Submission of Evidence
Review of Building Regulations and Fire Safety

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1. Introduction

This document provides a collective response from several University of Edinburgh academics to the questions posed as part of Dame Judith Hackitt's Call for Evidence, Review of Building Regulations and Fire Safety. The University of Edinburgh has been an internationally leading centre for fire safety engineering research and education since the mid 1970s, and was the first institution globally to offer masters degrees in this discipline (in 1974). The fire safety engineering group at Edinburgh currently comprises 9 academic staff and more than 25 full time PhD students.

1.1. Format of this Document

The scope of Dame Judith's review is specific to making "*recommendations to ensure a sufficiently robust regulatory system for the future and to provide further assurance to residents that the buildings they live in are safe and will remain so*".

We have reviewed the questions in detail. Each question raises multiple complex issues in terms of the interaction of the regulatory system with technical and societal issues. For this reason, we believe that the most coherent way to address these questions is to provide a discussion of the background and context to each of the key issues, and from this identify any recommendations.

In addition, it is worth noting that we have limited our commentary to those areas where we feel that we have insight gained from our combined academic research, educational activities, and first-hand professional experience.

Some of the questions are in areas that, while we may have opinions, we believe that our knowledge is insufficient to make a formal submission of evidence. Similarly, there are areas where we feel that other voices in the sector have a significantly stronger claim to authoritative knowledge. In these areas, we have refrained from making comment.

2. About the Authors

To respond to the questions raised by review, it is necessary to make strong knowledge claims about the regulatory system and its practical operation. Inevitably, therefore, each of the authors of this document are, in some way, a function of (and a part of) the system under analysis. In the interests of disclosure, and allowing the reader to form a view on the credibility and rigour of the authors' respective knowledge claims, the following paragraphs provide descriptions of the authors' backgrounds.

Dr Angus Law. BRE Lecturer in Fire Safety Engineering at the University of Edinburgh. Dr Law graduated with a degree in Civil Engineering at the University of Edinburgh in 2007; he graduated with a PhD in Fire Safety Engineering from the University of Edinburgh in 2010. Dr Law worked as a Fire Engineer for Ove Arup and Partners in their Leeds office from 2010-2014. He worked as a Lecturer at the University of Queensland, Brisbane, from 2014-2016, joining the University of Edinburgh in December 2016; Dr Law's current position is therefore part funded by BRE Trust. Dr Law is a Chartered Fire Engineer (2014) with the Institution of Fire Engineers.

Dr Graham Spinardi. Ove Arup Foundation/Royal Academy of Engineering Senior Research Fellow in Integrating Technical and Social Aspects of Fire Safety Engineering and Expertise since 2013. After a first degree in Ecological Science, he was awarded a PhD in the Sociology of Technology (The Development of Fleet Ballistic Missile Technology from Polaris to Trident) in 1988. Following a year at Stanford University, his subsequent research and teaching at the University of Edinburgh has dealt with issues of regulation, testing, technological 'lock-in', and the role of politics and organisational interests in a wide range of technological areas. His post is part funded by the Ove Arup Foundation.

Dr Rory Hadden. Rushbrook Senior Lecturer in Fire Investigation at the University of Edinburgh. He graduated in 2007 with an MEng in Chemical Engineering and in 2011 with a PhD in Fire Safety Engineering from the University of Edinburgh. He subsequently held postdoctoral research positions at the University of Western Ontario and Imperial College London before joining the University of Edinburgh as academic staff in 2013. His research has focussed on advancing the understanding of the ignition, flame spread, and burning of solid fuels.

Dr Stephen Welch. Senior Lecturer in Computational Methods for Fire Safety Engineering. Dr Welch has a PhD in combustion and over 20 years of experience in fire research and teaching. He worked for nearly a decade at BRE's Fire Research Station, with involvement in various full-scale fire test programmes at BRE Cardington, before joining the BRE Centre for Fire Safety Engineering at the University of Edinburgh as a Lecturer in 2004. His main teaching is related to fire safety engineering practice, providing a training in engineering approaches to applied problems, with critique and analysis of relevant regulations, codes and design principles, delivered to honours year and postgraduate students. He is Discipline Programme Manager for Civil & Environmental Engineering and Programme Director for the taught postgraduate degree in Structural & Fire Safety Engineering.

3. Legal Framework and Overall Context

In England & Wales, The Building Regulations 2010 control new buildings (or alterations), and the Regulatory Reform (Fire Safety) Order 2005 controls the occupation and operation of existing buildings. The link between these two pieces of legislation is "Regulation 38" which requires that, on completion, Fire Safety Information should be passed from the designer to the occupier.

Approved Document B provides practical guidance on how to meet the requirements of Part B of The Building Regulations, and a suite of "Fire Safety Risk Assessment" documents provides guidance about the requirements of the Regulatory Reform Order (RRO) and how to conduct "suitable and sufficient" risk assessments.

The logical structure of the legislation framework is clear and consistent; however, the degree to which it is successfully implemented is related to the competency and understanding of those responsible for doing so. This level of competency is highly variable across the different organisations, professions, and trades involved in the delivery of fire safety in the built environment. Consequently, while existing guidance (and legislative responsibilities) may be clear to those with a high level of competence – there is potential benefit in making some changes to the regulatory framework (and accreditation of professional disciplines) to mitigate the impact of lack of awareness or inadequate competence.

3.1. The Building Regulations (England & Wales)

The Building Regulations define the meaning of building work and establish the requirements that any building work should achieve. The requirements are expressed as "functional" statements about the necessary standard of performance that a building should achieve. Functional requirements use terms such as "reasonable", "appropriate", and "adequate". This generality allows the regulations to be interpreted for specific applications; adequate fire safety measures will vary depending on the building and other aspects of context, including assumed occupant behaviours. For example, it may be inappropriate to provide the same fire safety measures in a hospital as those which are provided in an agricultural shed.

Approved Document B (ADB) is provided under the powers granted by the Building Act 1984 to provide practical guidance with respect to the requirements of The Building Regulations. The document provides guidance for "more common building situations", and highlights that many of the fire safety provisions within the document are closely interlinked.

The measures in ADB are derived from the functional requirements of The Building Regulations. A more detailed set of expectations are provided regarding the intent of the fire safety measures within a building, and there is detailed "prescriptive" guidance about how the requirements can be met.

ADB does not identify solutions for every possible permutation of building type or arrangement. Instead, the reader is expected to understand the document's intent, and to interpret the guidance on the basis of this intent. If a reader is uncertain regarding the meaning of a clause (or encounters a situation that does not fit within the prescriptive guidance), then they should carefully consider and evaluate the fundamental intent of the document, as regards fulfilling the functional requirements of the Building Regulations. Therefore, irrespective of "the letter" of the guidance (i.e. ADB), there is an expectation that the reader is will follow the "spirit" of the document and will apply reasonable skill and care in undertaking their design work.

This approach to regulation is intended to be "fail safe" in that any lack of clarity within the guidance is clarified based on knowledge of the overall intent. Furthermore, this approach has the advantage that any new product, material, or system that does not exactly fit within the existing guidance must be evaluated on the basis of the overall intent. The document does not therefore have to be updated to prohibit (or allow) new products, materials or systems.

The use of the Approved Document therefore requires the reader to be familiar with the measures described in the guidance, the overall intent of the document, the manner in which the measures described in each section are interlinked, and the cases where the prescriptive guidance may not apply.

3.1.1. International Approaches to Building Regulation

The *functional* approach to fire safety regulation that is adopted within the UK[1] is not the only approach to regulating fire safety within the Built Environment. Three alternative approaches are discussed in the following sections; these represent exemplars of important variants.

NFPA 101, Code for Safety to Life from Fire in Buildings and Structures

NFPA 101 is a building code that is prepared by the National Fire Protection Association (based in the USA). Unlike the Approved Document, NFPA 101 is not prepared by a government, and therefore has no inherent legal status. Instead, jurisdictions (i.e. individual states) may choose to cite NFPA 101 as a means for achieving regulatory compliance.

The Code has stated objectives relating to the protection of life, and is primarily based around prescriptive provisions (rules). NFPA 101 states that compliance with these rules will necessarily achieve the objectives of The Code. Within this statement lies the key difference between the regulatory approach adopted in the UK, and the approach adopted by the NFPA. Unlike the UK approach, NFPA makes no requirement for any practitioner to consider the appropriateness of any solution for a given scenario.

To mitigate for the rigidity with which the rules must be applied, NFPA provides a high level of specificity with respect to different occupancies, and how the rules must be applied in

[1] Despite various differences, the Building (Scotland) Regulations have a similar "functional" structure to the regulations in England & Wales. Northern Ireland is not included within this review. For the purpose of this section England & Wales and Scotland will be referred to as UK.

different situations. Consequently, adherence to the rules provided within NFPA 101 requires a high level of knowledge and competence in navigating the document. A reflection of this is the fact that within the USA the specialist appointed to assist the design team is frequently referred to as a “Code Consultant”.

The regulatory system that is embodied by NFPA 101 has some key features which contrast it with the UK approach. Primarily these relate to the competence of the individuals who implement and regulate the application of The Code. Although it is not a trivial exercise to read and implement The Code, there is no requirement for the practitioner to critically evaluate the validity of any solution provided by The Code in the context of their building. Hence, so long as the rules are followed correctly, the practitioner holds no liability (or legal responsibility) for the safety of the building. There is no necessity for any practitioner to have a fundamental understanding of the relevant fire phenomena, wider fire safety engineering issues, or how unconventional design proposals may affect the validity of the Code solution. Consequently, this approach to regulation may lead to the deskilling of the profession in terms of its ability to critically analyse code solutions in the context of the key phenomena associated with fire safety. The responsibility for safety therefore tends to shift to the regulator, and any ambiguities of The Code are the fault of the regulator.

Building Code of Australia (NCC BCA)

The Building Code of Australia (BCA) is adopted within each of the states in Australia. It is prepared as a consortium between Federal Government, State Government and industry. It is adopted by State level legislation as the regulatory framework for new buildings.

The BCA is a hybrid of the UK approach (functional requirements) and the NFPA approach (prescriptive provisions). The BCA functional requirements are broadly similar to those described within Schedule 1 of the Building Regulations. The prescriptive provisions are termed “deemed to satisfy” (DtS) provisions, and if these provisions are followed, the code assumes that the legislative requirements are met. Consequently, the DtS provisions are philosophically equivalent to the rules within NFPA 101.

In parallel with the DtS provisions, the presence of functional objectives allows practitioners to deviate from the rules. If a practitioner wishes to propose an alternative solution, then they can do this by providing an engineering justification to demonstrate that the functional objectives are met. However, unlike the UK system there is no explicit imperative for the practitioner to consider the validity (or otherwise) of the DtS provisions. Hence, there is nothing within the system that ensures that it is “fail safe”. If a practitioner believes that a DtS is unsafe or inappropriate, then there is no legal mechanism to require them to adopt a different solution.

New Zealand Verification Methods

Within New Zealand, a hybrid system also exists. The Building Code (BC) sets out mandatory requirements. These requirements can be achieved by either following prescriptive rules (known as Accepted Solutions) or by the use of Verification Methods (VMs) to check the adequacy of a proposed solution.

The intent of a verification method is to ensure that engineering methodologies (e.g. modelling, or detailed analysis of a particular situation) have pre-agreed inputs and outputs. The intent is to allow approval authorities to easily check whether the proposed values are appropriate and therefore to expedite the design process, provide consistency between regional approval authorities, and ensure that practitioners are held to a minimum agreed standard.

The reason for the implementation of this system was that there was (previously) concern that there was insufficient competency amongst partitioners and regulators to independently define and agree appropriate criteria. However, it is the experience of the authors that this system has, instead, resulted in a further drop in the level of competence required to undertake (and check) fire safety engineering design within New Zealand. Practitioners are no longer formally required to think about the appropriateness of any solutions – they can simply adopt the VMs irrespective of whether this provides an appropriate solution.

3.1.2. Enforcement of The Building Regulations (England & Wales)

The Building Regulations require that a named individual is responsible for making a formal submission. It is likely that for a complex project this individual would be a member of the professional design team[2]. This individual is also required to ensure that the fire safety information is communicated to the "responsible person" under the RRO (as discussed further in section 3.2.2).

The regulator is responsible for taking such steps as are reasonable to enable them to be satisfied within the limits of professional skill and care that the requirements of The Building Regulations have been met. The regulator is also required to consult the Fire and Rescue Service (FRS) in relation to the submission. As part of this consultation, the regulator *"shall have regard to any views they express"*. Therefore, it should be noted that the FRS is consultative body, not an "approval" body, within the English system.

The practitioner is therefore responsible for ensuring that the requirements of the regulations have been met; the regulator (Local Authority Building Control or Approved Inspector) is responsible for taking reasonable steps to check whether the regulations have been met; the FRS has the opportunity to provide "views" about the proposed solution.

This approach means that the ultimate responsibility for the compliance (or otherwise) of a building rests with the applicant. There is therefore no guarantee that a building that has been "approved" by the regulator actually complies with the requirements of the regulations. It would be unreasonable to expect the regulator to check every component in every part of a building – consequently it is appropriate that the ultimate responsibility (and liability) rests with the applicant.

[2] In this document, reference is made to the professional design team. This term is intended to encompass anybody involved in the process of developing or specifying the design. Once a design has been specified, it must also be constructed. The design and construction are separate processes, but frequently there is considerable overlap as contractors may make changes to the design specification.

The degree to which all aspects of building work meet the requirements of The Building Regulations is therefore a function, primarily, of the competence of the applicant and, by association, the wider professional and construction team. Nevertheless, if aspects of the proposed scheme are unsatisfactory, a competent regulator may be able to identify this and ensure that appropriate changes are made.

Competence within the regulatory bodies is therefore a critical factor in mitigating the effect of poor practice within the industry. Further, if regulatory bodies are known to have a high level of competence, then incompetent practitioners will naturally find it difficult operate within the industry.

RECOMMENDATION 1

It is recommended that the current Building Regulations framework and associated guidance documents should be retained.

3.2. The Regulatory Reform (Fire Safety) Order

Section 3.2 has been drafted by Dr Graham Spinardi based on the research of Jim Baker[3]

The post-construction operation and occupation of buildings is regulated under the Regulatory Reform (Fire Safety) Order 2005. The post-construction phase is important because buildings and their usage can change significantly over a building's lifetime, which can last many decades, if not centuries. Deliberate changes in usage and material alteration of the building results in the building becoming subject to re-approval in accordance with The Building Regulations. Other, more incremental, changes can also have significant impact on fire safety. Some fire safety systems may naturally degrade over time whereas others may be affected, and impaired, by the actions of occupants or others with access to the building.

The primary purpose of the Regulatory Reform (Fire Safety) Order 2005, which is applicable to most buildings (in England and Wales) other than domestic premises, is to ensure that fire risks have been properly assessed and suitable precautions, including the maintenance of equipment and planning for evacuation, have been taken. This implies that the fire safety design approved under the Building Regulations remains functional and appropriate as the building ages.

The main mechanism of the Regulatory Reform (Fire Safety) Order 2005 is one of self-regulation by the *"responsible person"*. Where a workplace is concerned, the responsible person is the employer *"if the workplace is to any extent under his control"*; otherwise, it is *"the person who has control of the premises"* for the purpose of a business or other activity or the owner of the premises.

3.2.1. The Role of the Responsible Person

The responsible person is required to carry out a number of duties to ensure the provision of *"general fire precautions"* for employees or other relevant persons. The most fundamental duty of the responsible person is to carry out a risk assessment (typically referred to as the *"fire risk assessment"*) that should provide *"a suitable and sufficient assessment of the risks to which relevant persons are exposed for the purpose of identifying the general fire precautions he needs to take"*. Such an assessment must be

[3] Jim Baker is a former firefighter serving with both West Midlands Fire Service and Leicestershire Fire and Rescue Service. A portion of his service was spent dealing with fire safety regulation as an Inspecting Officer under the Fire Precautions Act 1971. Since leaving the Fire and Rescue Service in 2007, Jim has studied fire safety at the University of Central Lancashire, Loughborough University, and the University of Edinburgh where he is currently studying for a PhD in Sociology. His PhD study, investigating the sociological aspects of post-construction fire safety in the UK, is being funded by the Department of Science, Technology and Innovation Studies, which is part of the School of Social and Political Science at the University of Edinburgh. Jim is a graduate of the Institution of Fire Engineers and a chartered member of the Institute of Occupational Safety and Health.

reviewed and kept up to date if "*there is reason to suspect it is no longer valid*" or "*there has been a significant change in the matters to which it relates*".

This regulatory system thus relies on self-regulation whereby the responsible person must be aware that they have that legal role, and they must also know what constitutes a *"suitable and sufficient"* assessment for their premises, and whether any changes are so significant as to require the assessment to be reviewed. The responsible person can carry out the risk assessment if they have *"sufficient training and experience or knowledge"*, and the government provides guidance to assist the responsible person in carrying out their duties for a range of common types of premises, but warns that a responsible person who feels *"unable to apply the guidance … should seek expert advice from a competent person"* (DCLG 2006, 4). Moreover, it is noted that: *"More complex premises will probably need to be assessed by a person who has comprehensive training or experience in fire risk assessment"* (DCLG 2006, 4).

There is therefore a requirement for the responsible person to make judgments about whether they possess *"sufficient training and experience or knowledge"* to carry out their duties, what amounts to a *"suitable and sufficient"* risk assessment for a particular premises, and whether a premises is complex or not. In principle, this amounts to a logical flaw in the regulation because the responsible person may not have sufficient expertise to know whether an expert fire risk assessor is needed.

The other main task of the responsible person is to make *"fire safety arrangements … for the effective planning, organisation, control, monitoring and review of the preventive and protective measures"*. In addition to a well-planned and rehearsed evacuation strategy, these arrangements will include a number of material aspects of the premises including the presence of smoke alarms, other detectors, and of fire fighting equipment, and the functionality of evacuation routes. Some of these measures can be visually inspected, but ensuring all relevant fire safety systems and procedures are appropriately maintained may require access to the relevant design information accumulated during the design and approval stage of the project.

3.2.2. Fire Safety Design Information

Regulation 38 of The Building Regulations 2010 requires that the *"person carrying out the work shall give fire safety information to the responsible person not later than the date of completion of the work, or the date of occupation of the building or extension, whichever is the earlier"*. Although not part of the Regulatory Reform (Fire Safety) Order 2005, Regulation 38 is an important element of post-construction regulation because it is the only provision for ensuring the transfer of fire safety design information from the design team to the building users. However, there are a number of problematic aspects to this regulatory mechanism.

First, there is no guidance provided as to the format and content of the fire safety information that should be transferred. On the one hand, the fire safety information should contain all details relevant to enabling the safe future occupation and maintenance of the building, but, on the other hand, it should be comprehensible to the likely responsible person (which for some buildings may be someone with little technical background in fire safety). A level of competence is therefore required on both sides by (1) the designer to identify and collate the relevant information for the responsible person; and (2) the responsible person to receive, and interpret, and make use of the fire safety information.

Second, the requirement to transfer the information on the completion of the work (which would usually be before building occupation) is often impractical because the responsible person may not yet be *in situ* at that time. While the Scottish legislation stipulates that the fire safety information (known in Scotland as the "*fire safety design summary*") should, along with the building completion certificate, be lodged with the local building control on the completion of the work, there is no such requirement in England & Wales. Instead, in England & Wales, Building Control or an Approved Inspector simply require the project developer to confirm that they have provided the fire safety information (by signing a declaration on a form) without checking its contents or that it has reached the responsible person.

Thus, despite what Regulation 38 requires, the fire safety information provided by the design team rarely lands in the hands of the responsible person, and there is no regulatory oversight mechanism to ensure that it does so. The fire safety information documentation may be left in the building on completion, but, typically, it is not located and used thereafter for the purposes for which it was intended. This may not be a problem for simple buildings or for those that are strictly designed according to prescriptive guidelines, where the functioning of the fire safety design will be familiar to an experienced practitioner and can be inferred from readily available public documentation (e.g. Approved Document B). However, without the fire safety information it would not necessarily be clear whether the fire safety design was fully prescriptive or whether some element of fire safety engineering had been used. Where fire safety designs have involved extensive fire safety engineering it may be essential for the fire safety information to be used in any fire risk assessment.

The value of the fire safety information thus depends on it being available and containing the appropriate information in a way that is comprehensible to the person carrying out the fire risk assessment for the building. It also of course depends on the competency of that person.

3.2.3. Competency of Fire Risk Assessors

Although the responsible person bears ultimate responsibility for carrying out a risk assessment and ensuring the provision of fire precautions, they can employ a specialist fire risk assessor to do this. Competence to do this is defined as follows: "*A person is to be regarded as competent* [to assist the responsible person in carrying out their duties] *where he has sufficient training and experience or knowledge and other qualities to enable him properly to assist in undertaking the preventative and protective measures*".

However, such a definition of competence is not helpful if the responsible person does not themselves have the competence to judge whether a fire risk assessor has "sufficient" training, experience or knowledge. Assurance of competence could be provided by registration with a relevant professional body or certification by an accredited certification body, but neither is currently necessary to operate as a fire risk assessor. Moreover, there is no overall body that regulates the standards provided by these certification bodies, and perceptions of what combination of education and experience constitute competence vary widely within the industry.

3.2.4. Enforcement of Regulatory Reform (Fire Safety) Order

The shift in post-construction fire safety regulation brought about by the Regulatory Reform (Fire Safety) Order 2005 parallels what was already in place for Health & Safety, with the exception being that enforcement is to be carried out by the Fire and Rescue Service rather than the Health & Safety Executive (with some exceptions such as nuclear installations). As with Health & Safety requirements, many premises are not inspected to check whether they are complying with the Regulatory Reform (Fire Safety) Order 2005. Enforcement is focused on those premises that are considered higher risk.

This judgment of the risk presented by particular premises is made locally by a FRS using what is known in England as Integrated Risk Management Planning (IRMP). Many premises are thus not inspected because they are not considered to present a great enough risk, although what evidence there is (for example, as discovered when the fire services are called to a fire) suggests that many premises either have not been subjected to a fire risk assessment and/or do not have appropriate fire precautions in place (with a common failing being evacuation routes that are blocked or even locked).

The problem with this inspection approach is that it relies heavily on statistical analysis of previous deaths expressed as “societal life risk”. The IRMP approach to risk-based inspection relies on historical data of fire outcomes to provide “generic levels of relative risk” for different occupancy types (DCLG 2009, 5). A “relative risk score” for individual buildings can then be calculated using local knowledge “based on the extent to which an individual building moves away from the generic level of relative risk for that occupancy” (DCLG 2009, 5). A type of building that has not seen many deaths in recent years may thus not be a high priority for inspection, even if close inspection and analysis of the fire safety measures in those buildings might have raised concerns.

In addition to using historical statistics, societal life risk data can also “*be assessed by carrying out a site visit*” (DCLG 2009, 3). However, these site visits are carried out by Fire and Rescue Service personnel whose expertise and experience will typically limit their capacity to uncover some potential serious breaches of the fire safety precautions required under the Regulatory Reform (Fire Safety) Order 2005. Although many failings can be observed during a “walk through” inspection (e.g. evacuation routes blocked or locked, fire doors propped open, debris in stairwells) other fire safety issues may require more intrusive investigation, and specialist knowledge of fire safety engineering.

Moreover, although the principles embodied in the regulatory mechanism of the Regulatory Reform (Fire Safety) Order 2005 follow those that have been in place for Health & Safety since the 1970s, there are key differences that impact on the effectiveness of enforcement measures. The most dangerous Health & Safety risks are clearly identifiable and linked with particular business practices. Any organisation using these processes will have relevant specialist expertise, and those organisations with significant risk will be known to, and inspected by, the Health & Safety Executive. In many cases (e.g. the nuclear, chemical, aviation industries) there will be a strong safety culture backed up by training and organisational procedures.

RECOMMENDATION 2

It is recommended that:

- Regulation 38 should be strengthened to ensure that it is made available and used in the fire risk assessment and by FRS enforcement officers. Regulation 38 should therefore be explicitly referenced in an updated Regulatory Reform (Fire Safety) Order. A standard format for the fire safety design information should be used, and if possible (with regard to confidentiality restrictions imposed by the use of Approved Inspectors) this design information should be lodged in a public repository.
- Fire risk assessments should be submitted to the relevant FRS.
- There should be a national registration organisation (e.g. paralleling Gas Safe) that fire risk assessors are required to be registered with, with appropriate training, accreditation, certification, and on-going CPD requirements.
- It should be ensure that the scope of the risk assessment includes any aspects of the building that may affect the provision of General Fire Precautions.

4. Role Understanding and Competency

The previous sections demonstrate how the allocation of legal responsibility is clear within the various documents, although some clarifications of the Regulatory Reform (Fire Safety) Order are desirable. Furthermore, it has been described how the existing regulatory framework within the UK requires practitioners and occupiers to take responsibility for ensuring the requirements of the legislation are met.

In the case of the RRO, it has been highlighted that the responsible person may not be aware that they have a defined role as the responsible person. This individual must be competent to receive and make use of the Fire Safety Information, and, where they make use of an external fire risk assessor, to ensure that their appointed “competent person” is, indeed, competent.

In the case of The Building Regulations, it has been highlighted that ultimate responsibility for compliance with the requirements rests with the applicant (and their professional team). Absence of competence within the professional team can be mitigated by competence within the regulator.

Therefore, fundamental to ensuring adequate implementation of the legal framework is the reliance on the professional competence of the various parties. This section of the evidence will discuss the requisite competence for the various stakeholders, and the degree to which the parties achieve this.

4.1. Professional Design Team

In the case of the professional design team, responsibility for ensuring that requirements relating to fire safety were achieved has historically been held by the architect. The architect would read and apply the relevant guidance without significant deviation. Historically, building systems were sufficiently simple that it was feasible for the architect (who had little or no specialist fire safety engineering knowledge) to adequately interpret the relevant rules and guidance.

In the contemporary construction industry, however, there has been an increase in the complexity of building systems and there is often a desire for unusual forms (e.g. atria, extensive open plan areas, etc.). Consequently, the architect is often no longer competent to interpret the guidance and ensure that all of the requirements are adequately met. As a result, fire safety specialists frequently form part of the professional services team during the design phase; the principle consultant receives advice from the fire safety specialists to assist them in ensuring that the requirements of The Building Regulations are met. There are some inherent challenges with this arrangement.

If the principle consultant is reliant on a fire safety specialist to ensure compliance with the requirements, then they may also lack the ability to assess the quality of the information provided by the consultant. When appointing the consultant, it becomes of paramount importance that there should be a metric by which the principle consultant can evaluate the competence of potential fire safety specialists, particularly in the UK where "engineer" is not a legally protected term (as e.g. in the USA or Canada).

Across the industry, there is no agreed metric of competence. An obvious metric would be the specialist's track record of previous work. However, the comparatively infrequent occurrence of severe fires in buildings means that a judgement of track record is not a true or demonstrable judgment of safety, but a judgement of the consultant's ability to, for example, achieve regulatory approval while minimising cost.

This situation has the potential to lead to a "race to the bottom" whereby competent specialists are priced out of the market by cheaper, incompetent, actors operating as fire safety engineers in a system with no legal protection or required formal accreditation of this professional designation.

In the absence of a defined metric of competence for the professional design team, another proxy metric is an individual's perceived authority. The regulator (i.e. the Local Authority or Approved Inspector) have authority over the success (or otherwise) of any building regulations application. If this individual is satisfied that a proposed solution is appropriate, then no further thought, analysis, or justification is required to obtain approval. Hence within the professional design team, the fire safety engineering specialist may find that their advice is regarded as secondary to the opinion of the regulator.

This is potentially problematic because the regulator is required to have a wide knowledge of all relevant aspects of The Building Regulations. Often, therefore they are not a fire specialist, and may not have the competence to identify (or even check) a detailed fire safety engineering solution. Furthermore, they may not have the competence to recognise where aspects of the prescriptive guidance are not appropriate, since they may not understand the assumptions and limitations inherent within the guidance.

This lack of competence within the regulator has two problematic impacts: (1) it reduces the technical level of the check that can be completed and, therefore, the ability of the regulator to identify inappropriate solutions; (2) when combined with the perceived importance of the regulator's authority, it may lead to the acceptance of solutions on the basis that these can be "approved", rather than because they are necessarily appropriate under the circumstances. The latter of these problems has the potential to blur the line between designer (who should take responsibility for the design) and regulator (who should check the design is adequate).

4.1.1. The Role of the Fire Service

Irrespective of the regulator's competence, the organisation with the most fire safety authority within The Building Regulations process is often perceived to be the Fire and Rescue Service (FRS). This perception is not unreasonable as the FRS has legal powers that relate to the RRO and, of course, has authority over the actions taken to respond to any fire incident. In the mind of the public (and many built environment professionals), the FRS is therefore the custodian of fire safety. In the absence of a metric for competency within the professional services team, the authority of the FRS is an appealing alternative metric.

A regulator may recognise that they do not have the competence to evaluate a proposed fire safety engineering solution. Consequently, they may defer to the FRS's opinion when evaluating any proposed solution. To some degree, this is appropriate; indeed, consulting the FRS as part of the process is an explicit recognition that they have expertise (particularly in fire-fighting) that the regulator does not. However, when taken to extremes, the FRS can become the *de facto* regulator – and is therefore required to act beyond its role as a consultative body, and in some cases, beyond their technical competence.

In response to this, some FRSs have developed in-house fire safety engineering teams who can review the details of proposed solutions. These FRSs are effectively performing the role of the regulator by effectively recognising that unless they provide a check, there would be no effective regulation of the professional design team. By providing these services, FRSs are, arguably, attempting to discharge their duties under the Fire Service Act 2004 (to make provisions for the purpose of promoting fire safety in their area).

The ability of any FRS to fulfil this role is highly variable depending, for example, on its level of resource, and the frequency with which it encounters occasions where such levels of competence are required.

4.1.2. Competency of the Professional Design Team

It is clear that the competency of the professional design team is fundamental to meeting the requirements of the regulations. The checking (whether by regulator or fire service) is a method for discouraging incompetence. It is therefore vital that the regulator has adequate competency to perform a credible check. If the professional service teams are broadly competent, then the identification of inappropriate solutions by the regulator would be an occasional circumstance.

Experiential evidence and the widespread issues associated with building cladding that have been identified by the post-Grenfell DCLG screening test programme suggest that: 1) The professional design team (in its broadest sense) is frequently not competent to meet the requirements of The Building Regulations; and 2) The competence of the regulator is often not sufficient to identify or rectify this.

To ensure that the requirements have been met, a competent fire safety engineer must: understand the letter of the guidance, understand the intent of the guidance, and understand the fundamental science and engineering that underpins fire safety. In combination, these qualities will allow an individual to follow the guidance as appropriate, and also to identify situations where the guidance is not appropriate, and alternative solutions (based on fundamental principles) should be adopted.

When a structure is designed, a structural engineer will always be consulted. This is because it is recognised that a thorough understanding of the physical principles is necessary in order to ensure that any proposed solution is appropriate. Furthermore, the structural engineering community has a clearly identifiable metric of competence – the professional accreditation of Chartered Structural Engineer. This accreditation is supported by a strong institution and, in the mind of the public, Chartered Structural Engineers are the custodians of structural safety within the built environment.

Unlike the Chartered Structural Engineer (who is regarded as a pre-requisite for any professional structural engineering), a Chartered Fire Safety Engineer is generally regarded as an optional consultant.

The reasons for this are as follows. First, the provision of detailed guidance allows individuals to implement the guidance without, necessarily, having an understanding of the principles behind that guidance. Consequently, as part of the building design process it is not necessary to consult an individual with a thorough understanding of the physical principles behind fire safety. The appointment of a specialist only becomes necessary where there is a specific need due to a recognised lack of competence, or a difficulty has arisen in obtaining the relevant approval from the regulator.

Second, the Chartered Fire Safety Engineer is not widely regarded as the custodian of fire safety within the built environment. Instead, the Fire and Rescue Service is perceived to occupy this role. This weakens the status of the profession of Chartered Fire Safety Engineer (and its professionals) as Fire Safety Engineers are often regarded as having less authority than the FRS. This weakening of the profession is compounded by the fact that the awarding body for Chartered Fire Engineer status, i.e. the Institution of Fire Engineers (IFE) is primarily comprised of current and former fire service personnel, the vast majority of whom are not Chartered Fire Engineers.

Fire and Rescue Service personnel are extremely skilled and knowledgeable in relation to the operational aspects fire-fighting. However, unlike the structural engineering profession, the core education and experience of fire service personnel is not focussed on fundamental scientific understanding of the physical principles and their implementation within building design. Their education and training necessarily relate to more operational aspects of fire service activities.

The Institution of Fire Engineers therefore has an inherent conflict within its membership. Its members who are current and former fire service personnel have an interest in continuing to be regarded as the custodians of fire safety; however, the professionally chartered fire engineers also have an interest in being perceived as the custodians of fire safety. One way for the Institution to resolve this conflict would be to maximise the number of former fire service personnel that are able to achieve Chartered status. However, given the fundamentally different educational backgrounds required for a fire-fighter and a professional engineer, this process requires either significant re-education of the fire-fighter, or a reduction in the educational requirements associated with becoming a Chartered Fire Engineer. The latter is a route to incompetence within the population of engineers who receive Chartership from the Institution of Fire Engineers.

This professional competence situation is unique within the built environment because fire safety is the only area where there is a government-funded professional interventional response unit. There is no parallel “structural brigade”. If a structural engineering failure occurs, then structural engineers themselves are called upon to investigate.

In summary:

- The fire safety engineer is a uniquely weak professional within the design process due to: the perceptions of, and strength of, the Fire and Rescue Services; and the presence of guidance that can remove any perceived need for a professional;
- There is little evidential basis for judging the competency of fire safety engineering specialists due to the rarity of fires and the resulting minimal capacity for feedback to the fire safety engineering design and assessment professions.

RECOMMENDATION 3

It is recommended that measures should be taken to ensure that competence is increased across the fire safety engineering and assessment professions. It is recommended that this should focus on:

- Increasing and regulating the competence of the regulators (i.e. the Local Authority and the Approved Inspectors), as this would be the quickest way to both identify inappropriate solutions, and require professional design teams to improve their competence.
- Separating the accreditation of Fire Engineers from the interests of the Fire and Rescue Services. While these two groups are linked, there is:
    - An inherent conflict between regulator and design professional;
    - An inherent conflict regarding which group should be the custodian of Fire Safety within the building design process.

5. Testing Frameworks

The use of tests to assess and verify the adequacy of a product is commonplace across many industries. Often these tests become embedded within regulatory frameworks, and "passing" a test becomes a route to compliance with relevant legal requirements.

The fire performance of a product or system is underpinned by fundamental scientific concepts (e.g. heat transfer, chemistry, fluid dynamics). These fire science principles control how a system responds when subjected to different external stimuli (e.g. severe heating in a fire). Some test methods represent an attempt to reproduce the stimulus and the product in a way that is somehow representative of end use. The intent is that the results of a test can be used to infer conclusions about the performance of a product or system in a real situation. Naturally this requires some understanding of the likely (or "worst case") situation for the external stimuli and the product or system.

The alternative approach is to build up a body of fundamental fire science that allows the processes and parameters that govern how materials, products and systems perform to be understood through *experimentation*. When these fundamental processes are adequately understood, the performance of a system can be understood. This approach delivers robust knowledge on the performance of materials and, when adequately described, allows extrapolation to new scenarios or applications. This necessarily requires detailed knowledge of fundamental fire science phenomena which is often lacking in the fire engineering community.

The rationale for standardised *testing* is that it is not possible to know in advance all the phenomena (and their coupling) which govern the product or system response. These tests therefore seek to allow comparisons between materials rather than deliver fundamental understanding. While testing is undertaken on products or systems, it is ultimately the interactions between materials and the external stimuli that govern the fire behaviour.

Designing an adequate test therefore requires detailed understanding of the fundamental processes such that these are adequately represented. However, because of the focus on regulatory testing to demonstrate compliance for prescriptive fire safety regulation, many of the processes governing fire behaviour are not well understood beyond laboratory conditions.

Consequently, the interpretation of results from testing is extremely subjective. No fundamental knowledge can be obtained as the results are dependent on the test setup, which is typically inadequately defined and the results inadequately reported to allow scientific understanding or interrogation. To circumvent the need for full scientific understanding of a particular system or product, conditions are created in standardised tests that are believed to be sufficiently representative of reality. It is therefore claimed that adequate performance with the tests can be assumed to deliver adequate performance in reality. The potential limitations of this approach are well documented within the aerospace testing industry (e.g. Downer 2007).

Within the context of fire safety engineering, there are many test methods that are available and which are cited by ADB. Test results typically lead to products being “classified” according to whether they achieve a particular performance in the test, and, on the basis of this classification, products are permitted (or not permitted) for use in buildings.

The use of classification methods for categorising products is not, inherently, problematic. However, within the context of fire safety engineering (and the context of limited practitioner competence) there are particular challenges with this approach as are described below.

5.1. Reaction to Fire

The flammability properties of materials are controlled by a range of well understood scientific principles. There is a vast body of literature on ignition, burning, flame spread, and the parameters that control these phenomena. However, the system by which products are specified (or permitted) in buildings does not use fundamental material properties or parameters relating to the fire performance. Instead, materials and products are subjected to a series of tests – and based on the results of these tests, they are allocated a “classification”. Products are classified from A to F, and terms such as “combustible”, “limited combustibility”, “non-combustible” are used to describe the behaviour of the materials.

The aim of such a system is to allow classification of materials against a standard set of tests to determine whether (and where) they can be used in a building. Although these terms are adequately defined, they do not necessarily capture the true characteristics of how a material burns (material flammability, and dependence on the fire environment) and subsequently it is extremely difficult (and perhaps impossible) to extrapolate product classifications to an understanding of the risks posed when assembled into a construction system.

The absence of quantitative behaviour characteristics means that for practitioners, there is little incentive to acquire or retain knowledge of the fundamental physical processes that affect fire spread or development. Hence, even where knowledge of the actual risks of particular products or systems is required, many practitioners are unable to adequately comprehend the relevant processes.

So long as the test design is sufficiently realistic, this lack of fundamental knowledge gathered from material testing is not a problem *per se* for prescriptive regulation, but it creates an inherent disconnect between the regulatory system and any “first principles” engineering. The absence of quantitative behaviour data might mean that there is a challenge in undertaking design of solutions other than those presented in ADB; and it may be that practitioners are unable to interpret the data – even if it is available.

RECOMMENDATION 4

It is recommended that the testing regime should be updated to include fundamental parameters, and quantification of the testing environment in the classification of materials. This would allow engineering judgements to be made, and would embed within the regulatory system an inherent value to understanding the fundamental principles.

5.2. Fire Resistance Ratings

The fire resistance ratings provided within Approved Document B represent the period of time that an element of structure or compartmentation is expected to survive within a standard furnace test. The furnace test is a historical testing method that is now deeply embedded within codes and standards around the world. The procedure of furnace testing involves the exposure of the test specimen to a mixture of hot gases within a well insulated closed chamber, and the measurement of performance against various discrete, quantifiable “acceptance criteria” e.g. temperature rise on the unexposed face, leakage of flame or hot gas, structural deflection, collapse, etc. The time of failure in the tests (typically rounded down to the nearest 30 minute interval) is the tested “period of fire resistance” of the element of construction.

The fire resistance test is also the product of a compromise between representativeness and reproducibility – and the shortcomings of such tests are well documented within the technical literature (Bisby, 2013). Irrespective of these shortcomings, this system of testing and fire resistance rating provides a clear and objective method for classifying types of construction.

The standard fire resistance test suffers from similar issues as the combustibility tests. The test method obscures many of the fundamental phenomena that govern structural behaviour during a fire and therefore it can be difficult (if not impossible) for practitioners to develop and retain an understanding of the governing physics based on the results of these test.

Furthermore, the furnace tests, and the fire resistance classification system suffer from an additional problem. The period of fire resistance of an element of construction in a furnace test is often confused/conflated with the time to failure in a real fire. This confusion is rooted in a misunderstanding (or lack of understanding) of the background history and origins of the test method and the resulting classification system, and a failure of individuals to recognise that conditions in a real fire differ – sometimes very significantly – from those in a standard furnace test.

This confusion is problematic for several reasons:

- False comfort. Conflation of furnace time and *real time* can falsely lead people to assume that elements of construction will provide a level of performance that, in fact, they do not (in a real fire). This can, and does, lead to decisions about evacuation or fire-fighting that are not based on sound technical reasoning.
- Additive fire resistance. The use of “minutes” as a measure of performance can lead people to assume that periods of fire resistance are additive (e.g. two 30 layers of protection are equivalent to one 60 minute layer of protection). This is an incorrect assumption and can lead practitioners to provide construction that has a level of performance substantially less than that intended by Approved Document B.
- Actual performance intent. The use of “minutes” of fire resistance can lead people to assume that failure after this time is acceptable. This is not necessarily the case and was not the historical basis upon which this testing and classification system was devised. The original intent of high periods of fire resistance (particularly for tall

buildings) was to ensure that construction could endure complete burnout of all the fuel within the fire compartment. This misunderstanding can lead people to adopt solutions for high rise buildings that might not be able to resist burnout of the fuel load – and therefore undermine the fundamental intent of the regulatory framework.

RECOMMENDATION 5

It is recommended to update the classification system for fire resistance rating that is used within the Approved Document B. Rather than using "minutes of fire resistance", it is recommended that the Approved Document should adopt a "fire grading" classification system. For example, Grade A construction, Grade B, Grade C etc. These can then be mapped against appropriate standard test results.

This classification approach would change the language associated with 'fire resistance'. The change in language would be an explicit acknowledgement that "fire resistance periods" do not equate to time in a real fire, and would discourage people from casually or technically making this flawed comparison.

6. Evidence of Adequacy

This document has discussed the various technical and social factors that regulate and deliver fire safety within the built environment. There are two methods to "close the loop" and evidence the adequacy (or otherwise) of the fire safety within the built environment: (1) statistical evidence; and (2) physical evidence from fires.

6.1. Statistical Evidence

Analysis of statistics makes clear that there has been a reduction in the number of fires (large fires are not a common experience in society). The cause of this decrease is far from trivial to identify; however this suggests that fires have become harder (and less likely) to ignite than previously. These trends at least partly coincide with the introduction of The Furniture and Furnishings (Fire) (Safety) Regulations 1988 (and subsequent amendments).

However, additional statistics available from the insurance industry suggest that the average cost of a fire claim has increased suggesting that the damage occurs when a fire is ignited is increasing. This may be in part indicative of an increased tendency for fire spread from the compartment of origin.

The complexities of the interactions between the building regulations and their interface with other regulations (e.g. furniture fire safety) mean that it is not simple to identify whether the building regulations are sufficiently robust and reliable in maximising fire safety. It is acknowledged that these statistics are incomplete, and that it is difficult to draw definitive conclusions due to the evolution of the built environment, responsibilities of professionals (and professional bodies) etc.

6.2. Evidence from Real Fires

There is no requirement for fire investigations (either those carried out by the FRS or in the private sector) to identify the mechanisms of fire growth, spread and development. Consequently, there is no requirement for direct 'feedback' from the observations on fire scenes to lead to revisions in the regulations – although large numbers of casualties typically trigger revisions.

While the FRS have the statutory power to undertake an investigation into the origin, cause and development of a fire, they do not have a statutory duty to do so. Private fire investigations (e.g. those carried out on instruction by insurance companies) may be extensive; however it is likely that many civil actions are settled out of court with non-disclosure clauses.

RECOMMENDATION 6

It is recommended that the requirements for and duties related to investigation of fires are re-assessed. Detailed fire investigations, and open reporting, will allow evaluation (on a rolling basis) of where there are deficiencies or misunderstanding of the regulations to be identified. This must be undertaken by a competent individual and the FRS may not be the appropriate body to undertake this task.

7. Updates to Existing Guidance

The previous discussion has identified that the guidance provided in ADB is "fail safe" in that any ambiguity can be corrected by reference to the intent of the document. However, it has also been identified that, in many cases, the individuals responsible for interpreting the document or checking that the document has been followed are not competent to do so.

Consequently, there are aspects of the document where additional guidance would provide clarity, and prevent unsafe practices from occurring. Suggestions are made in the following section. It should be noted that these suggestions are not intended to be comprehensive, but represent areas where the authors have knowledge and experience.

7.1. Subdivision of B4

B4 captures the requirements for external fire spread. There are two aspects of external fire spread that are defined:

- Fire spread on the external walls of the building; and
- Fire spread from one building to another.

These two aspects are thematically linked. However, it would be possible to express these as two different requirements. This would potentially enable a more explicit identification of the fire safety measures provided to achieve each objective. This approach is already adopted for internal fire spread (which is split into B2 and B3) – it would therefore be in-line with the existing approach within the document to separate B4 into two sections.

RECOMMENDATION 7

It is recommended that B4 (External Fire Spread) should be further sub-divided to define separate functional requirements associated to:

- Spread over the walls; and
- Spread from one building to another.

The benefit of this is that it would facilitate more explicit definition within the fire safety strategy (and associated approval discussions) of the intent of the fire safety measures within the building.

7.2. Curtain Walls

Curtain walls are panelized cladding systems that hang from the perimeter of the building. The detailing of the junction between the curtain wall, and the floor slab is mentioned in ADB clause 8.26 as follows:

At the junction of a compartment floor with an external wall that has no fire resistance (such as a curtain wall) the external wall should be restrained at floor level to reduce the movement of the wall away from the floor when exposed to fire.

The intent of this section is to provide compartmentation in order to *"prevent rapid fire spread which could trap occupants of the building"* and *"reduce the chance of fires becoming large"*.

From this it would be reasonable to infer that some kind of fire protection measure is provided at these details. However, this raises the more fundamental question of "where is the edge of the building?", and do these systems potentially introduce a route for vertical fire spread. For example, some curtain wall assemblies have a 2-hour fire stopping detail abutted to external glazing; clarification on whether these typologies of detail adequately meet the requirement would be of potential value.

RECOMMENDATION 8

It is recommended that additional guidance should be provided with respect to the interface between compartment walls and floors, and curtain walling.

7.3. Mass Timber Buildings

Cross-laminated timber is increasingly becoming a popular form of construction within the UK. This form of construction has large timber panels that form the walls and floors of a building; these are exposed within a room, or "encapsulated" with fire protection material (typically gypsum plasterboard).

The fire resistance ratings in ADB are based on an assumed fuel load within a given occupancy of building, and intended to allow the burnout of that fuel. In non-combustible construction (e.g. steel or concrete) the structure of the building makes no contribution to that fuel load. In the case of mass timber buildings, any exposed timber will burn – and therefore contribute to the overall fuel of the fire. Furthermore, where timber elements are exposed (or become exposed due to fall-off of the encapsulation) there is no guarantee that these will stop burning once the original fuel load (i.e. furniture) is consumed. Consequently, it is possible that mass timber buildings may continue to burn until structural failure occurs.

A thorough understanding of Approved Document B and its underlying assumptions (including the functional requirements of the Building Regulations 2010) would lead any reader to the conclusion that additional checks (beyond those expressed in Table A2 of ADB) are required to enable the use of mass timber construction. These checks would account for the additional fuel load that could be liberated from the mass timber, and ensure that "self-extinction" of the timber occurs following consumption of the fuel load.

However, there are an increasing number of project examples where these aspects have not been considered during design. It is recommended that additional clarity should therefore be provided within Approved Document B to ensure that adequate checks are made.

RECOMMENDATION 9

It is recommended that Approved Document B should be updated with language to suggest that:

In the case of mass timber construction, it should not be assumed that the values provided in Table A2 are guaranteed to meet the requirement. Additional checks should be completed as appropriate to ensure that the fuel load associated with mass timber construction is incorporated into the design and that, if appropriate, any involved timber linings are able to cease flaming without fire service intervention.

This would ensure that any future mass timber buildings are able to deliver a level of performance commensurate with that achieved in other contemporary forms of construction.

7.4. The Role of BS 9999

BS9999 is a “new” code which provides an approach to prescriptive design that is orientated around risk profiles derived from classes of occupancy characteristics and fire growth rates.

This standard provides a broader range of solutions than those provided in ADB. It also requires that the designer make explicit judgements about aspects of the building. For example, decisions about fire growth rates (and the possibility of the impact of change of use).

As with ADB, this demands competence from the designer and regulator.

There are two issues where it is suggested that changes may be appropriate with the use of BS 9999. First, it would be appropriate to integrate this into ADB (the latest 2013 edition makes no reference at all to BS 9999, which came into force in 2008, and much of the BS 5588 series was withdrawn on 6 April 2009). Second, queries have been raised about the justifications for ratings provided in Tables 26 and 27 of BS 9999. The concept of this approach is clear and it could, in principle, provide an important route to further engineering analysis of the appropriate fire resistance periods. However, no justification is given for the conditions cited in Table 27. It may be that more fundamental work is needed in this area and some revisions required.

In relation to the differentiation between building classifications, BS 9999 specifically addresses some issues that overlap high-rise/multi-occupancy residential buildings, e.g. in Annex Q. It may be useful if these issues were addressed in a separate code, though problematic given the need for duplication of some of the fundamental concepts.

RECOMMENDATION 10

It is recommended that ADB should be updated to include reference to BS 9999. In addition, it is recommended that supporting information should be included with respect to the assumptions in Table 27 of BS 9999.

8. References

Downer, John (2007) ‘When the Chick Hits the Fan: Representativeness and Reproducibility in Technological Tests’, Social Studies of Science, Vol. 37, No. 1, 7-26.

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