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ToolSHeD™: The development and evaluation of a decision support tool for health and safety in construction design

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ABSTRACT

Purpose: The paper describes an innovative information and decision support tool (ToolSHeD$^{\text{TM}\,)}$ developed to help construction designers to integrate the management of OHS risk into the design process. The underlying structure of the prototype web-based system and the process of knowledge acquisition and modelling are described. **Approach:** The ToolSHeD$^{\text{TM}}$ research and development project involved the capture of expert reasoning regarding design impacts upon occupational health and safety (OHS) risk. This knowledge was structured using an innovative method well-suited to modelling knowledge in the context of uncertainty and discretionary decision-making. Example 'argument trees' are presented, representing the reasoning used by a panel of experts to assess the risk of falling from height during roof maintenance work. The advantage of using this method for modelling OHS knowledge, compared to the use of simplistic rules, is discussed. **Practical implications**: The translation of argument trees into a web-based decision support tool is described and the potential impact of this tool in providing construction designers (architects and engineers) with easy and inexpensive access to expert OHS knowledge is discussed. **Originality**: The paper describes a new computer application, currently undergoing testing in the Australian building and construction industry. Its originality lies in the fact that ToolSHeD$^{\text{TM}}$ deploys argument trees to represent expert OHS reasoning, overcoming inherent limitations in rule-based expert systems.

KEYWORDS

Case study, occupational health and safety, construction design, knowledge-based system, decision support

INTRODUCTION

Design OHS

The failure to address health and safety in design is at odds with contemporary thinking in risk management, in which the most effective means of dealing with a hazard is to eliminate it at source. There is compelling evidence to suggest that decisions made during the design stage of a project can have a significant impact upon OHS during the construction, occupation, maintenance and demolition stages of a building's life cycle (Williams 1998). Designers make choices about the design, methods of construction and materials used, which can significantly impact upon the health and safety of those who build, occupy, maintain, clean, renovate, refurbish or eventually demolish a building/structure (ECI 1996; Hinze and Gambatese 1994). Recent analysis has confirmed design as a causal factor in fatalities and serious injuries in the construction industry (Suraji et al. 2001; Behm 2005). Gibb et al. (2004) conducted a detailed review of 100 construction accidents that occurred in the UK and report that in 47% of cases, a design change would have, at least, reduced the risk of injury. Behm (2006) analysed 450 reports of construction workers' deaths and disabling injuries in the USA and reports that in151 cases (about one-third of those studied), the risk that contributed to the incident could have been eliminated or reduced if design-for-safety measures had been implemented.This is not to say that design is the only contributing factor in construction accidents but that, to a significant extent, design factors can increase the risk of injury. In Australia, an analysis by Driscoll et al (2005) suggests design issues contributed to 44% of recorded work-related fatalities in the Australian construction sector, though the researchers acknowledge limitations inherent in the information upon which this analysis was based.

In Australia, the *National OHS Strategy 2002–2012* defines the elimination of (physical) hazards at the design stage an area of national priority (NOHSC 2002). The strategy aims "to build awareness and observance of this approach and to give people the practical skills to recognise design issues and to ensure safe outcomes". Consequently, specific obligations for OHS designers of buildings and structures have been established in preventive OHS legislation in four Australian jurisdictions (Western Australia, South Australia, Queensland and Victoria) (Bluff, 2003).

One way to improve design safety outcomes in the building and construction industry is for architects and engineers to conduct a thorough risk assessment of each design component of the facilities they design. At present, it is doubtful that construction Australian designers are equipped to do this because OHS has traditionally not been well integrated into the tertiary qualifications or professional training of architects or engineers.[1]

In the UK, where specific OHS obligations for construction design professionals have been in place for over 10 years, yet research indicates that designers are still unsure about how to comply (Summerhayes 2002). In the USA, where statutory responsibility for designers to consider the OHS of construction and maintenance personnel does not exist, designers have expressed concern about adopting design for safety concepts in case they increase their liability in the event of a death or injury (Gambatese, Behm & Hinze 2005). Overcoming these concerns and recognising that there is much that construction designers can do to reduce OHS risks to those who construct, occupy and maintain the facilities they design is very important. Designing for safety requires integrating construction process knowledge into the design. Thus, there is a need to provide design professionals with specialist OHS knowledge and guidance. This paper reports on an innovative web-based tool being developed in response to this need.

Knowledge-based systems

The *Computer User High Tech Dictionary* defines a knowledge-based system (KBS) as a computer system that is programmed to imitate human problem-solving by means of artificial intelligence and reference to a database of knowledge on a particular subject. Knowledge-based systems seek to replicate, by computer, the problem solving expertise of human specialists in a specific area of application. KBSs are ideally suited to providing OHS decision support because OHS is a specialist area in which it is undesirable to learn from one’s mistakes. The deployment, through software, of OHS expertise that would otherwise be unavailable to the decision-maker can be of considerable benefit in the management of OHS (Roberston and Fox 2000). Given the paucity of OHS experience among construction design professionals (architects and engineers), the provision of OHS decision support via a knowledge-based system has the potential to improve designers’ ability to integrate OHS into design decisions and comply with legislative requirements for OHS in construction design.

There are already a number of examples of the use of KBSs in construction design. MacMullum et al (1987) describe knowledge-intensive computer-aided design tools. These tools provide designers with expert knowledge that has a bearing on the performance of their design by encoding expertise, standards and regulations that underpin a given design problem. Knowledge-

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[1] Although the authors would like to note the guidance material ‘*Safe Design for Engineering Students*’ developed by the Australian Safety and Compensation Council and disseminated to all tertiary institutions offering engineering courses within Australia.

based systems (KBS) have been successfully applied to provide various forms of decision support within the construction design process. For example, a KBS named ‘HWYCON’ has been used by highway departments to support decisions concerning selection of materials as well as repair and rehabilitation activities for concrete structures. The CORONET system (www.corenet.gov.sg) has also been developed by Singapore’s Building and Construction Authority to apply artificial intelligence (AI) techniques for the automated assessment of building plans against building regulations. In this system, building elements are represented using the International Alliance for Interoperability's (IAI) Industry Foundation Classes (IFC). The CORENET knowledge base represents Singapore’s building regulations as rules applicable to each building entity and its properties. During an automated plan checking session, rules associated with each building entity are examined in order to identify breaches of the building regulations. Davison (2003) reports on the development of a prototype that deploys the CORENET technology to provide knowledge-based advice on OHS in building design. Elements are encoded as IFC’s but, rather than apply building regulation rules, OHS rules are applied to identify risks inherent in the design of each building entity. However, the effectiveness of rule-based KBSs for evaluating compliance with OHS legislation is likely to be limited due to the performance-based nature of the OHS legislation in many countries (see below).

Knowledge representation

Despite their potential, few viable commercial knowledge-based systems have been developed (even outside the construction sector). This is arguably due to the cumbersome method of representing knowledge deployed by the majority of KBSs. Until recently, the majority of KBSs under development solved problems using a series of IF-THEN rules. For example, an early expert system called Mycin (Shortliffe et al 1976) encoded the knowledge that medical specialists use to discern meningitis symptoms from those of an ordinary cold. The knowledge was encoded as a series of IF-THEN rules and looked something like:

Rule 1<IF temp=high AND throat=sore AND neck=stiff THEN meningitis=yes>
Rule 2<IF neck=stiff AND light sensitive=yes THEN meningitis=yes>
Rule 3<IF thermometer reading > 37 THEN temp=high>

These rules are clear statements that define the relationship between the variables, in this case body temperature, throat soreness, neck stiffness, light sensitivity, and thermometer reading. Rule based technology is appealing because it is simple and easy to comprehend. However, in practice it presents considerable limitations to the modelling of expert knowledge.

Developing a rule base that comprehensively copes with a real world problem is a tedious and difficult task. Enormous time is required to elicit knowledge from experts, translate their knowledge into rule sets and validate the resulting rules. For example, it is not uncommon to have a rule set in excess of 10,000. Lenat (1983) coined the phrase ‘knowledge acquisition bottleneck’ to refer to the time-consuming process of acquiring this knowledge and developing rules to be deployed in problem-solving. To exacerbate this problem, inference engines (which are used to control the selection and use of data in the knowledge base and apply the reasoning necessary to resolve a problem) are not efficient enough to cope with large sets of rules. To create an inference engine able to deal with large rule sets rapidly enough for real time and web-based applications is very difficult. However, even if these problems could be overcome, the use of rules to represent expert knowledge is still problematic.

Rules are not well-suited to the representation of the knowledge and reasoning used by experts in many situations. This is because real world problems are often characterised by the possibility of vagueness and not all issues needing to be considered in problem solving can be neatly assembled into a set of IF-THEN rules. The term ‘open texture’ has been used to describe this possibility. Thus, even when the intended meaning of a word or concept appears to be clear, there still exists the possibility of debate and disagreement in hypothetical situations (St Vincent, Poulin & Bratley, no date). In situations of open texture, the use of simplistic rules to model expert reasoning is fraught with difficulty because decisions are the product of ‘rational reflection’ rather than ‘naturally occurring’ phenomena (Bench-Capon, 1993).

Legal reasoning

The problem of ‘open texture’ is a widely recognised problem in the modelling of legal reasoning (St Vincent et al, no date). Although rule-based KBSs have made a significant contribution towards the development of computational models of legal reasoning, it is now widely accepted that reasoning represented as rules is applicable only in highly structured and narrowly contextualised situations (Bench-Capon, 1993). Susskind (1987) suggests that key concepts in law are imprecise, stating that ‘*words are vague when they clearly have no definite set of necessary and sufficient conditions governing their use and application. Terms such as ‘fair’ and ‘reasonable’, in this sense, can be seen as vague*’ (p.187).

In many countries, the requirements of OHS legislation are expressed using open textured concepts. A shift in legislative approach, which commenced in the United Kingdom in the mid-1970s, has seen many countries reform their OHS legislation to replace detailed and prescriptive OHS requirements with performance-based requirements. Consequently, legislators in jurisdictions following the UK model (including Hong Kong and all Australian States & Territories) have enacted legislation establishing broad brush ‘general duties’ for employers, employees, suppliers of plant and materials and, more recently (in some jurisdictions), construction designers.

These ‘general duties’ provisions differ from the requirements of early legislation in that they do not clearly spell out the methods by which legislative compliance is to be achieved. Moreover, the general duties are not absolute. The duties of care placed upon duty holders are limited by words like ‘so far as is practicable’ or ‘reasonably practicable.’ For example, section 28 of the Victorian *Occupational Health and Safety Act* (2004) requires that:

> *“A person who designs a building or structure or part of a building or structure who knows, or ought reasonably to know, that the building or structure or the part of the building or structure is to be used as a workplace must ensure, so far as is reasonably practicable, that it is designed to be safe and without risks to the health of persons using it as a workplace for a purpose for which it was designed.”*

IF-THEN rules could probably have been used to model the reasoning behind identifying how to comply with the old-style prescriptive OHS requirements. However, in deciding how to comply with performance-based OHS requirements requires decision-makers to consider a large number of inter-related, heterogeneous factors that interact with each other in a variety of ways. Implicit in this process is the requirement for duty holders to carefully balance OHS risk against cost and technical possibility. In short, they must decide ‘how safe is safe enough?’ In this context, open texture seriously impedes the usefulness of ‘IF-THEN’ rules to represent expert reasoning. The use of argument trees is one alternative approach to modelling expert reasoning which is better suited to solving problems in such situations. The use of this approach to the modelling of design OHS risk knowledge is described in the remainder of this article.

ToolSHeD™ (Tool for Safety and Health in Design)

An Australian research and development project was undertaken to develop and evaluate a decision support tool for design OHS in the construction industry. The aims were: (a) to develop a prototype web-based tool which reproduces the reasoning used by design OHS experts in assessing the risk of falling from the roof of a building during maintenance work; and b) to evaluate the usefulness of this tool in providing decision support to construction designers. The intent of the ToolSHeD™ prototype was to provide a simple step-by-step approach to the assessment of the risk of falling from heights presented by features of a building's design. The risk assessment prompts designers to enter information about relevant design features that experts agree could impact upon the risk of falling from height. The data entered are then used to infer a risk rating based upon a reasoning model agreed by a panel of experts. A risk report is generated as a system output. This advises the designer as to the level of risk of falling from height (Extreme, High, Medium or Low) and an explanation of the design factors contributing to this inferred level of risk.

For example, the risk of falling from the roof during maintenance is *extreme* because:

- the likelihood of a fall is high because the roof is steeply pitched and there is no parapet or edge protection;
- the exposure to the risk is frequent because the type of roof covering requires frequent maintenance; and
- the likely consequence of falling would be death.

On the basis of this report, a designer can choose to accept this level of risk and proceed, or to track back through the design decisions made and modify 'high risk' design features to reduce the risk to an acceptable level.

ToolSHeD™ recognises that not all risks can be eliminated at the design stage, given that some decisions impacting upon OHS risk may be made beyond the scope of the designer's influence. For example, the local statutory authorities may require a minimum 18° pitch roof. This would have an impact on the safety of persons needing to access the roof for maintenance and would necessitate a designer to consider alternate ways in which the risk of falling could be reduced, for example by specifying safe access to the roof and suitable walkways. Some design decisions are beyond the control of the designer and, in recognition of this, ToolSHeD™ provides free text boxes for all design decision points, permitting designers to enter notes, recording the rationale for the decisions they make at each decision point and providing a 'decision history' of the design. This information can be printed as a report, retained for records and/or provided to a client, or other stakeholders as required.

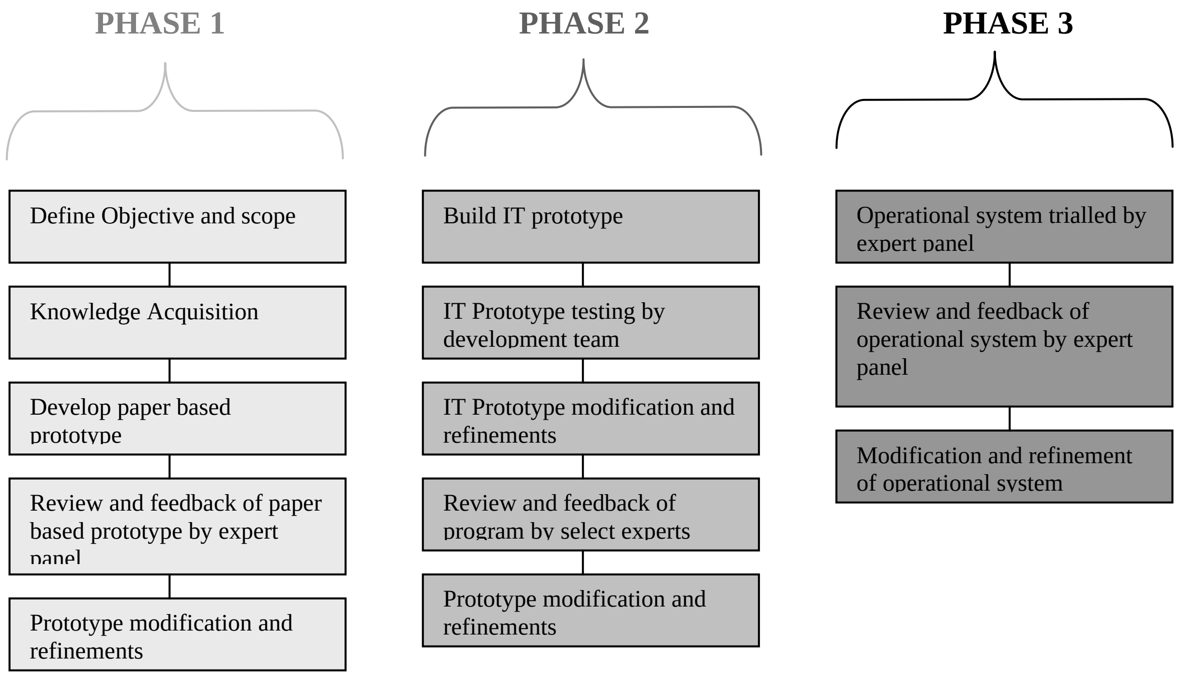
The development process

To test usefulness of the ToolSHeD™ prototype, the data capture, modelling and presentation was initially restricted to conducting an assessment the risk of falling from the roof of a building during maintenance operations. Falls from roofs were selected because fall hazards are the

Australian building industry's most frequent cause of accidental death and second largest cause of non fatal injuries. Recent research in Hong Kong revealed nearly one third of accidents in the construction industry occurred during maintenance and repair works (Yam, 2006) and an analysis of five years of construction fatalities in the UK showed that between 34 and 50% of construction fatalities occurred during maintenance, of these the largest proportion involved falling through or from a roof (HSE, 1988).

The ToolSHeD™ prototype was developed in three stages (see Figure 1). The first stage involved knowledge acquisition and the development of a reasoning model. OHS, facilities management and design experts were used to ascertain the design factors that contribute to the risk of falling from height during maintenance work. This knowledge was then structured in the form of 'argument trees,' which are described below. These trees were first developed in a paper-based exercise and refined in an iterative process until agreement as to their content and logic structure was agreed by the panel of experts. The second stage involved the conversion of this model of reasoning into a web-based decision support tool. The final stage evaluated the prototype model to determine its usefulness as a decision support tool (Lingard et al, 2006). Evaluation of the tool by construction designers in Australia is continuing.

Figure 1: R&D Project Stages



Knowledge acquisition

To build the decision support tool, expert knowledge relating to the risk of falling from heights during maintenance work on roofs needed to be captured and modelled. At the knowledge acquisition stage, the relevance and completeness of the information captured is extremely important. Whether or not a factor is included in the knowledge model and used in the process of inferring a solution must be based upon its relevance. Irrelevant factors should not be included. Although relevance is difficult to define formally, agreement about which factors are relevant to solving a particular problem is central to the creation of a shared understanding within a discursive community. Thus, the desired outcome of the knowledge acquisition stage was a shared understanding (among the panel of experts) of the factors that should be considered in the assessment of the risk of falling from height during roof maintenance. For example, the adequacy of protection for people who must maintain roof lights is a relevant factor in assessing risk when designing a structure containing roof lights. However, the colour of the roof light is not a factor in the risk assessment. Completeness of knowledge about factors contributing to risk was also very important because the omission of a relevant factor at this stage would result in a failure to consider the impact of this factor in the automated risk assessment.

For the purpose of identifying design features with the potential to impact upon the risk of falls from heights during maintenance on roofs, a number of secondary data sources were consulted, including OHS guidance material, industry standards and codes. Information gathered from these sources was used to develop an initial representation of the relevant knowledge. This representation was then reviewed by an expert panel at a workshop convened to comment on the knowledge representation. Various professions within the building industry (designers, building surveyors, OHS experts, constructors and facilities managers) made up the expert panel, providing a number of different perspectives.

To ensure all safety concerns relating to a risk assessment were addressed, the capturing of information was broken down into three main sections, in line with risk assessment methodology. Members of the expert panel were asked to consider the design issues with the potential to influence 1) the *likelihood* or probability of a fall happening*;* 2) the likely result of a fall should one occur, i.e. the *consequence;* and 3) how often maintenance workers would be exposed to the risk of falling from a roof, i.e. the *frequency of exposure.* The only restriction placed on the identification of issues to be included in the knowledge model was that they had to relate to decisions over which a design professional would have some influence, i.e. they had to be *design-related*. For example, issues relating to the training and expertise of maintenance workers were not included because this factor (though relevant to the risk of falling from heights during roof maintenance) is not something a designer can influence.

Further refinement of the knowledge representation was achieved following an iterative Delphi–type process, a structured process for collecting and distilling knowledge from a group of experts with controlled opinion feedback (Adler and Ziglio, 1996). This process did not require the expert panel members to physically come together because, subsequent to the initial knowledge acquisition workshop, the communication and dissemination of the knowledge representation was undertaken remotely. This process was well suited to the achievement of consensus as it avoids the negative effects of face-to-face group discussions and overcomes the problems of balance associated with group dynamics. All correspondence between the research team and the expert panel members took place via e-mail. The intention was to generate ideas and develop a mutually agreed representation of the knowledge base from which the level of design OHS risk is to be inferred. Information provided during this process was analysed, irrelevant information was filtered out and the knowledge model refined until consensus was reached.

Argument trees

The shortcomings of rule-based KBSs have already been discussed. In the current project, an alternative method of modelling knowledge was deployed. As an alternative to rules, knowledge was modelled in a series of logic diagrams called ‘argument trees.’ Argument trees represent a template for reasoning in complex situations. They provides a practical way of representing knowledge when the outcome being considered is subjective and interrelated to other issues that need to be considered simultaneously, such as design OHS.

This method of representing knowledge derives from the argumentation ideas advanced by Toulmin (1958). In attempting to demonstrate that scientific reasoning is more like a kind of jurisprudence than a deductive logic, Toulmin (1958) sought to identify procedures, by which any argument is advanced. In doing so, he identified an argument structure that is constant, regardless of the content of the argument. Building on this, Yearwood and Stranieri (2005) made use of ‘argument trees’ to graphically illustrate the hierarchical ordering of factors relevant in decision making process.

Argument trees consist of a number of ‘child’ ‘and ‘parent’ nodes ultimately feeding into a single ‘root’ node. Throughout an argument tree, a linguistic variable value on a ‘parent’ node is inferred from values on ‘children’ nodes, with the use of pre-determined inference procedures. An inference procedure is essentially a mapping of child variable values to parent variable values, ultimately representing a template for reasoning in complex situations. Thus, argument trees are intended to capture a shared understanding of relevant factors in the determination of a value.

In the ToolSHeD™ prototype, the risk rating is the ‘root’ node at the bottom of the tree. The linguistic variables “extreme”, “high”, “moderate” and “low” are used to denote the magnitude of risk at this root node. This risk rating is inferred with knowledge of three factors: the *likelihood* that an injury or illness will occur; the severity of the *consequence* of that injury or illness should it occur; and the *frequency* with which a person is *exposed* to the hazard. This inference is consistent with risk management theory, which holds that risk is a product of likelihood, consequence and frequency of exposure. In turn, each of the three child nodes of the risk rating (i.e. likelihood, consequence and exposure) is inferred from a series of child nodes representing the relevant factors agreed, by the panel of experts, to influence the magnitude of these variables. A sub-section of the ‘argument tree’ upon which the ToolSHeD™ prototype is based is presented in Figure 2. Note that the entire tree is too complex and cannot easily be shown.

Each node in the tree, regardless of it position, is assigned a set of linguistic values with a corresponding numerical value. The values relate to the design options available to a designer when deciding upon aspects of design relevant to the risk of falls during roof maintenance. A linguistic value (and its corresponding numerical value) on a parent node in the tree is inferred from values on the child nodes subordinate to it. This inference procedure continues through the tree (from left to right) until a linguistic variable value is inferred at the root node, i.e. the risk rating. In Figure 2 these inference procedures are denoted by the letters A,B,C,D,E and R. When all the argument trees are placed in a structured order the inference process replicates a risk assessment by calculating the likelihood, consequence and exposure, providing a risk rating of Extreme, High, Medium or Low based on the values entered by a designer at each of the child nodes.

Given the relatively high number of design issues identified as being relevant to the risk of falling from height during maintenance on roofs, the ‘argument trees’ were broken into sections, each of which constituted a component of the complete tree. Table 1 shows the groupings of design-related features believed to be relevant to the likelihood of a fall from height during maintenance work on roofs. One advantage of grouping relevant design factors in a series of smaller trees is that the information can be formatted and presented more readily. Another advantage was that structuring the knowledge in this way permitted the exclusion of certain design features that could be eliminated at the early stage of the risk assessment if they were not included in the design. For example, not all buildings are designed with skylights, therefore assessment of the risk presented by the inclusion of skylights was easily be omitted from a consultation by asking a designer to indicate whether skylights were to be included as a design feature at the commencement of the consultation.

Table 1: Groupings of child issues feeding into the 'Likelihood' parent node

Likelihood Argument Tree Grouping	***No. of relevant factors within tree***
Siting of Plant	8
Location on roof of Plant	17
External Conditions	18
Roof Access	10
Slips and Trips	13
Fall Arrester Systems	10
Skylights	15
Pitch of Roof	6
Roof Coverings	4

Development of ToolSHeD™

Stage Two of the project required the agreed knowledge representation (i.e. the argument tree) to be translated into a programme enabling an interactive automated risk assessment consultation to take place. The programme was developed such that a user will not be required to have in-depth knowledge of either OHS or risk management methodology. During a consultation the user is stepped through a series of simple questions. Only the child node statements from the argument trees appear to the user. The responses to these questions are used to generate values, which are then drawn upon to infer all other interconnected nodes in the knowledge base. Inferences are made from the left to the right hand side of the trees, back to the single root node, ultimately providing the user with a risk rating.

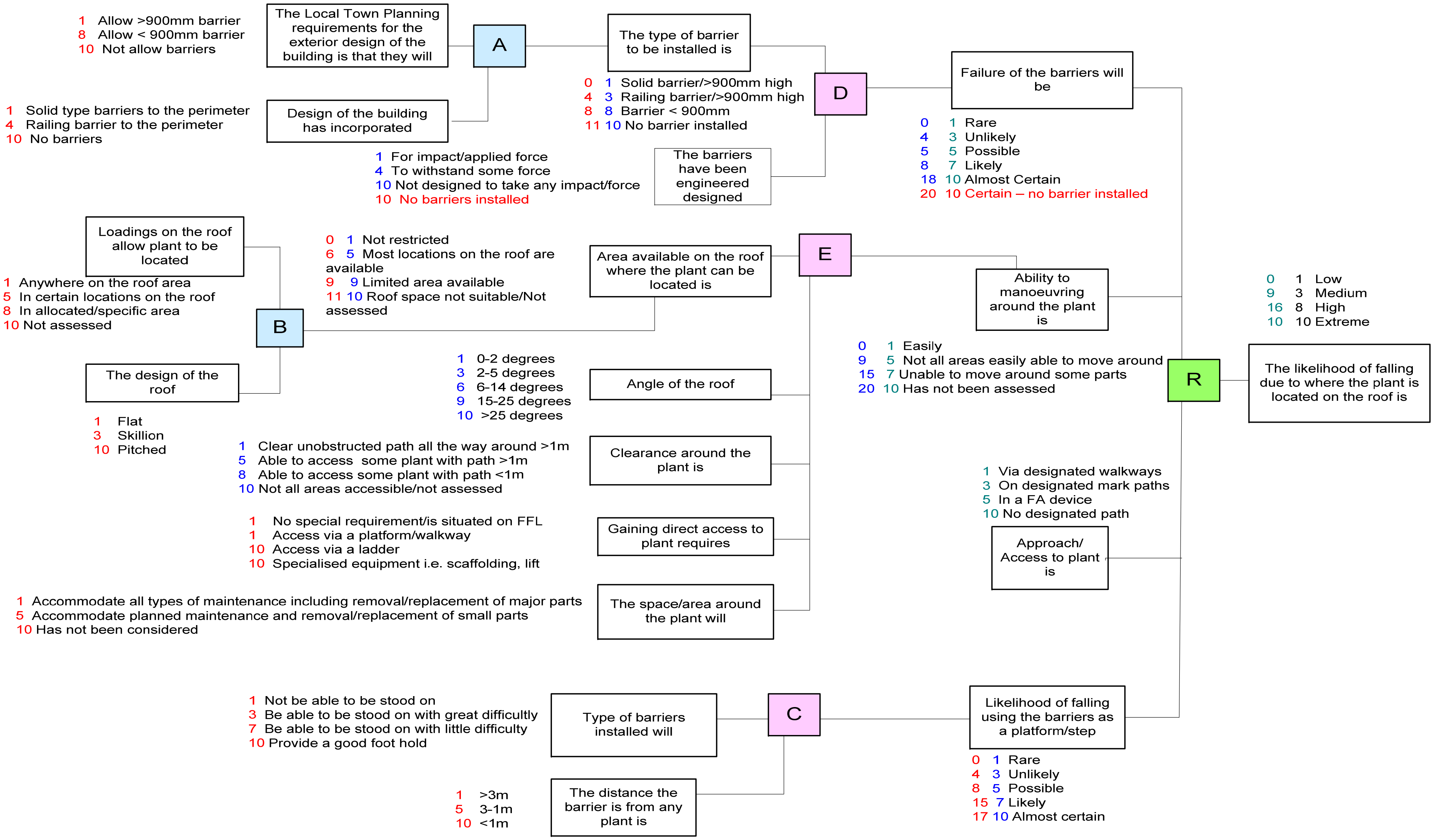


Figure 2: Example argument tree showing the inference procedure

ToolSHeD™ recognises that not all building designs will present the same hazards. To overcome this, the user is required to confirm certain design inclusions prior to undertaking a full risk assessment. For example if the proposed design was not to incorporate fall arrest equipment then the user could indicate this at the outset, excluding the evaluation of design issues relevant to fall arrest equipment from the risk assessment. However, hazards applicable to all designs, such as roof access, slips and trips etc, are hard-coded and the relevant prompts must be answered in orderto complete a full risk assessment for the design. This is to ensure that the designer is prompted to consider all of the relevant factors during each risk assessment.

Where a full risk assessment is not required, but the designer would like to assess certain aspects of a design, ToolSHeD™ allows for the user to select single design elements for review by using 'A Quick Hazard Assessment.' For example if a designer would like to review only the safety issues relating to the type of roof access, then the tool has the ability to review that single element, while cautioning the user that this quick assessment should be understood in the context of the whole design. Unlike a safety risk assessment, following which the user can determine whether the design presents itself as an acceptable risk or not, a Quick Hazard Assessment only provides the user with an indication of the influence that a selected hazard will have in determining the outcome of a full risk assessment.

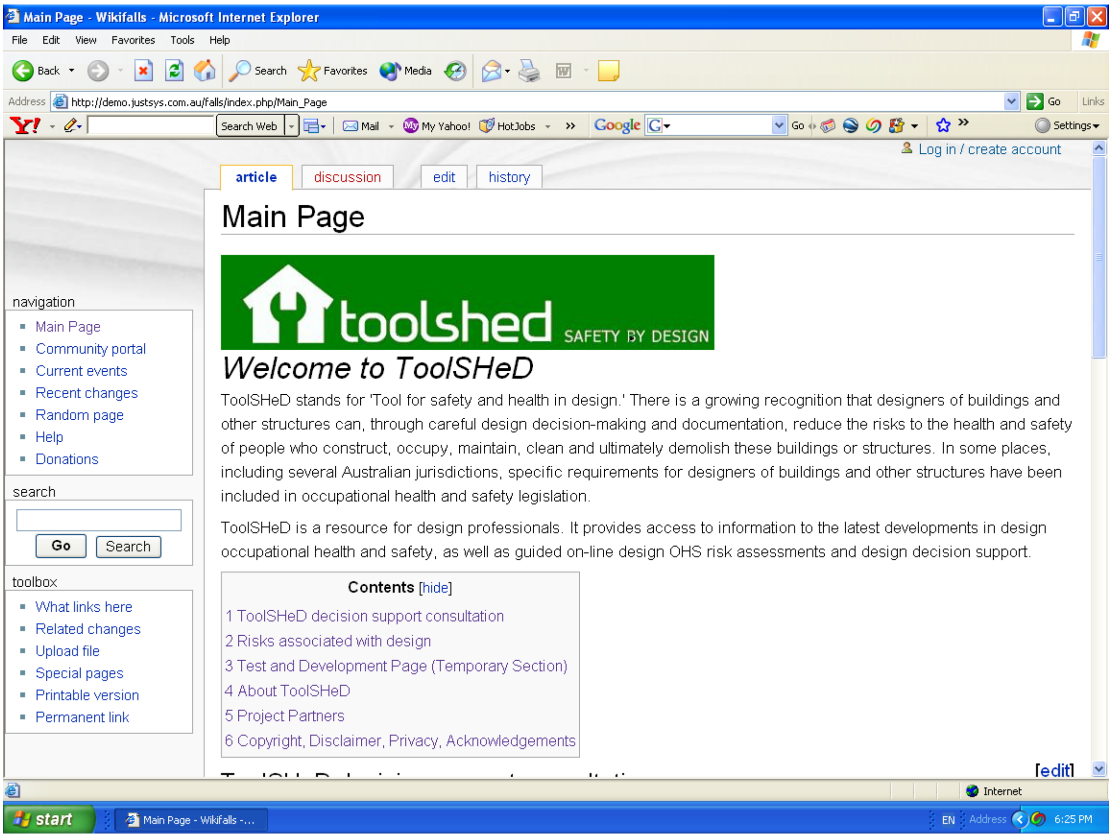
ToolSHeD™ outputs

At the completion of a full risk assessment ToolSHeD™ provides the user with a printable report which provides an overall risk rating and maps the decisions and comments made throughout the assessment. The report provides the user with enough information to make an informed decision about whether OHS risk has been reduced so far as reasonably practicable. If an overall risk rating is above the designer' pre-determined tolerance level, they are able to identify 'high risk' design design features that gave rise to this risk rating. These can then be reviewed and modified to reduce the level of risk and/or more robust protection systems (for example suitable safe walkways) can be included. Changes made can be recorded in the ToolSHeD™ prototype, permitting a designer to keep full records of their risk mitigation decisions and providing the ability document their decision- making process and communicate relevant information to clients, maintenance contractors and other relevant stakeholders as appropriate.

Web interface

An added feature of the ToolSHeD™ prototype risk assessment tool is the embedded a ‘wiki’ page (See Figure 3). A wiki utilises the same technology as the on-line encyclopaedia ‘Wikipedia.’ It is a web page, which looks like a normal internet web site. However, unlike an internet web site the wiki allows users to easily add, remove, or otherwise edit and change the content contained within. This ease of interaction and operation makes a wiki an effective tool for mass collaborative authoring, adopting an ‘open editing’ format. This means that users are free to create and edit pages within the wiki, thus promoting additions to the pages. It is anticipated that users will create and edit pages in the wiki encouraging democratic use of the pages and promoting content composition by users. Given the relative newness of the design OHS concept in Australia, this sharing of information is likely to be critical in sharing and disseminating OHS design knowledge among the construction design community.

Figure 3: Introductory Design OHS ‘Wiki’ page



Main Page

Welcome to ToolSHeD

ToolSHeD stands for 'Tool for safety and health in design.' There is a growing recognition that designers of buildings and other structures can, through careful design decision-making and documentation, reduce the risks to the health and safety of people who construct, occupy, maintain, clean and ultimately demolish these buildings or structures. In some places, including several Australian jurisdictions, specific requirements for designers of buildings and other structures have been included in occupational health and safety legislation.

ToolSHeD is a resource for design professionals. It provides access to information to the latest developments in design occupational health and safety, as well as guided on-line design OHS risk assessments and design decision support.

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The advantage of using wiki technology as a platform for the ToolSHeD™ decision support tool is that it has the ability to support the sharing of information relevant to design OHS. Like the risk assessment tool, very little training or computer programming expertise is required for users to modify the Wiki pages, enabling design professionals to share experiences, upload case studies and examples of how particular design OHS problems have been overcome.

The design OHS wiki contains information about design OHS and broader risk management information. It also contains links to other sources of design OHS guidance and the relevant sections of OHS statutes relevant to designers' responsibilities. At any point, the user can move from the wiki into a risk assessment consultation. Similarly, from the risk assessment consultation users can move back to the wiki page, enabling designers to explore the relevance of design OHS issues they are prompted to consider in the risk assessment. It is envisaged that the ToolSHeD™ site will provide a 'one-stop-shop' for designers who want to learn more about design OHS.

The evaluation

In order to validate the design OHS knowledge captured and represented in the argument trees that underpin the ToolSHeD™ prototype, a preliminary review has been undertaken. Three sample risk assessments were conducted, one on a proposed design, the other two on existing buildings which had plant located on the roof. The results of these assessments were compared with independent expert assessments of the risk of falling from the roof of these three buildings. The expert's risk ratings were consistent with the ratings inferred by the ToolSHeD™ prototype providing some evidence that the knowledge contained in the tool is valid. Further validation testing is occurring.

In addition, demonstration sessions have been held with potential user groups. Thus far, feedback from the design community has been positive. Members of the Royal Australian Institute of Architects (RAIA) and the Building Designers Association of Victoria (BDAV) have participated in introductory reviews of ToolSHeD™. In the future, the tool's usefulness as a training/education tool will also be formally evaluated.

Conclusion

The ToolSHeD™ decision support tool addresses an issue of emerging importance, i.e. the need to address OHS in construction design. The potential to reduce OHS risks during the design stage of buildings and other structures has gained considerable recognition among industry policy-makers and legislators. It is also a key issue for the future of professional practice in construction design (Lingard, Tombesi, Blismas & Gardiner, 2007). However, the problem of design OHS in construction is significant, with the majority of design professionals unsure as to how to incorporate OHS considerations into their design decision-making and concerned that doing so may expose them to greater legal risk. The development of ToolSHeD™ is therefore timely, offering easy-to-access expert OHS information and decision support in an area in which learning from one's mistakes is undesirable.

The innovative method of modelling design OHS knowledge deployed in ToolSHeD™ also overcomes problems inherent in rule-based alternatives. This makes the system more adaptable and efficient. Argument trees are also an improved method for modelling OHS, risk management and regulatory compliance knowledge because they can accommodate situations of complexity, uncertainty and 'open texture'. As such, ToolSHeD™ is likely to be more viable than cumbersome rule-based systems.

However, at present the ToolSHeD™ application is limited in that it deals only with the design-related risks of falls from heights during maintenance work on building roofs. Now that the argument tree method of modelling design OHS risk information has been tested and proven, further funding is being sought to expand ToolSHeD™ to include other areas of OHS risk (for example manual handling, ergonomics, noise and hazardous substances) and to cover all stages of a facility's life cycle (i.e. construction, occupation, maintenance, refurbishment and ultimately demolition).

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