children vary significantly in chronological age, physical and cognitive development a range of responses in emergency situations could be expected. The uniform treatment of different age groups can be linked to a society's focus on cost reduction where the level of risk appears acceptable <sup>8</sup>.

This paper presents a comparative analysis of the statutory requirements, the design assumptions and the evacuation strategies for primary schools in Korea and the Scotland. The

findings of questionnaire and field studies assessing fire safety awareness and the factors influencing evacuation behavior of primary school children are also reported. The factors examined included the level of teacher dependency, the impact of building design, the effect of gender and differences between questionnaire and observed responses.

## **Primary Schools in Scotland: Current Practice**

### ***Building Design***

In Scotland the key criterion for determining the specific level of performance required with respect to a particular statutory requirement (e.g. fire resistance of elements, number of escape routes) is the 'purpose group' classification. The purpose group effectively combines an assessment of both the fire hazard and the fire risk and is a technically informed social policy decision. The purpose group classification for schools is 'Assembly and Recreational: Low Hazard'. The risk and hazard with respect to fire growth and development and life safety is categorized as comparable to that in libraries, air and rail stations and sports stadium. In general the structural fire protection requirements are therefore less onerous for schools than for offices and retail whereas the requirements for means of escape for schools are comparable to those for retail and more onerous than those for offices.

For means of escape the main differentiating requirement with respect to other purpose groups is the maximum permitted travel distance to a protected zone<sup>F1</sup> from any point within the building. The maximum travel distance allowed depends on the number of escape routes available at any point in the building. For schools the travel distances are 15m. for one escape route and 32m. for more than one escape route.

A manual fire alarm point system with a bell, or siren, alarm signal must be installed in schools. The regulations do not require smoke detection-alarm or sprinkler systems. The Fire Service and local authorities in Scotland<sup>10</sup> perceive the manual point and bell alarm system to be appropriate as the occupant population is stable, familiar with both the buildings and the emergency procedures, and supervised.

The prescribed fire resistance requirements are based on purpose group, story area and building height. Primary schools in Scotland are generally low rise and characteristically the fire resistance requirements for compartment walls and the enclosure of protected zones is 60 minutes.

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<sup>F1</sup> a protected zone is an escape route (corridor or stairwell) within a fire resistant enclosure separated by fire doors from the unprotected circulation spaces.

While the spatial organization, particularly with respect to the use of open plan spaces, can vary significantly primary schools in Scotland are required to incorporate; teaching rooms, cloakroom\lockeroom facilities, an assembly area, a gymnasium, a cafeteria area and associated kitchen facilities, toilets, staffrooms and administrative offices. For the characteristic school role of approximately 300 pupils the current architectural approach is to have classrooms and offices opening onto common central spaces in a single story building.

Following the tragedy at Dunblane Primary School in 1996 where a gunman entered the school and shot pupils and staff in the gymnasium, school security has become an important issue. Pilot studies examining the effectiveness and practicality of controlled single point entry, video surveillance and internal communication systems within schools have been initiated. The introduction of such systems in all primary schools would necessarily have an impact on evacuation management.

Within the statutory requirements primary school buildings are treated as equivalent to a number of other building types. The physiological and psychological factors which differentiate a primary school population from an adult, or a mixed age, population are therefore clearly not considered to have a significant impact on life safety issues.

While it may be reasonable to assume that flow rates, and hence maximum allowable travel distance, are comparable for young children and adults there may be significant differences in the decision-making process which affects pre-movement time, a parameter which is of at least equal significance <sup>1,11, 12</sup>, and in the decisions taken. The regulations specify the minimum escape route width based on an 'effective unit width' per person. Although an appropriate scaling factor is not used for primary school populations this is not inappropriate as the effect is to increase occupant flow rate.

The majority of schools destroyed by fire in Scotland are unoccupied and the fires have not therefore resulted in loss of life. However this does not mean that the statutory requirements for building design achieve a balance between hazard and risk that is socially acceptable <sup>4</sup>. It may simply be that balance is not fully understood <sup>13,14</sup>. The Fire Service has recently expressed concern at the ease of ignition and rate of fire spread in school buildings and this would suggest that the performance level specified for fire containment is inadequate <sup>10</sup>.

### ***Evacuation Management***

Schools are required to have an evacuation plan and fire evacuation training exercises are

carried out at least once per year. The evacuation plan is based on teachers leading their classes through the escape route to a designated assembly point where a roll call is taken. The standing instructions are that in the absence of a teacher pupils should walk quickly from the building and then to the designated assembly point for their class <sup>4</sup>.

The statutory guidance <sup>15</sup> on fire evacuation training exercise is that there would be no prior warning, however local authority guidelines are not explicit and it is common practice in many Scottish schools for teachers and pupils to be alerted prior to training exercise.

One consequence of giving prior warning of a training exercise is that pupils have no experience of evacuation without a teacher. The acquisition and maintenance of emergency evacuation skills is therefore limited to one scenario as written or verbal instructions are a less effective method for conditioning behavior <sup>9</sup>. In this context there is a difference between secondary school pupils between the ages of twelve and eighteen, whom it may be reasonable to consider as a single group with the ability to assimilate instructions, and primary school pupils between the ages of five and eleven with significantly different levels of cognitive skills, dependency and experience <sup>11,14,16</sup>. The specific problems associated with the safety of disabled pupils and the potentially dual roles for teachers were not studied directly in this project however there is evidence <sup>17,18</sup> that for practical reasons adhoc solutions are adopted.

## **Fire Safety in Primary Schools: Korea**

### ***Building Design***

In Korea the key criterion for determining the specific level of performance required with respect to a particular statutory requirement is also the 'purpose group' classification. The purpose group classification for schools is 'educational and research facilities'. The risk and hazard with respect to fire growth and development and life safety is categorized as comparable to that in training center, academy, institute, library, and juvenile facilities.

For schools the travel distances from a stairway to an exit are less than 30m, in case of that main structures consist of nonflammable materials the distances are less than 50m, and from any point of living room to exit are less than 60m, in case of that main structures consist of nonflammable materials the distance are less than 100m.

In schools there must be some portable extinguishers, direction lights and direction signals. In case of more than 3,500 m<sup>2</sup> schools indoor hydrant must be installed, more than 2,000 m<sup>2</sup>

schools emergency amplifier system must be installed and more than 2,000 m<sup>2</sup> automatic fire detecting system must be installed. The regulation does not require sprinkler systems.

Recently almost schools are serviced by private security company, so at night fast fire detecting and responding are impossible and fire prevention is hard to do.

Within the statutory requirements primary school buildings treated as equivalent to a number of other building types too in Korea.

In primary, middle, and high school the width of corridor is more than 1.8m and the width of corridor by which there are rooms both side is more than 2.4m.

Fortunately there have been not fire tragedy by which many pupils died in schools. However this does not mean that the statutory requirements for building design achieve a balance between hazard and risk that is socially acceptable.

### ***Evacuation Management***

The regulation does not require any evacuation plan and fire evacuation exercise. Some schools voluntarily do those.

### **Field Study Methodology: Survey and Evacuation Monitoring**

The aims of the field study were to determine the attitudes and the level of fire safety awareness of primary school pupils and to compare these with pupil's behavior in different evacuation scenarios. A questionnaire survey was used to provide data on attitudes and level of awareness, pupils did not confer while completing the questionnaires (Appendix 1). For the youngest age groups, 4 to 6 years of age, the questionnaire was completed by a researcher interviewing the pupils in small groups. Teachers also completed a questionnaire to provide background factual information (e.g. number of visits by a fire officer, evacuation procedures). A series of evacuation exercises were carried out to examine behavior. There was no prior warning of the evacuation exercises and the following scenarios were examined:

- i) pupils in the classroom without supervision for several minutes prior to alarm,
- ii) pupils without direct supervision carrying out a measurement exercise in the school grounds.
- iii) pupils without direct supervision who have permission to be outside the classroom but within the building(e.g. cafeteria duties, messages, toilets).

The scenarios are all realistic and require the pupils to apply their knowledge of fire safety procedures to individual and collective decision-making. The evacuation exercises were monitored by a combination of observers and video cameras.

In Korea evacuation monitoring omitted because many pupils can not distinguish the fire alarm so there is no way to be believed real situation by pupils. While completing the questionnaires (Appendix 2) pupils did not confer and teacher helped that.

In Korea a sample of 100 pupils from three primary schools completed the questionnaires and the evacuation exercises were carried out in two schools involving a total of almost 500 pupils.

In Korea a sample of 606 pupils from three schools which consist of the schools in large city, small city, and rural area completed the questionnaires.

### **Field Study: Scotland**

#### **Survey Summary**

The basic assumption of a stable population that is familiar with the school building, the main escape route and the sound of the alarm is supported by the survey findings. In the sample 99% of pupils had attended the school for more than six months and 83% had entered in primary 1. The sound of the fire alarm could be identified, and differentiated from other cells, by 96% of pupils and 83% of pupils were able to make a complete description of the main escape route. A similar proportion of pupils (80%) demonstrated general knowledge of fire safety issues, although primarily related to domestic fire safety and fireworks. In relevant responses only 9% of pupils specifically referred to fire safety in schools although this may reflect the situation and the wording of the questions.

The pupils have a clear view that it is the role of their teacher (96%), or another person in authority, to make the decision to evacuate the building and to supervise the process. This is in line with education authority guidelines. However the tendency to reliance on, or reference to, a teacher may in certain cases be counter productive. The presence of a more senior pupil in a supervisory role (e.g. monitor during lunch break) appears to have little affect on the behavior of a significant proportion of pupils. Of the sample, 34% would attempt to evacuate without further instruction, or reference to the monitor, however if the class was unsupervised this number would only rise to 37%. In both situations the separation of the group would increase confusion, and could possibly lead to confrontation, as about 15% of these pupils would

attempt to evacuate the class as a group and go to the assembly point. Of the remaining pupils in the monitor supervised scenario 60% would either follow the monitor's instructions or await/seek the teacher. The 'waiting' or 'seeking' actions are categorized as delaying and hence ineffective <sup>1</sup>. The range of potential decisions by the monitor increases the uncertainty associated with this scenario because they are not trained to evacuate a class and may not be familiar with the main escape route and assembly point for the class. In an unsupervised class over 50% of pupils would wait/seek the teacher or join the class next door.

In both the unsupervised and monitor supervised scenarios a significant proportion of pupils (approx. 9%), under the age of 8, were unsure they would do and suggested inappropriate, or non-adaptive <sup>2</sup>, behavior such as hiding under desks.

In unsupervised situations outwith the school building 60% of pupils would assemble at their classes designated area. However 30% were unsure what they would do and 3% would seek the teacher which could involve entering the building. Of equal concern 9% of the older pupils would leave the school grounds.

Reliance on action by teachers impacts on the perceived effectiveness of the detection-alarm system. On identifying fire cues almost 60% of pupils would seek a teacher to activate the alarm compared with 27% would activate the alarm themselves. This problem could probably be minimized by a more effective training system using experiential learning as discussed by Randall and Jones <sup>9</sup>.

If their escape was blocked by fire or smoke 68% of pupils were aware that they should use an alternative exit. However in contrast to their familiarity with the main escape route only 21% were able to describe the alternative escape route from their classroom. Nearly 10% of pupils, mostly male, were prepared to continue along the escape route either holding their breath or crawling along the floor. This is clearly indicative a deficiency in the fire safety training. There may also be a lack of awareness of the hazard possibly correlated with the 'little fear of a fire' expressed by 66% of male pupils. Alternatively while indicative of an attitude this may not correlate with behavior in practice.

### **Evacuation Exercises Summary**

*Scenario 1: pupils in the classroom without supervision for several minutes prior to alarm.*

On hearing the alarm pupils immediately left their desks and lined up at the classroom door with a number commenting that it was 'fire drill'. The classes then remained at the door prior to

entering the hallway where they again stopped and waited. Only when other classes on that story had cleared the story did they rapidly proceed to their own escape stair and subsequently out of the building to their assembly point.

There was no evidence of social inhibition identified by Latane and Darnley <sup>19</sup> or of the potential peer disagreement indicated by the questionnaire survey. After the interviews it was established that the two delays were because they were waiting for their teacher to return or for other guidance. This is line with the responses to the questionnaire survey although there was no attempt to seek their teacher or to approach a teacher from another class. The behavior of the pupils was consistent with the 'diffusion of responsibility' identified by Latane and Darnley <sup>19</sup>.

*Scenario 2: pupils in small groups without direct supervision carrying out a measurement exercise in the school grounds*

On hearing the alarm all pupils moved to their assembly point although they appeared uncertain. However they all reached their assembly point before their class exited from the building. No pupils attempted to enter the building.

*Scenario 3: pupils in small groups without direct supervision who have permission to be outside the classroom but within the building*

On hearing the alarm all of the pupils in the study attempted to return to their classroom, irrespective of distance or location within the building, rather than leave the building by exit doors which were close, and visible, to them.

This behavior was consistent with the survey responses and the lack of specific training for this situation.

The scenario study while involving more pupils in total than the survey had only a limited number of pupils in each situation. However for the scenarios examined, reported here, the behavior of pupils of all ages was comparable. An important, and predictable, difference was that the younger pupils appeared distressed whereas the older pupils exhibit a degree of ambivalence which has been identified by Horason and Bruck <sup>20</sup> in secondary school pupils. However unlike secondary school pupils the primary school pupils did not appear to be inhibited in responding to the alarm or in evacuating quickly in class lines without their bags.



## **Conclusions**

It was concluded from the survey that the effectiveness of the detection and alarm systems and the evacuation plans for primary schools in Scotland were reliant on the presence of a teacher, or person in authority, and that there was a significant risk of non-adaptive behavior by pupils in an emergency situation. The normal fire safety training such as that discussed by RANDALL??? could contribute to remedying this weakness.

The limited sample size and number of scenarios in the evacuation study affects the generality of findings however the observed behavior is consistent with the analysis of the questionnaire survey.

The differences in design between the three schools in Scotland did not appear to influence the pupil behavior either in the given scenarios, or as assessed by the survey. The only observed difference was in the response of pupils from the single story school, with exit doors from each classroom, where over 50% would evacuate the building immediately in an unsupervised scenario. This compares with approximately 30% of pupils in the other schools which are both two story buildings. This would appear to support the NFPA Life Safety Code which recommends that classrooms for younger pupils should be on the ground floor with fire exit doors to the outside.

## **Field Study: Korea**

### **Survey Summary**

The basic assumption of a stable population that is familiar with the school building. In the sample 98% of pupils had attended the school for more than six months and 82% had entered in primary 1. Almost pupils can not identify the sound of fire alarm. Because there is no regular training or education in school, almost pupils can not describe how they can evacuate effectively.

Some of pupils gain fire safety issues from teacher (63%), fire officer (67%), and mass media (53%), although primarily related to domestic fire safety and fireworks.

62% pupils said they wait teacher in the classroom when fire break out. This reflects pupil's tendency to reliance on, or reference to, a teacher. 50% pupils said they think the safest place as

gather point is ground. 5% of pupils wanted to pick up their belongings from classroom in which the fire break out. This action is very dangerous and inappropriate. If they are confined in the classroom, 69% pupils show appropriate response that is waiting rescuer at window side. The most appropriate first action they do when they find out fire is screaming 'fire' and the portion is 46%.

Many pupils (80%) think the cause of fire is careless of related people. Only 60% pupils think the fire is very afraid. 24% pupils want to be a fire fighter, paramedics, and rescuer.

### **Conclusions**

It was concluded from the survey that the effectiveness of the evacuation plans for primary schools in Korea were reliant on the presence of a teacher and that there was a significant risk of non-adaptive behavior by pupils in an emergency situation. Especially there is no regular training or education so that in case of real situation there may be confusion and this can be concluded to tragedy.

Fortunately pupils acquire several fire safety issues from mass media (especially TV) and fire officer who visit schools. It will be important information they need in emergency situation.

The pupils in large city were more reliant on the presence of teacher. But about any other question they show more appropriate response than the pupils in small city and rural area. There is no distinguished tendency between different age and sex.

### **Scotland and Korea: Comparative Analysis**

In Korean schools there are no principles those are where they gather, which route they pass through, how anyone inform the fire situation to everyone. These problems are because of absence of regular training and education.

### **References**

1. Canter, 'Studies of Human Behavior in Fires: Empirical Results and Their Implications for Education and Design', Building Research Environment, 1985
2. Bryan, 'Behavioral Response to Fire and Smoke', Society of Fire Protection Engineers Handbook, 2nd ed., 1996

3. Hillman, 'The Acquisition and Maintenance of Fire Emergency Skills: Effects of Rationale and Behavioral Practice', *Journal of Pediatric Psychology*, 11, 1986
4. Strathclyde Regional Council, Revision of Standard Circulars 24-24a General Instruction on Fire Precautions, 1993
5. Jones and Oldendick, 'Fire Emergency Skills in Children: The Impact of Fear and Anxiety', Southeastern Psychological Association Conference, 1986
6. Jones and Williams, 'Impact of Self-Instruction on Response and Maintenance of Children's Fear of Fire', *Journal of Child Psychology*, 18, 1989
7. Pauls, 'Building Evacuation Management and Other Fire Safety Measures: Some Research Results and Their Application to Building Design, Operation and Regulation', Canadian National Research Council Report, 1989
8. Takeyochi, *Fire Safety Science*, P.734, Building Research Institute, Japan
9. Randall and Russell, 'Teaching Children Fire Safety Skills', *Fire Technology*, vol. 29, no.3, National Fire Protection Association, 1993
10. Fitzpatrick, interviews with Fire Service, dissertation, 1995
11. Ramachandran, 'The Human Aspects of Fires in Building – A Review of Research in the United Kingdom', *Fire Safety Science*, 1985
12. BSI Draft Code of Practice (1996) & JSO Draft Fire Safety Engineering Design Code TC92 (1997)
13. Canter, 'Human Behavior in Fires in Public Buildings', report to scientific research and development branch, Home Office, UK, 1982
14. Canter and Mathews, 'The Behavior of People in Fire Situations: Possibilities for Research', Building Research Establishment Report, UK, 1976\
15. Health & Safety at Work Act, Section 13, Safety Advice, Fire Precautions ( General Information) UK, 1974.
16. Hinks, 'Modeling and Managing Escape From Fires', internal report, University of Salford, UK
17. Zuraini, Msc Thesis, Glastow Calednian University, 1996
18. Tayside Regional Council, 'Guidance Notes for Fire Procedures for the Disabled', 1992
19. Latane and Darnley, 'Group Inhibition of Bystander Intervention in Emergencies', vol.10, no.3, pp.215-221, *Journal of Clinical Psychology*, 1986
20. Horason and Bruck, ' Investigation of a Behavioral Response Model for Fire Emergency Situations in Secondary Schools, Strathclyde Regional Council, UK, 1992

## Appendix 1 (Questionnaire for Scotland pupils)

These are the questions. For young pupils they were interviewed verbally.

1. How old are you?
2. Are you male or female?
3. How long have you been at this school?
4. Can you describe how you can tell the difference between the fire alarm signals and other signals?  
(e.g. break time)
5. Are you usually told if you are going to have a fire drill?
6. If you hear the fire alarm, and are in class, do you wait until the teacher tells you to leave?
7. Do you know the way out of the school that you are supposed to follow when you hear the alarm?
8. Can you describe the route or would you follow the teacher? (if you can describe the route)
9. If the alarm goes off during break-time, and you are in class, what would you do?
10. If you are in the playground and the alarm goes off, please describe what you would do.
11. If your teacher has left the class for a short while, and the alarm goes off while he/she is away, what would you do?
12. If the way out of the school that you are meant to follow is blocked, say by fire or smoke, what would you do?
13. If your class and teacher talk about what to do should the alarm go off, what kind of things do they say?
14. Has someone from the Fire Brigade visited your school and talked to you about fires?  
What do you remember about what they said?
15. What would you do if you found a fire in your school?
16. Do you know how to set the fire alarm off in your school? Please describe how.
17. Where is the nearest alarm to your class.
18. What do you think causes fire?
19. Why do you think some people cause fire?
20. Have you seen TV adverts or read magazines telling you what to do in a fire? If so, what can you remember about them?
21. Are you afraid of fire? If you are, how afraid are you?  
Very afraid                      afraid                      just a little afraid                      not at all afraid
22. Apart from the fire alarm what other ways might you be able to tell if there was a fire in your school?

## **Appendix 2 (Questionnaire for Korean pupils)**

1. How old are you?
2. Are you male or female?
3. What grade are you in?
4. How long have you been at this school?
5. Can you distinguish the fire alarm among other signals?
6. Have you ever been trained or taught about fire situation in school?
7. When fire break out in school do you wait to evacuate till teacher permit that?
8. In school fire situation where do you go to for evacuation?
9. What do you do first the fire break out in other classroom during break time?
10. You are in the playground and find out the fire in your classroom. What would you do?
11. The route you can pass through is blocked by flame and smoke. What would you do?
12. Have ever been told about what you must do in fire by teacher?
13. Have ever been told about what you must do in fire by fire officer who visited your school?
14. If you find out fire first in your school, what would you do?
15. Why the fire break out?
16. Have you seen TV adverts or read magazines telling you what to do in a fire?
17. Are you afraid of fire?
18. Describe all way to inform the fire to everyone.
19. If you are in 3<sup>rd</sup> floor classroom, and confined because of a fire, what would you do?
20. Do you want to be a fire fighter, paramedics, or rescuer?