Construction Product Incident Data

Prepared for the Office of Product Safety and Standards

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1. Summary

The project

This report has been produced by Total Flow for the Office of Product Safety and Standards (OPSS), as one of several workstreams that support preparations for the new responsibility for Construction Products.

This is a small project. It is about available published data and by inference what **further data OPSS might be able to access** by engaging with the holders. There will also be **data which is privately held** and from which no or minimal analyses are published. Although we can assume that this data exists, we **cannot comment on its quality or utility**. Examples include most reports of forensic investigations, product manufacturers data on warranty repairs and production quality control, insurance claims data, results of inspections of buildings carried out on behalf of their owners etc.

The final scope of this report emerged from post contract award discussions with the client, based on a paper presented to them.

Incident data

There are generally two types of data about incidents: statistical returns and forensic reports. Statistical returns are based on collecting basic information about every incident, allocated to predefined categories. Although there may be some inaccuracies and missing incidents, these largely act as noise within the overall data. Data analysis and trends are still robust, within the limits of this noise, which has the same character as other sources of random variation.

Forensic reports are based on examining physical evidence, interviewing witnesses and critical analysis of the evidence against different event scenarios, including potentially computer modelling, laboratory experiments and examination of other buildings and products. The utility of reports depends on the skills of the principal investigator, their purpose in carrying out the investigation and the resources available to them. Examples of investigations (with increasing depth and resourcing) include initial media reports of noteworthy incidents, fire investigations, investigations by the police and HSE where a crime might have been committed, inquests and public inquiries. The depth of investigations depends on the resources applied. Only in very mature safety-management cultures does the depth of investigations relate to the potential rather than actual consequences of an incident.

OPSS would like to gain a better understanding of the product journey, to help support the development of its regulatory approach.

Working with statistical data presents familiar challenges. Even where there is a genuine intent to understand, many times there are errors of interpretation:

- Absence of evidence is taken as evidence of absence, which is especially problematic in terms of understanding the potential for rare major tragic events[1] (such as Grenfell Tower).
- Correlation is taken as implying causation.
- Random variation is interpreted as a change or trend, including reversion to the mean.
- Apparently different results (from different samples) are not tested, to establish whether the differences are statistically significant.
- Factors of interest are believed to be explanatory, rather than considering alternative possibly hidden factors (ie confounders).
- Proposed interventions are expected to have the desired effect and no harmful unintended effects, despite lack of evidence on system structure and therefore response.

Within the Section on incident data, there is a mention of reports of concern received and reviewed by CROSS-UK. These are mostly not incident data, although some appear to have been associated with investigations. These reports illustrate the value of reports of concern where incidents have either not yet occurred or not been raised into industry and regulatory issues. They also demonstrate the value of broad and independent expertise to issue management actors. Given that such reports are not statistically representative, except insofar as they represent at any one time the reported concerns of professionals, it might be important to stimulate more reporting and to pay attention to assisting professionals to increase the regulatory utility of such reports.

Using incident data

There is a paradox in using statistical data to detect dangerous conditions, in this case the presence of potentially dangerous construction products in the market. Enough products must be installed for long enough in buildings for their risk to become apparent from incident data (accepting the harms that occur before that happens). By that stage, the base of installed products is high enough to present sufficient societal risk to require removal or repair, rather than just removing the product from the market.

It is also foreseeable that the risk level uncovered by statistical analysis of incident data from the **general population** will sometimes be so high in the **populations most at risk**, that repair is urgent and might either require the buildings to be evacuated until they can be made safe, or special and expensive additional precautions to be taken.

We are most concerned about rare large-scale events. These occur when multiple factors combine, almost always including failures of multiple layers of protection[2]. For smaller events there may need to be many incidents before the trend rises above the noise. For larger events, weak signals of the potential for an event of that scale will be spread across the factors, often not including the specific construction product. Faults with construction products will only be one element in the causative factors in major incidents.

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[1] For example, see Major incidents in Britain over the past 28 years: the case for the centralised reporting of major incidents, Carley et al, J Epidemiol Community Health 1998;52:392-398

[2] https://www.dekra.com/en/layers-of-protection-analysis/#:~:text=Layers%20of%20Protection%20Analysis%20(LOPA)%20is%20a%20method%20used%20to,meets%20a%20company's%20risk%20tolerance

The importance of layers of protection and of testing those layers to prevent major incidents was described by Professor Nick Pidgeon in paragraphs 7 & 8 of his written evidence to the House of Lords Select Committee on Science and Technology, February 2021[3]. Professor Pidgeon refers to practices in aviation. An extreme example of testing layers of protection occurs in the nuclear industry where a team of senior staff from one facility spend up to a year at a facility in another country on an "access all areas" basis, sponsored by the facility Director. Their task is to find latent faults with the technical and human infrastructure that could lead to a nuclear incident and then produce a final report.

These are both examples of broad systems audit to prevent incidents, rather than waiting until incidents occur before addressing their specific causes.

For risks in buildings, most of the layers of protection concern their design, construction, management and maintenance (including emergency response and actions). OPSS need to make judgements about the extent to which failures in these make harms from product faults more likely and more severe. In a perfect world: products with missing information would never be used, fire spread would be mitigated by fire stops, rubbish would not be allowed to accumulate in dangerous areas, and incipient faults would be reported and addressed before developing into a serious incident.

The combination of incident statistics with forensic investigations is powerful in establishing event tree models and nodal probabilities that can be used in risk assessments and management plans. Collecting data on common harms (including fatalities, serious injuries, insurance claims, repair costs and other economic harms) enables estimation of the potential overall impact of issues where construction products are involved.

Data from other countries

There are challenges with interpreting data from other countries in a UK context and with assurance of the reliability of statistics and incident investigations. The body of the report discusses the US accident database NEISS. There seem to be limited collections of published statistics from other countries. For example, see this comment on EU fire statistics[4]. In the US, the Fire Administration publishes high level fire statistics that resemble some of the UK FIRE datasets[5]. There may be value in using datasets from other countries to address specific questions, although its relevance will always be questioned – there are many uncontrolled differences between countries, not least in construction methods and materials.

Nevertheless, incident reports from other countries can provide insight into the potential for serious incidents in the UK. Who would not want to be aware that a new construction adhesive system had failed in early life service in North America, or that Aluminium Cladding Material panels were involved in a series of tower block façade fires in the Middle East.

The question is how to source and interpret such information in an effective and cost-effective way, which goes beyond the scope of this piece of work.

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[3] https://committees.parliament.uk/writtenevidence/22275/pdf/

[4] https://www.europeanfiresafetyalliance.org/our-focus/statistics/#:~:text=Our%20Focus%20%C2%BB%20EU%2DWide%20data%20on%20residential%20fires&text=Every%20year%2C%20cautious%20estimates%20suggest,estimate%20is%20not%20used%20randomly.

[5] https://www.usfa.fema.gov/data/statistics/

Relying on incident data

Following the section on incident data sources, some hypothetical issues are considered, to evaluate how incident data (statistical and forensic reports) alone would perform as a risk management tool. These test issues were constructed from real events but are not intended to be identical to them. Lack of access to the underlying detailed statistical data and forensic investigation reports make these illustrative rather than definitive examples.

It might seem surprising to anyone with experience in managing major industrial hazards that safety statistics and incident reports would be the only tool used to detect dangerous conditions. Nevertheless, even in that world some management teams have held that belief, regrettably in some cases in the period leading up to a major event with multiple fatalities and severe economic loss.

The test cases confirm that incident data has very limited predictive value in relation to tragic, rare multiple-fatality events. Of note is the central estimate of slightly higher than 50% chance of a building collapse in the UK with significantly more than 3 fatalities within the next 20 years. An industrial safety management group would take that as a prompt to investigate the underlying factors rather than a definitive prediction. This is largely an issue for HSE, although there are implications for OPSS.

For smaller scale incidents, that might be repeated multiple times before they are identified from incident data, there are three key conclusions:

- Effective market surveillance by product manufacturers is more likely to identify safety issues than analysis of forensic reports and incident statistics by the regulators.
- Increasing the number of reports of concern could be a powerful route to reduce the lead time to identify the presence of intolerable product risks.
- Relying on incident data alone will lead to an accumulation of deaths, serious injuries and economic loss that might be considered unacceptable (before regulatory action is prompted).

Researching real examples also illustrated that almost all "product recalls" in functioning systems start from market surveillance by the manufacturer, or reports of concern. In a functioning system the costs of product issues to economic actors are too high for them not to invest in market surveillance; and the safety culture of the industry is such that professionals feel an ethical obligation to report concerns. Regulatory actions can shape and encourage both behaviours.

Preventing faulty products

Focussing on faulty products already in the market and detecting their presence in buildings is one essential regulatory task. Investing in industry capability and culture to reduce the number of faulty products entering the market is also important, not least because it reduces societal costs and harms, including (in the longer-term) regulatory costs.

Where the regulators work in partnership with actors across the 3 domains of Products, Projects and Assets, most of the effort involved in improving industry performance will be provided by industry. Ensuring that the new systems (for example for product information, for risk assessment, for production control and testing, for building information etc.) have built-in metrics and reporting systems should be part of that. Leveraging a modest amount of regulatory effort can produce both better industry performance and insight into where remaining risk is concentrated, enabling forensic actions to uncover and address it. The report hints at additional data that OPSS and HSE might invest in collecting.

The report does not discuss these final issues.

2. Contents

Contents

3. Acronyms

A&E	Hospital Accident and Emergency Department
ACM	Aluminium Composite Material[6]
AD	Approved Document(s) (under the Building Regulations)[7]
Biobank	A UK longitudinal health study[8]
CO	Carbon Monoxide
CQC	Care Quality Commission[9] (and by reference the equivalents in the other UK nations)
CROSS-UK	Building safety concerns reporting system[10]
EU	European Union
FAI	Fatal Accident Inquiry (Scotland)
HASAWA	Health and Safety at Work etc Act 1974[11]
HES	Hospital Episode Statistics[12]
HMIP	HM Inspectorate of Prisons[13]
HSE	Health and Safety Executive[14]
ICD-10	International Classification of Diseases (10th Edition)[15]
LPS	Large Panel Systems (described in the report)
MSA	Market Supervisory Authority
MW	Megawatts (of power)
NEISS	National Electronic Injury Surveillance System[16]
NHS	National Health Service (of England, Northern Ireland, Scotland and Wales)
OPSS	Office of Product Safety and Standards[17]
QC	Quality Control[18]
RIDDOR	Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 2013[19]
RIDDO	Data on reported Dangerous Occurrences[20]
RIDGAS	Data on gas incidents[21]
RIDIND	Data on reported injuries at work[22]
US(A)	United States (of America)
WAID	Water Incident Database[23]
WHO	World Health Organisation[24]

6 https://www.designingbuildings.co.uk/wiki/ACM_cladding
7 https://www.gov.uk/government/collections/approved-documents
8 https://www.ukbiobank.ac.uk/
9 https://www.cqc.org.uk/
10 https://www.cross-safety.org/uk
11 https://www.hse.gov.uk/legislation/hswa.htm
12 https://digital.nhs.uk/data-and-information/data-tools-and-services/data-services/hospital-episode-statistics
13 https://www.justiceinspectorates.gov.uk/hmiprisons/
14 https://www.hse.gov.uk/aboutus/index.htm
15 https://icd.who.int/browse10/2010/en
16 https://www.cpsc.gov/Research--Statistics/NEISS-Injury-Data
17 https://www.gov.uk/government/organisations/office-for-product-safety-and-standards
18 https://asq.org/quality-resources/quality-assurance-vs-control
19 https://www.hse.gov.uk/riddor/
20 https://www.hse.gov.uk/statistics/tables/riddo.xlsx
21 https://www.hse.gov.uk/statistics/tables/ridgas.xlsx
22 https://www.hse.gov.uk/statistics/tables/ridind.xlsx
23 https://www.nationalwatersafety.org.uk/waid
24 https://www.who.int/about/what-we-do/thirteenth-general-programme-of-work-2019---2023

Total Flow

4. Introduction

The Office of Product Safety and Standards (OPSS) commissioned Total Flow to product a report on construction product incident data, as part of their preparations for assuming regulatory responsibility for such products.

OPSS expects to use such data in:

- Strategic planning and prioritisation to inform its construction products national regulator role.
- Development of regulatory (enforcement) intervention strategies and plans – i.e., to select targets/sub-sectors that justify proactive interventions (as well as those that do not).
- Identification of which stakeholder groups should be prioritised for engagement.
- Identification of knowledge gaps and areas for further research.

In a previous report on the nature of risks from construction products, Total Flow identified multiple different data sources and types, including potential new information gathering activities. At the request of OPSS the scope of this report has been narrowed from placing incident data within the context of an outline intelligence strategy to considering in more detail what conclusions could be drawn from published data alone, including inferences about what additional data OPSS might be able to access from the data owners behind published data and analyses.

From this perspective, incident data is a lagging indicator. By the time that sufficient “faulty” products have been installed in buildings that there is even one serious incident (or hundreds of less serious incidents), rectifying the faults is already problematic and the cost may be out of all proportion to the original value of the products.

Section 5 discusses data sources and Section 6 uses examples of potential product issues to illustrate how incident data might be used to identify faulty products in buildings. Until products are incorporated into buildings there can be no incidents. The incident rate is the primary factor in the probability that a product issue will be identified. Incident rate increases over time, as more buildings incorporate the faulty products.

5. Incidents

This section discusses incident data. It considers 2 perspectives:

- Evidence about the causes of deaths and injuries.
- Evidence from certain types of events (such as fires).

As well as errors when interpreting statistics, there are issues involved in their collection:

- Bias involves factors which produce consistent deviations from the underlying reality; for example, data from hospital statistics about casualties who die in hospital does not represent casualties who die before reaching hospital, and longitudinal studies will suffer from recruitment bias (absent postcode lottery selection and exhaustive pursuit).
- Inconsistency can arise where information produced by different sources from the same (or similar) incidents differs in material aspects; measurement and testing laboratories have systems for ensuring that results are standardised as between different staff and equipment and cross-checked between laboratories. Collecting universal hospital or fire statistics requires systems too large to achieve standardisation. Inconsistencies create noise, which reduces statistical confidence level from a given sample size.
- Category definition changes mean that data from the period before each change can only be compared with data from the period after with a degree of caution.
- Intolerable events are rare. Their expected frequency can only be estimated from a combination of other data about the system, including characterisation of the system.

Larger sets of statistical are usually collected, curated and analysed by teams with considerable expertise. It is well worth reading and understanding their notes and papers about their data sets. Their advice about using the data will be invaluable and there may be limited cases where they are willing to change what is collected or how it is collected, to improve its utility to OPSS and HSE. Changing these large data systems is a slow and cautious process.

None of the published resources include individual data records with all collected fields. The extent of granularity varies from *UK Biobank*, where all that is published are the findings of research based on the data, through to fire reports, where some publications are quite detailed but none of them cover all the data fields. There can be various reasons for restricting the degree of public access.

On the assumption that OPSS will generally be able to negotiate significantly greater access than just the published data, data availability and utility in each dataset is not discussed in every detail. Each of the data sources mentioned is worth following up. OPSS should make efforts to access the most detailed data and internal reports on its collection and quality. It is unlikely that any one data provider will be able to compare data across multiple sources in the way that OPSS needs to.

Data owners sometimes respond to requests for underlying data access with an offer of Special Reports; these then become bogged down in resource constraints, communication issues and the inevitability that comparison with other data sources will generate new questions, requiring a new Report. OPSS does not have the time or resource to support this process on an ongoing basis. Sometimes you need to engage in this process to demonstrate that Special Reports is not an effective approach.

ICD-10

WHO ICD-10 codes are used as the current UK standard for categorising injuries and illnesses by causation. The form <Letter><n><n> is used. For example, V00-Y99 are codes for *External causes of morbidity*. Within that, X10-X19 are *Contact with heat and hot substances*.

In some UK datasets, a third <n> is added to show the location of incidents. For example, The England and Wales death register shows that Home and Residential Institutions were the main locations of deaths caused by contact with hot substances, mainly hot water. The meta data for each collection describes how to interpret each data field.

Micro data

This term is typically used for data which is at the basic level of reporting each incident with all fields included, following any QC process. To respect the privacy and dignity of the people involved, data is subject to processes of deidentification and aggregation. Deidentification removes information about people, place and time. Aggregation groups data together in a way that makes it harder to reidentify individuals and connect them to incident data. The legal framework for this is provided by GDPR, including legitimate purposes for accessing personal data.

Micro data is collected, and access is typically granted, for the purposes of legitimate research. There is no doubt that OPSS has a legitimate public interest in accessing data. Handling such data requires policies, systems, training, professionalism and data security protocols, including physical and IT barriers between staff who have access and staff who do not. There is an internal process of ensuring that aggregated results from analysis are not at significant risk of reidentification. This has become a more challenging question with the spread of social media. There can be legitimate reasons why sensitive data is put into the public domain, for example for Court and Inquiry proceedings.

OPSS is used to handling sensitive information professionally, but it will have to satisfy third parties that it has the right culture and systems to grant access to data that they curate.

Deaths & Injuries

Deaths

The most comprehensive and least detailed data set on deaths is from **death registrations**.

- England and Wales[25]
- Scotland[26]
- Northern Ireland[27]

Each statistical authority will have its own documentation. The dataset for England and Wales contains an overview to this, with links to more detail on definitions, collection and quality control. Rather than working with the public data sets, OPSS should make contact with each authority to understand what underlying data is available and how OPSS might best use it. For example, microdata is not published because of the risks of identifying individuals, but OPSS might wish to identify geographical clusters of certain types of accidental death. Examining the regional statistics for accidental deaths will illustrate how limited the granularity of data on accidents is, due to the low number of accidents of any one type.

The link between deaths and construction products is at best tenuous, however ICD-10 coding is detailed and death registration is a robust process. These data sets can provide a final check and catchall. They provoke the question – if construction products were implicated in these deaths, how would we know? They also provide a broader context - that construction only causes a small proportion of accidental deaths.

Coroner's Courts hear evidence in cases where the coroner considers that an inquest is required because:

- the cause of death is still unknown (following a post-mortem).
- the person might have died a violent or unnatural death.
- the person might have died in prison or police custody.

Inquests are open to the public, but their proceedings are not published. There is a system of Reports to Prevent Future Deaths[28], where the Coroner's Letters and responses are typically published[29]. Each Report is categorised according to the nature of the death. One possible category is Product, which covers a wide range of product types. Most of these Reports are not relevant to OPSS, but some are.

There is a different system in Scotland, where the Procurator Fiscal investigates deaths and may refer them to the Sheriff's Court for a Fatal Accident Inquiry (FAI).

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[25] https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/deaths/datasets/the21stcenturymortalityfilesdeathsdataset/current

[26] https://www.nrscotland.gov.uk/statistics-and-data/statistics/statistics-by-theme/vital-events/general-publications/vital-events-reference-tables/2020/list-of-data-tables#section6

[27] https://www.nisra.gov.uk/statistics/deaths/death-statistics

[28] https://www.judiciary.uk/wp-content/uploads/2013/09/guidance-no-5-reports-to-prevent-future-deaths.pdf

[29] https://www.judiciary.uk/subject/prevention-of-future-deaths/

Although inquests and FAIs are a limited source of data, they can be very revealing of issues that might otherwise not come to the attention of OPSS. The judicial processes act as a skilled filter to identify issues that fail the tolerability test. OPSS might consider engaging with the Chief Coroner and the Scottish judicial system to understand where there are opportunities to:

- Ensure that significant inquests and FAIs are attended by a suitable MSA who can form a view of issues that might need further attention.
- Highlight the opportunity for Reports to Prevent Future Deaths to be addressed to OPSS.
- Refine the categorisation of Reports to Prevent Future Deaths, so that OPSS can more readily identify ones with product safety implications.

Injuries

There are many more injuries than deaths and injury data is therefore more abundant, although systems for capturing injury data are less robust than for deaths.

The primary source of data is hospital A&E attendance:

- England[30]
- Scotland[31]
- Wales[32]
- Northern Ireland[33]

Coding of this data is by ICD-10 category, age, sex and the extent of treatment, stay etc. This enables an overview of accident types and consequences. Some of the datasets are used to produce routine and one-off analyses of accidents, which are published. OPSS should engage with the data set owners to understand the capture and validation process and access the underlying data. Online documentation and derived analyses from Hospital Episode Statistics can act as a briefing for the general issues of A&E data capture, quality and analysis.

Unlike NEISS data, this is a complete data set on A&E attendances, but without the depth of incident narrative provided in NEISS[34]. NEISS is based on a stratified sampling system, given the significantly greater effort required to produce narrative data. It is an example of investment in collecting more data from a representative subset of the population to gain greater insight into causation. As the example of Falls in the risk report illustrates, it is debatable whether this greater investment produces significantly more insight in respect of construction products. This is a question that should be further explored – could greater depth of data capture from a subset of A&E Departments provide meaningful insight into accident causation for a range of stakeholders?

As with death registrations, information on A&E attendance is unlikely on its own to identify specific product issues, but it can act as a prompt for further investigation, especially where micro data can identify new clusters.

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30 https://digital.nhs.uk/data-and-information/data-tools-and-services/data-services/hospital-episode-statistics
31 https://www.isdscotland.org/Health-Topics/Hospital-Care/Inpatient-and-Day-Case-Activity/
32 https://www.awiss.org.uk/
33 https://www.health-ni.gov.uk/articles/episode-based-activity
34 https://www.cpsc.gov/Research--Statistics/NEISS-Injury-Data

Illness

A problematic area of harms arises from chronic low-level toxic exposure, where there is no "accident", but well-being, life-expectancy etc are impacted. In terms of deaths and hospital attendances, these will be categorised as ill-health, rather than accidents. Sequelae from accidents are also not always obvious, for example long term cognitive deficits from incidents of non-fatal CO exposure[35]. Such events are typically associated with boiler and flue gas systems, ie construction products (although partly regulated by more specific enactments).

A generic issue with illness is the challenge of complexity, limited data availability, and the considerable medical and analytical expertise required to produce robust analyses. It is likely that OPSS will have to commission expert research focussed on specific questions, for example:

- To what extent do construction products and their use in new builds contribute to poor ventilation in UK homes and what evidence is there of ill-health resulting from mould and radon?
- What kinds of combustion products are produced from materials of construction during fires and to what extent could death and ill-health from smoke inhalation be reduced by changes of materials?
- Which construction products might emit hazardous materials during normal use and what ill-health effects might this cause? For example, can fireplaces made from reconstituted marble produce toxic gases (from polyester degradation) above their OEL if improperly designed and installed?

Such questions could be brainstormed and prioritised by using an expert group, considering materials hazards and degradation processes.

Industrial

There are recognised industrial diseases in the UK[36]. Categories B6, B15, C1, C24, D1, D4, D5, D6, and D7 are most relevant. It is assumed that risks from asbestos are recognised from the presence of asbestos in the products. There are other materials relevant to C categories which are also likely to be recognised from the presence of the material.

There is a data analysis tool available (to registered users) for Industrial Injury Benefits[37]. Industrial illness is the regulatory domain of HSE, but attention to the data could:

- Provide early warning of construction product related risks to workers.
- Draw attention to materials which might also be harmful to the public.

Comparing claims data for the benefits with death registration and hospital event data could also identify changes which signal new issues, especially based on micro data. HSE provide high-level data on occupational ill-health and disease[38]. There will be more detailed data behind these reports.

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[35] Neurocognitive sequelae after carbon monoxide poisoning and hyperbaric oxygen therapy, Ning et al, Med Gas Res. 2020 Jan-Mar; 10(1): 30–36. Published online 2020 Mar 13. doi: 10.4103/2045-9912.279981

[36] https://www.gov.uk/government/publications/industrial-injuries-disablement-benefits-technical-guidance

[37] https://www.gov.uk/government/publications/industrial-injuries-disablement-benefit-on-stat-xplore-user-guide

[38] From https://www.hse.gov.uk/statistics/tables/index.htm#thor onwards.

Radon

Radon is a specific health hazard in buildings, where construction products may have a contribution[39]. The challenge of analyses of substance exposure can be illustrated by radon[40]. The difficulty of reducing the significant number of deaths in existing buildings and the steps required to avoid this risk in new buildings are noteworthy in this piece of research.

Longitudinal Studies

There are different types of longitudinal studies, but cohort studies based on cohort categorisation[41], and from volunteers[42] that meet study criteria, are both active in the UK (and other countries).

HSE has carried out investigation of health risks to construction workers, using different sources of data, including UK Biobank and worker surveys. Conclusions from these are reported in the HSE Construction Industry annual report series.

UK Biobank staff would be well-placed to act as advisors of the first instance as to how OPSS could make use of longitudinal studies to uncover health issues with construction products.

Events

As well as examining incidents in terms of their consequential deaths and injuries, they can also be viewed through the lens of event type – fires, falls, explosions, drownings, structural collapses etc. In some cases, there are agencies involved in these incidents which collect statistics and carry out forensic investigations, where considered appropriate.

HSE and OPSS are about to become such agencies, raising the issue of what additional primary data collection and analysis they might undertake and what reports they might publish. The annual Construction Industry report by HSE shows what information is produced about worker safety. HSE collect and analyses various statistics[43] and investigate incidents as part of their existing responsibilities.

Apart from falls and chronic illnesses, the main cause of deaths within buildings is fire. Most fires are caused by human acts and are limited in their extent. However, some fires are caused by faulty electrical systems or by inappropriate location of products (such as routers in linen cupboards). Whether routers are construction products or consumer products, they will undoubtedly be regulated by OPSS.

Fires

Fires are well into the zone of tolerability. A material increase in the frequency or severity of fires would be intolerable. Fires that cause multiple (>>3) fatalities across more than one household are rare and likely to be regarded as intolerable individual events. Fires have therefore received a great deal of attention. While OPSS will need to avoid focussing on fires to the exclusion of other risks, it will inevitably be a major area for intelligence, analysis and enforcement.

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[39] https://www.ukradon.org/information/risks

[40] Lung cancer deaths from indoor radon and the cost effectiveness and potential of policies to reduce them, https://doi.org/10.1136/bmj.a3110

[41] https://cls.ucl.ac.uk/

[42] https://www.ukbiobank.ac.uk/

[43] https://www.hse.gov.uk/statistics/tables/index.htm

The main data sets on fires are collected from (or by) Fire and Rescue Services[44]. Data collection is split between England, Northern Ireland, Scotland and Wales. From the published English and Scottish data sets, it seems that the primary (unpublished) data is extensive.

From experience analysing this data for the risk report, published analyses do not cover the questions of most interest to OPSS, although it appears that the primary data does contain the relevant data.

OPSS are interested in fires that:

- Might have been caused by construction products, including technical systems such as oxygen supplies.
- Spread beyond the first item ignited, that caused injuries or deaths.
- Spread beyond the room where the fire started, whether injuries occurred or not.
- Occurred in medium- and high-rise buildings.

In 20/21, there were just over 30,000 accidental and 3,300 deliberate dwelling fires in Great Britain. Of the 62,000 dwelling fires in Scotland from 2009/10 to 19/20, only 451 led to fatalities – 467 fatalities and 72 non-fatal casualties in total. There were other fires that only caused injuries. Only 13 accidental fires caused more than 1 fatality and no fire caused more than 3. There are only a tiny proportion of fires where the involvement of construction products might be the cause of fatalities. Significant numbers of fatalities are very rare:

- People are likely to escape fires unless they are asleep and the fire is started deliberately, by an appliance or by a building system.
- Dwellings in medium- and high-rise buildings are less common than low-rise, so escape tends to be relatively straightforward when people are awake.

People who fall asleep while smoking, younger children, the disabled and the elderly are more at risk than teenagers and most adults. Escapes from hospitals and hotels seem to be effective, although care homes may be less effective, due to lower overnight staffing levels.

Once OPSS have access to the full historical fire data, there should be an exercise in constructing a model of event trees, nodal probabilities and populations at risk. In effect, this amounts to a pre-processed analysis for use in risk assessments and understanding the implications of changes in consumer and construction product risk profiles.

It seems very likely that fire statistics alone would not have provided a clear risk signal for Grenfell Tower. We know that the risk was much discussed from at least 2000 onwards and major fires in other countries provided strong supporting evidence. The question is therefore how analysis of fire statistics would have contributed to a broader analysis of information.

Ongoing analysis will inevitably include analysis of individual fires to understand the chain of events in fires with multiple fatalities or the potential for multiple fatalities. This will include factors of occupation and use, not just the construction. For example, the potential for cold appliances to cause fires that spread beyond the compartment where they start will be part of such a model.

[44] https://www.gov.uk/government/statistical-data-sets/fire-statistics-data-tables

As examples of questions that a fire events and populations model might address:

- An uptick in fires caused by portable electronic device chargers would signal the potential for a larger number of major fires in buildings with other vulnerabilities.
- A fashion trend for balcony furniture with higher fire load and fire spread potential might be important in high-rise buildings with balconies.

The National Fire Chiefs Council appears to maintain an online registry of useful reports. This is not accessible to non-members. However, individual reports may be accessed if they show up in web searches. This is not an efficient way of accessing the knowledge base. Individual Fire Services also maintain registries of investigation reports; even when you can find them by searching, access is denied.

Gas Explosions

These are rare events but typically catastrophic. The prototypical explosion involves almost complete destruction of a mid-terrace dwelling, with ejection of debris over distances of up to 200m and structural damage of the neighbouring dwellings. Fatalities and serious injuries are common when people are at home; ignition can be caused by human acts, so there is a putative link between occupation and the explosions. Some explosions lead to fires, but most appear not to.

Explosions in high-rise buildings are now almost unknown, given the new regulations that followed the disproportionate collapse at Ronan Point. Nevertheless, some mid- and even high-rise buildings still have gas supplies.

Gas explosions and serious equipment defects are reportable under RIDDOR and investigated by specialist teams with considerable experience in these kinds of events. HSE publish high-level statistics as RIDGAS[45]. Underneath these, there must be both primary datasets and incident reports, including investigations.

There are typically 30 gas explosions per year in Great Britain, with 38 casualties and a small number of fatalities. With such small numbers of events, the variation from year to year is significant.

There is little evidence that construction products contribute to the frequency or severity of gas explosions. A plausible contribution would be sparks from electrical components, such as light switches. The primary control for gas explosions is to avoid leaks and the secondary one is not to supply gas (or use LPG) in buildings at risk of disproportionate collapse.

Structural Failure / Collapse

Major building collapses with fatalities are rare in the UK. In other countries (with weaker regulatory systems), there are a mix of collapse during construction and collapse during occupation.

Table 2 of RIDIND (from HSE RIDDOR statistics), shows between 2 and 7 fatalities in the general public from construction activities each year from 2014/15 to 2020/21. Investigation reports from these incidents would show to what extent construction products might have contributed to them.

Structural failures are separate categories (23 & 24) of Dangerous Occurrence reporting. RIDDO shows between 80 and 119 structural failures and 14 to 39 falsework failures each year from 2014/15 to 2020/21. It seems likely that the majority of these (and all the falsework failures) were during construction.

[45] https://www.hse.gov.uk/statistics/tables/ridgas.xlsx

CROSS

CROSS UK provides a confidential reporting and expert advice system for fire and structural risks in buildings from design through to occupation. While the data is statistically unreliable due to sample bias, the quality of the reports makes this a valuable resource, both for structural and fire safety[46]. Most of the reports concern the Construction Project and Building Occupation domains but some discuss product related issues.

Reading relevant reports and seeking assistance from CROSS staff are both likely to be very helpful. Recent reports include unavailability of critical product information from an overseas supplier[47], and failure to select, integrate and test components of smoke systems as a whole system[48]. The full database includes 85 reports categorised as failures of product testing and information. Many of these reports are complex with the contribution of products being only part of the issue.

Drowning

The Water Incident Database (WAID)[49] provides data on drowning incidents, based on combining and analysing data from other sources. The reliability of this data is unproven. It would be valuable to discuss WAID with its host, as an exercise in gathering and analysing incident data from multiple sources.

Of 242 accidental deaths by drowning in the UK in 2020, WAID reports 5 as due to drowning in a bath (including hot tub, jacuzzi etc). Understanding the incidents behind bath drownings would show if any were related to construction products.

Care Settings

The Care Quality Commission (CQC) collects data on incidents in care settings (other than those notified to the NHS) under Care Quality Commission (Registration) Regulations 2009: Regulation 18. A small minority of these may have a contribution from construction products. Discussions with CQC will ensure that statistics and reports on such incidents can be made available to OPSS.

Prisons

Incidents in prisons will be investigated by the Prisons and Probation Ombudsman and HM Inspectorate of Prisons[50].

Statistics and reports on any incidents involving construction products may be available from HMIP.

[46] https://www.cross-safety.org/uk/safety-information-search-results?f%5B0%5D=safety_area%3A35
[47] https://www.cross-safety.org/uk/safety-information/cross-safety-report/cladding-and-decking-certification-1095
[48] https://www.cross-safety.org/uk/safety-information/cross-safety-report/testing-smoke-control-systems-1099
[49] https://www.nationalwatersafety.org.uk/waid/
[50] https://www.justiceinspectorates.gov.uk/hmiprisons/wp-content/uploads/sites/4/2022/02/PPO-HMIP-MOU-FINAL-signed-Feb-22.pdf

Insurance and lending data

Very little data is available in the public domain, but the Association of British Insurers collects industry data and makes it available at a cost.

Fire and subsidence are non-trivial categories in terms of insurance claims, although the most common is water damage. There may be rare cases where a loss adjuster highlights a key contribution from a construction product. Apart from that, the main value of insurance data is likely to be the economic value of fire damage and the distribution of that value between extensive damage involving the building, smoke and water damage, and damage local to the fire only. US fire data includes estimates of economic loss, which could be used as benchmarks.

It is not clear that lenders collect or retain information about buildings that might reveal issues with building products. If they do, this is likely to be based on reports by surveyors and building engineers and the opportunity is to provide them with easier routes to report concerns.

6. Using Incident Data

We know that concerns about cladding flammability were expressed well before the fire at Grenfell Tower and declining incidence of fires and fire fatalities across the UK was given as a reason why these concerns were not justified. This section therefore addresses the question of how you would use the data sources discussed in the previous section to detect the presence of unsafe construction products, including potentially safe construction products badly installed.

Given that published data is typically extracts and analyses based on an underlying data set, it is not possible to show what OPSS will be able to do when there is access to the underlying data. However, it can be discussed and illustrated.

The following examples are used: facade fires (Grenfell Tower), structural collapse from Large Panel Systems (Ronan Point), faulty fuse boxes causing fires, faulty smoke extraction system, shop barrier systems injuring children (Topshop), balconies falling from buildings.

Facade Fires

There is an extensive report of the body of knowledge about facade fires in *Fire Hazards of Exterior Wall Assemblies Containing Combustible Components*, Springer Briefs in Fire, 2015, ISBN 978-1-4939-2898-9. One chapter illustrates the use of statistics from the US and Finland, while commenting on the lack of utility of data from Australia and New Zealand. No UK data was analysed.

The only UK incident discussed was Knowsley Heights 1991[51]. In the risk report, we also included Mercantile Credit Building 1991, Sun Valley Poultry Factory 1993[52], Garnock Court 1999[53], Telstar House 2003, Lakanal House 2009[54] and Shepherds Court 2016, occurring before the fire at Grenfell. There was a fire at The Cube 2019[55], after Grenfell. Garnock Court, Lakanal House and The Cube have the closest relationship to Grenfell Tower, although the others have some relevant elements.

The report also mentions a 1997 report[56] into the fire safety of sandwich panels (like Sun Valley), which analysed fires in commercial buildings and concluded that the risks are largely to fire fighters where a fire becomes established in an unoccupied building, such as a warehouse. The main concern otherwise was destruction of the building. This report was based on new data collection from Fire Services and on laboratory testing, not on central data sources available at the time.

Façade fires leading to multiple fatalities in occupied buildings include a combination of:

1. Either an external source of ignition of the façade or an internal fire intense enough to eject sufficient hot gas to ignite the façade, including fuel from balconies and outdoor furniture.
2. A façade that can sustain a fire that spreads across the building.
3. Re-entry of the fire into the building, igniting further compartments.
4. Some combination of very rapid spread and delayed evacuation, causing occupants to become trapped.
5. Inability to control the fire for various potential reasons, including insufficient reach of external equipment and inability to safely enter the building.

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[51] https://en.wikipedia.org/wiki/Knowsley_Heights_fire
[52] https://www.ife.org.uk/Firefighter-Safety-Incidents/sun-valley-1993/34014
[53] https://en.wikipedia.org/wiki/Garnock_Court_fire
[54] https://en.wikipedia.org/wiki/Lakanal_House_fire
[55] https://www.bbc.co.uk/news/uk-england-manchester-50438177
[56] https://www.ukfrs.com/sites/default/files/2017-09/Sandwich%20Panels%20.pdf

For illustrative purposes, we can hypothesize that the fire at Grenfell had 5 key elements:

1. A fire started in or around a fridge, one of a limited number of appliance types capable of producing enough heat (~1MW) to be likely to spread a fire beyond the room where it started (through flashover). This model likely had a higher rate of fires than the benchmark for fridges, although this was not known at the time.
2. The fire breached the window and ignited the façade, which likely did not pass the standard test for façade fires (although that test arguably is not rigorous enough for some geometries).
3. The fire re-entered the building, partly because fire stops had not been installed as intended in the design.
4. Sprinklers might have contained the fire spread but fitting them in a refurbishment was not a requirement. If the other layers of protection had not failed, they would not have been required.
5. On-site fire command followed the standard policy of leaving occupants in place until they could be rescued.

While this may not be a robust and fully accurate description of the actual fire, it illustrates the process of event tree model building. The standard policy of wait in place until rescued is based on a very low frequency of fire spread between flats and therefore the balance of risk favouring avoiding smoke inhalation in unmanaged evacuations. Re-entrant façade fires and fires in buildings with failed compartmentalisation have a higher chance of escape if it starts as soon as the fire is detected, as was seen in The Cube. There was no re-entry in the Tamweel Tower fire and several US hotel fires, and everyone escaped despite the scale of the fires.

To use statistics to predict the frequency of multiple fatality cladding fires, we would have to construct models of:

1) The frequency and causation of fires that spread beyond the room where they started – possible from the underlying fire statistics data but not from what is published.
2) The pool of risks from the causation of such fires and any trends in them – in the case of Grenfell not possible due to the risk from model FF175B not declared by Ariston/Indesit but in principle possible from fire statistics.
3) The frequency of cladding fires and the scale of installation of such cladding in medium and high-rise buildings – not possible from UK fire statistics, but a high index of suspicion should have been raised by events in other countries.
4) The frequency of omission of fire stops in medium and high-rise buildings – not possible from fire statistics.
5) The extent of sprinkler installation in medium and high-rise dwellings and hotels – not possible from fire statistics.
6) The proportion of fires where the Fire Service was unable to evacuate occupants in time and the types of buildings in which this occurred – potentially some clues in fires statistics but not clear from what is published.

Although reports of fire investigations in the public domain are often very outline, and there does not appear to be a consolidated repository of UK fire investigations, the value of forensic reports in showing how different factors combine to produce serious outcomes is unarguable. In combination with statistics, this might lead to revised estimates of the probability and confidence limits of cladding fire major events as new information is available. The Springer report makes an outline attempt to do this for US data, but it is not convincing. It seems that the Finnish attempt was also not successful.

An alternative perspective on this, is that the possibility of cladding fires causing major fatalities was evident for perhaps twenty years before Grenfell. Refrigerator fires causing major damage was also discussed in the UK and other countries. At the very latest, following the deaths at Lakanal (due partly to delayed evacuation) and the ACM cladding fire at Tamweel Tower, it should have been obvious that this possibility was a very real one and not remote.

Once the possibility became reality, a series of actions started without a probability estimate (fatality frequency) being required. The later fire at The Cube very nearly caused multiple fatalities in the student occupants, due to the speed of spread of the fire across the High Pressure Laminated cladding. Students are of an age which has the highest chance of escaping a fire (from fire statistics), which probably prevented a tragedy, consistent with of some of the near-death witness statements. Even when the risks of flammable cladding had been recognised, it took time for the difficult and expensive actions to contain these risks to be rolled out.

Where there is a real possibility of serious consequences but uncertainty on probability, the precautionary principle requires action to contain risks and reduce the uncertainty. Taking insufficient action while waiting until the probability could be shown beyond reasonable doubt to be too high cost 78 lives (Lakanal and Grenfell) and will require many billions of pounds spread between taxpayers, product suppliers, builders and owners to remedy properties suffering from cladding blight. There is also severe stress on owners and occupants of these properties, leading to real harms, including at least one suicide.

The report on risk assessment by market supervisors includes a discussion of the implications of possibility and probability for tolerability, along with the credibility of systems for providing assurance of the integrity of governance and risk management systems (ie layers of protection).

Large Panel Systems

Structural collapses leading to major fatalities are very rare in the UK. We only found 6 incidents of collapses with the potential to cause major injuries while producing the risk report: Ronan Point 1968[57], Sophia Gardens Pavilion 1982[58], Apollo Theatre 2013[59], Liberton High School 2014[60], Cleddau Bridge 1970[61] and Gerrards Cross Tunnel 2005[62].

The Cleddau Bridge collapse occurred during construction and was partly due to inadequate design standards, established by a forensic investigation. The investigation into the Gerrards Cross Tunnel collapse concluded in 2015 but has not been published for legal reasons. A child was killed at Liberton when an internal wall collapsed due to poor workmanship – subsequent inspections showed similar faults at other schools built by the same contractor. Both the Sophia Gardens and Apollo collapses were specific to their circumstances and history, relevant only to converted aircraft hangars and very old theatres.

The Paris airport terminal roof collapse provides an example of where sophisticated computer modelling was required to show how the interaction between design methods and structural component properties led to an unforeseen failure mechanism.

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57 https://en.wikipedia.org/wiki/Ronan_Point
58 https://en.wikipedia.org/wiki/Sophia_Gardens_Pavilion
59 https://en.wikipedia.org/wiki/Apollo_Theatre#2013_ceiling_collapse
60 https://en.wikipedia.org/wiki/Death_of_Keane_Wallis-Bennett
61 https://en.wikipedia.org/wiki/Cleddau_Bridge
62 https://en.wikipedia.org/wiki/Gerrards_Cross_Tunnel

Ronan Point remains the only multiple fatality incident in an occupied building in the UK in the last 60 years. It was constructed using a Large Panel System (LPS). LPS were used in the 1960's and 1970's to build blocks of flats to meet surging housing needs. LPS are large reinforced concrete panels, manufactured offsite, and assembled to make walls and floors in buildings[63].

There are two concerns with LPS buildings:

- The structure is not strong enough to withstand foreseeable loadings, such as major storm gusts (in the case of Ronan Point a low-pressure gas deflagration).
- Gaps can open up in the structure which destroy fire compartmentalisation, making a block of flats very vulnerable to major fires.

Following the Grenfell Tower fire, cladding removal on some LPS buildings showed that gaps had opened up in the structures, which had not been detected in previous less intrusive inspections.

LPS is a historic version of offsite modular build, illustrating the design, manufacture, installation and inspection/maintenance challenges of this approach (currently collected with other technologies under the heading of Modern Methods of Construction).

Despite previous reviews of LPS buildings and remedial work, faults continue to be found which (in current expert opinion) require either demolition or major remedial work[64]. Gas supplies are still being removed from blocks of flats which are now considered to be potentially at ongoing risk of disproportionate collapse[65],[66].

The recent decant of occupants from the Paragon development, shows that modular construction continued to be problematic after LPS[67]. Although the article discusses mainly fire safety, we understand from private communications that the structural issues were significant.

From collapses in other countries, catastrophic collapses of medium and high-rise buildings are not preceded by minor collapses. The only way of understanding the possibility of a collapse in the UK is to interrogate the layers of safety preventing it, at every stage from module design, through to maintenance/inspection. There is no trail of increasing minor incidents as a predictor.

We understand from private communications that, from a mixture of design reviews and physical inspections of a non-random sample of thousands of buildings post-Grenfell, about 1 in 5 have structural issues. The reviews were likely undertaken with a bias towards buildings where there was some suspicion of potential issues. They were almost certainly medium and high-rise buildings. The risk in those buildings will be reduced by actions taken following the reviews.

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63 https://www.whatdotheyknow.com/request/601636/response/1442882/attach/4/Large%20Panel%20System%20Construction%20Redacted.pdf?cookie_passthrough=1

64 https://www.insidehousing.co.uk/news/news/residents-to-be-moved-out-of-clarion-tower-block-due-to-safety-concerns-72706

65 https://www.insidehousing.co.uk/news/news/housing-association-removes-gas-from-all-tower-blocks-72561

66 https://www.worcesternews.co.uk/news/8350597.the-tower-blocks-that-will-lose-gas-supplies-for-good/

67 https://constructionmanagement.co.uk/residents-evacuated-from-modular-blocks-due-to-fire-safety-concerns/

There are around 500,000 individual flats in blocks of 6 storeys and over in England. Of these, maybe around 100,000-150,000 are in high-risk buildings in the terms of the Building Safety Act. If we assume that 200,000 of the remainder have been subjected to a review, that leaves 150,000 flats in unreviewed buildings. There are therefore, possibly 5,000 blocks which are unreviewed. If only 1 in 10 of these have structural faults, then there are only 500 structurally unsound blocks without a management plan in England.

If we assume that the chance of a collapse of an unsound block of flats is 1 in 10,000 years, then the chance that there will be no collapse in England in the next 20 years is about 40%. If there is a collapse, it will be through a combination of unlikely circumstances that removes enough layers of protection that the block fails. In case this seems implausible, from the data Grenfell Tower was a 1 in 40,000 year event for a high-rise block of flats. This estimate also illustrates that possibility can be evident, but the probability of rare and completely unacceptable events is elusive.

What could initiate a collapse?

There are various potential events, including: gas explosion, wind loading, earth tremor, subsidence etc. There is some evidence that maximum windspeed gusts are increasing across the UK. It is outside the scope of this report to analyse the evidence behind this, but there is general acceptance that climate change is driving more energetic storms globally.

For example, the Plymouth Weather Station reports the following maximum windspeeds:

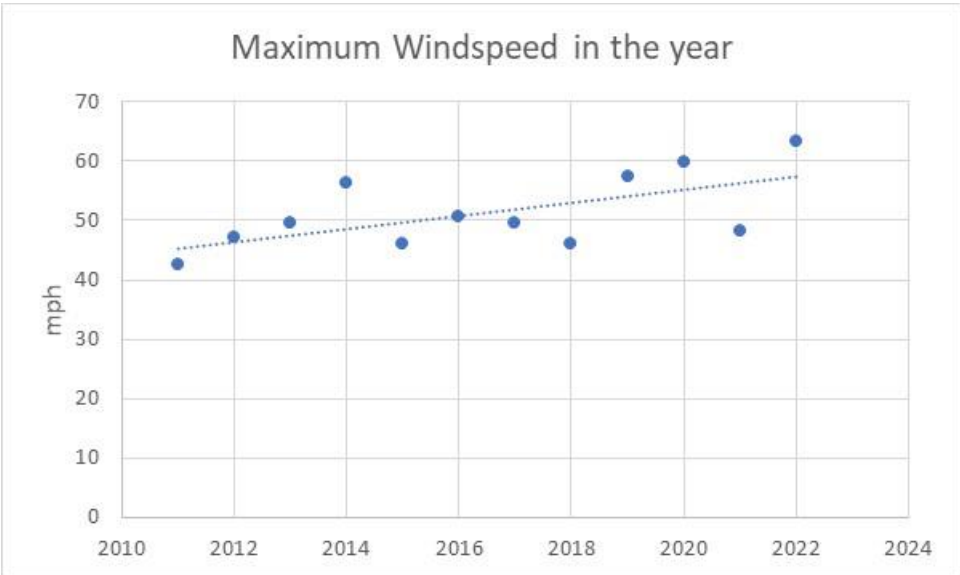

Figure 1 - Maximum annual windspeed reported by Plymouth Weather Station

One consequence of this might be that maximum wind loadings have been under-estimated during previous building design and review activities.

Managing the risk of collapse of existing buildings is not an OPSS responsibility. However, if a serious incident occurs, there will be a further review of buildings that might be considered at risk, including those constructed between the date that OPSS becomes the construction products regulator and the date of the incident. There are likely to be pressures to take a conservative and therefore expensive approach to remediation, more conservative than if the programme had been undertaken prior to a serious incident.

Given the evidence and judgements that were shared with Total Flow during the preparation of the risk report, it seems plausible that a non-trivial number of modular buildings constructed from today will require remediation if there is ever a deep review following a collapse. One problem with interrogating any system through formal channels, absent a strong independent forensic element, is that systemic faults in layers of protection remain hidden. The Grenfell Tower inquiry is providing examples of that, as are contemporary inquiries in other fields, such as healthcare.

Faulty Fuse Box

This example assumes that there are faulty consumer units ("fuse boxes") installed in houses, flats and commercial premises but that the supplier has not identified an issue. Although this is a hypothetical example, faulty consumer units have been sold and recalled[68]. There is a small chance that any individual unit might overheat and cause a fire.

The question is whether fire statistics would identify this risk if the manufacturer did not. The most likely ways that the issue would be identified would be through forensic investigation of an individual fire that had been caused by a faulty unit or a report by an electrician of a unit that had overheated without causing a fire.

Between 2010/11 and 2020/21 there were 101 fatalities in fires caused by electrical distribution systems where the cause was either Not Human or Other/Unspecified. 93 of these fatalities were in dwellings. There were also 4,699 casualties. These fatalities and casualties arose from 80,281 fires, of which 34,299 were in dwellings.

If we assume that faulty consumer units enter the market, how might we detect this in the absence of an issue being raised by their manufacturer?

1) A fire investigator identifies the unit as the source of a fire.
2) An electrician reports over-heating of a unit when inspecting or replacing it, in the absence of a fire.
3) The number of fires started by electrical distribution systems rises over a multi-year period, so that it is clear that there is an issue, enabling effort to be deployed to uncover it.

Each Fire Service will have a policy on fire investigations (for example it is policy 399 for the London Fire Service). These policies and the reports are confidential, so it is not possible in this report to assess the probability that a faulty consumer unit would be identified through Fire Service investigations. Where a fatality occurs, then the inquest will have access to the investigation report, making it more likely that it will be highlighted. Confidently identifying the cause of a fire can be problematic, as the evidence is destroyed within about 15 minutes of the fire starting. There are a lot of fires to investigate, so there will be a prioritisation of effort and possibly a bias to accepting the first explanation found.

In theory, an electrician finding a faulty consumer unit should notify it under category 4 of the General requirements of RIDDOR. In practise, this seems unlikely. It would be useful to check with HSE if any such faults have ever been reported. We will assume that it is unlikely that faults occurring much after one year will involve the original contractor and that the chance of a report to Trading Standards or the HSE is far less if a different contractor is involved. Where the original contractor is involved in that first year there is a possibility of a warranty claim, fed back to the manufacturer through the distributor.

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[68] https://www.electricalsafetyfirst.org.uk/product-recalls/2013/04/mk-sentry-switches-and-consumer-units

If we take 3,100 fires per year from electrical distribution systems, probably less than one in a hundred are associated with consumer units. Most fires are likely to be from wrongly installed systems and damaged systems, rather than faulty components.

If we assume that the chance of a nominally faulty consumer unit starting a fire is 1 in 1,000 years; that the chance of a consumer unit overheating and being recognised as faulty is 1 in 50 years (mostly due to the fault being minor in many units); that the chance of an overheated consumer unit being identified by an electrician and being reported to OPSS via Trading Standards (or HSE via RIDDOR) is 1 in 200 events; that the chance of a fire investigation correctly assigning the cause of a fire to a specific model of a faulty consumer unit and reporting it to OPSS in the 1 in 10 fires caused by consumer units where there are either fatalities or casualties is 1 in 4; then we can estimate the time it would take for the probability of the fault being identified reaching 95%.

Initially the reporting route through the original contractor is most likely, driven by the annual installation rate. At a constant annual installation rate, this remains constant. As the installed base of units increases, the chance of being reported by a fire investigator increases in line with the number of fires caused by faulty units. If the rate at which contractors make warranty claims is significantly higher than 1 in 200, then easily the fastest route for uncovering an issue is the manufacturer recognising it.

It takes 6 years for the cumulative probability of being reported by a contractor to exceed 95% and 7 years for identification by a fire investigator. The chance of being known by the combination of routes exceeds 95% by the end of year 2.

Year end	Expected fires caused by the unit	Units installed
2	15	10,000
6	105	30,000
7	130	35,000

There has been a recent trend for fires caused by distribution systems from non-human causes to decrease. The standard deviation of the distribution around this trend is 96 fires per year. An additional 130 fires over 7 years will not be distinguishable from noise and is most likely to be interpreted as reaching the end of whatever factors were driving the downward trend.

From this we might conclude that:

- It is important to have multiple routes to uncover issues before too many faulty products have been installed.
- Market surveillance by manufacturers is the best route, where it is effectively implemented.
- Unless we are very confident in the ability of forensic investigations to get to root causes and identify products in all fires without an obvious human causation, the other routes are required.
- For products which can fail without causing a serious incident, safety management by asset managers is the best way of catching problems before they become widespread and cause too much damage, injury and death; as well as warranty claims and market surveillance by manufacturers in owner occupied dwellings; a duty on landlords might also be important, especially for higher risk populations.

- Increasing the rate of reporting by asset managers and contractors might be critical, where confidence in manufacturers is low.
- It is very unlikely that specific faulty products would be visible from analysing incident statistics; there are too many other factors at play.

There is also an issue about registering higher risk products, given the ongoing risk of harms while faulty products are recalled, especially where it can take many years for a faulty product to be identified.

Time to identify and products in service are used as the performance metrics in this analysis. A more thorough analysis would estimate the lifetime impact of the effectiveness of the intelligence process in terms of total death, injury and economic loss, including the effectiveness and costs of product recall. Since market surveillance by manufacturers is the most robust route, one might make a regulatory argument that manufacturers who fail to implement a reasonable market surveillance process should face enforcement actions proportionate to these harms.

It should be noted that various assumptions have been made in the absence of key information, to create an illustrative example of how a faulty consumer unit might be detected and the scale of economic loss, injury and death that might occur before all the installed units could be identified and replaced.

Faulty Smoke Extraction System

This was a real incident where the opening vents on a smoke extraction system were operated by sensors on each floor of a building. The vent on the floor where the fire started opened and the extraction fans operated but sensors on other floors were also opened due to leakage from the vent duct. This allowed smoke onto floors where there was no fire, breaching the escape route compartmentalisation. It is unclear from this brief overview to what extent this was due to faulty products, poor installation instructions, poor design or poor installation (including testing). In any case, poor design and installation are foreseeable misuses of the sensor.

For the purposes of the example, we will assume that better product information would have significantly mitigated the risk. Review of similar installations using the same sensor would be required to understand whether this was a one-off incident or a weak signal of an underlying problem. In extremis, it might be concluded that the risk of poor design and installation required either a different sensor design or banning the use of similar sensors in such applications.

How likely is it that this risk would be picked up purely from incident statistics?

The consequence of widespread smoke extraction failures would be a higher risk of smoke inhalation during evacuation of buildings with smoke extraction systems. Unless and until a fire investigation report identified this issue, it would be almost impossible to identify a higher rate of casualties in such buildings. The risk of a major incident with multiple fatalities that could have been avoided had the smoke extraction system operated correctly is probably low, but low does not mean tolerable. Where multiple unsafe conditions remain undetected in medium and high-rise buildings, it is only a matter of time before there is a major incident.

There are multiple potential causes of higher casualty rates during fires, which in any case would have to reach a level of statistical significance before being investigated. For example, the use of materials with higher toxic smoke generation potential might be an alternative explanation.

Balcony Collapse

We know that building inspections in the UK have found incidents where the fixing of balconies is insufficient and there is a possibility that the balcony will collapse under load, seriously injuring the users. Although such incidents have not occurred recently in the UK, they have occurred in other countries[69].

Apart from the possibility that a balcony starts to come loose before collapse, the first warning of these faults is when the balcony is highly loaded and fails. These incidents therefore almost always involve multiple fatalities and serious injuries. In some cases, the collapse injures people below.

There are no incident statistics that can predict what is likely to be a rare serious event. The only way of assessing it is through reports from inspections. We hope that such reports have already reached the current regulators and actions are in place to determine and rectify the root causes. It is likely that the issue stems from a combination of product design, product information, building design, installation and building inspection.

Shop Fittings

This was a real incident occurring in multiple Topshop stores. The issue was revealed when a boy was killed by a heavy barrier falling on him[70]. The HSE chose to pursue the parties involved under the Health and Safety at Work Act, equivalent in the case of the company that supplied the barriers to the General Safety Principle of the Building Safety Act. The inquest jury had previously produced a verdict of accidental death.

Although HSE may continue to investigate similar future incidents and prosecute offenders under HASAWA, they may leave further enforcement activities on the product supplier to OPSS and Trading Standards, following their principle of not pursuing enforcements where there are more specific enactments. For the sake of this example, we assume that this is what HSE and OPSS will agree.

The company that supplied the barriers provides a design, manufacture and install service for shop fittings[71]. In this case the fitting was carried out by another shop fitting company, who admitted liability. HSE pursued the construction product supplier on the basis that e-mails showed they were aware of the possibility of the barrier over-turning but had not addressed this during design validation.

This would be a breach of a future requirement to carry out a risk assessment and produce a risk management plan. As a company involved in design, manufacture and fit, they would be well-placed to understand foreseeable misuse. Given their position in the market, the lack of formal risk assessment and management is concerning in relation to their other products and activities.

The fatal incident was preceded by an incident in another shop where a child's skull was fractured six days before. Two years before that, a shopper had a serious foot injury from an unsecured barrier in the same shop group.

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[69] https://www.bbc.co.uk/news/world-europe-42068198

[70] https://www.bbc.co.uk/news/uk-england-berkshire-59996101#:~:text=A%2010%2Dyear%2Dold%20boy,family%20shopping%20trip%20in%202017.

[71] https://www.realm-projects.com/

Both prior incidents should appear in A&E Department statistics, but the chances of identifying a construction products incident are low. There were no media reports found of the two previous incidents. The only other report of a shop fitting causing serious injury was a child killed by a very heavy changing room mirror which had been propped against the wall rather than fixed to it, which is not likely to have an element of product design involved.