Safe Design with Precast

Centre for Construction Work Health and Safety Research

School of Property Construction & Project Management

www.rmit.edu.au

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Program

Centre
- Overview of the Centre
- Research areas
- Outputs

Design
- Does considering safety early make any difference?
- Demonstrating the link

How?
- How can we consider H&S earlier?
- Some ideas…

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Concrete house research

Funding & Partners

Loughborough University

Lend Lease

Australian Government
Australian Research Council

ACEA
The Association of Consulting Engineers Australia

VirginiaTech
NIOSH

VicHealth

An Australian Government Initiative
AusIndustry

ENERGY Pipelines CRC

ENGINEERS AUSTRALIA

Port of Melbourne Corporation

CRC Construction Innovation
BUILDING OUR FUTURE

METRO

Australian Government
Department of Communications, Information Technology and the Arts

Queensland Government

PROPERTY COUNCIL of Australia

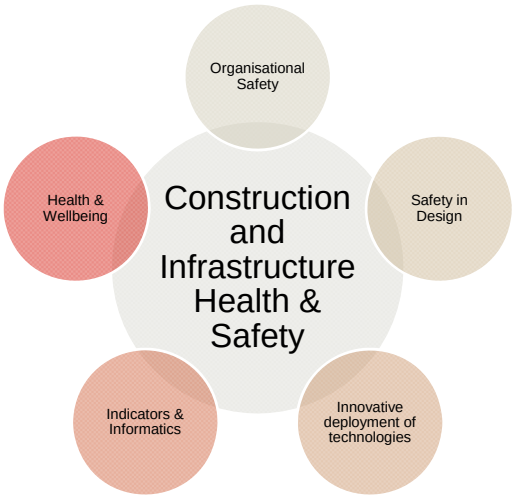
Australian Institute of Architects

CodeSafe Solutions

AUSTRALIAN CONSTRUCTORS ASSOCIATION

Hyder

Centre research areas



Centre research expertise

Themes	Expertise
Workforce health and wellbeing	• Work-Life Balance • Workplace stress • Workforce health and lifestyle factors • Aids/HIV – corporate strategies, stigma
Organisational safety	• Client safety leadership • Organisation of work • Structure of work/procurement strategies
Design for safety	• Process design - construction safety • Operational safety/asset management/risk • Design process mapping and analysis • Knowledge transfer • Risk perception
Innovative deployment of technologies	• Assistive, adaptive and rehabilitative work wear • Experiential digital engagement • Remote sensing technology
Indicators and Informatics	• Safety 'lead-lag' indicators • Big Data analytics

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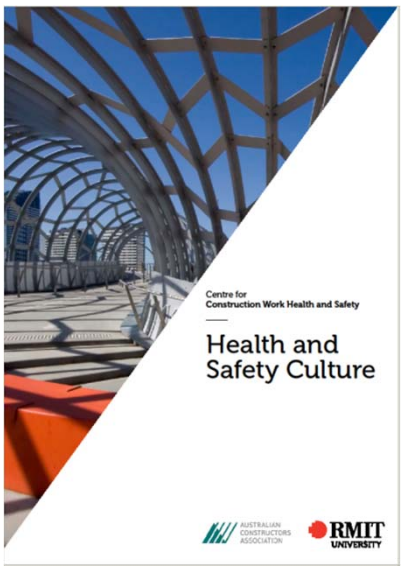
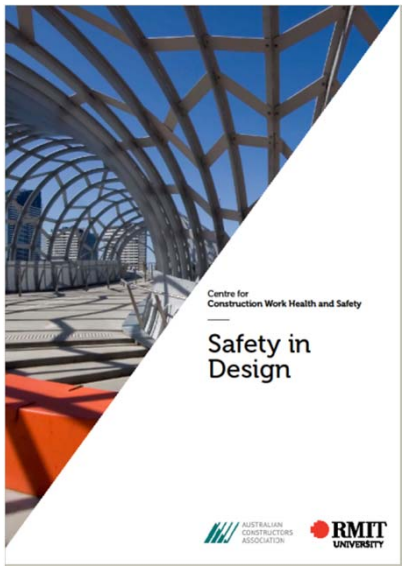
RESEARCH-TO-PRACTICE

Research-to-Practice

toolshed SAFETY BY DESIGN

Australian Constructors Association Reports





Does considering safety early make a difference?

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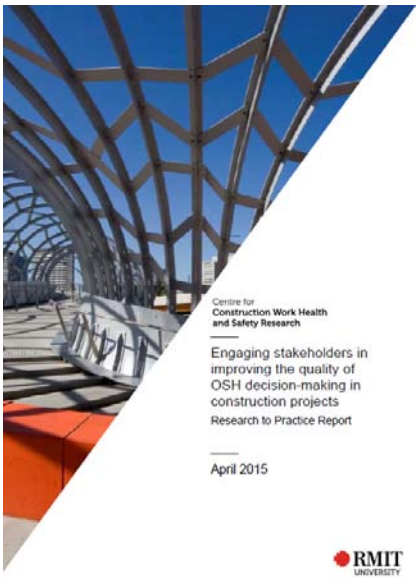
Research to Practice Reports



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www.rmit.edu.au and search ***cwhsr***

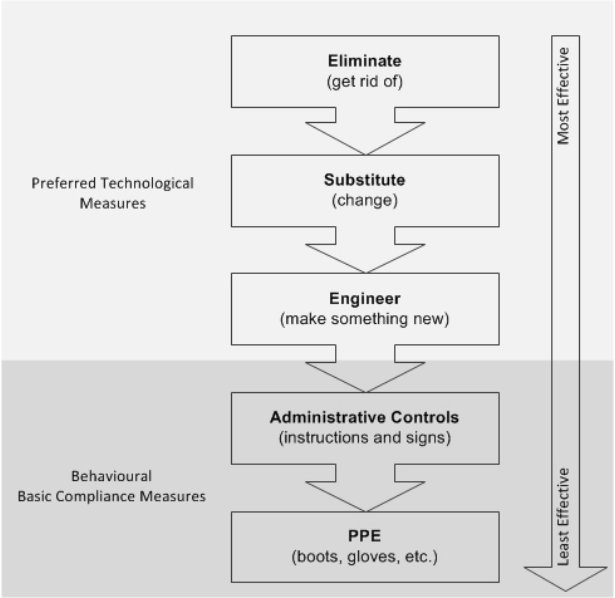
NIOSH/Virginia Tech./RMIT international benchmarking study of construction H&S

- Five year research project to:
  - investigate the extent to which health and safety considerations are integrated into project decision-making in US and Australia
  - compare the health and safety performance and practices in US and Australian construction projects
  - identify opportunities for both countries to learn and improve health and safety performance.

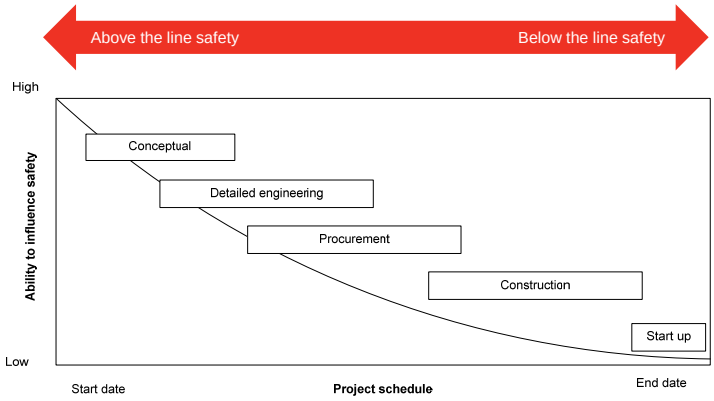
Safety in design

- Safety in design (SiD) is a key component of Australian occupational health and safety legislation.
- Should enable "above the line safety," yet:
  - there remain significant gaps between policy and practice
  - design decisions are made without input from people who do the work
  - detailed knowledge of construction processes and inherent H&S risks resides with specialist sub-contractors who are not engaged when important decisions are being made (even in D&C projects)
- International research:
  - designers "do not fully understand what good practice looks like" (Brace et al. 2009)
  - many design modifications represent fairly modest solutions to construction H&S risks (Atkinson & Westall, 2010)

“Above the line” safety



Testing the time-safety influence curve



Adapted from Szymberski (1997)

What did we try to show?

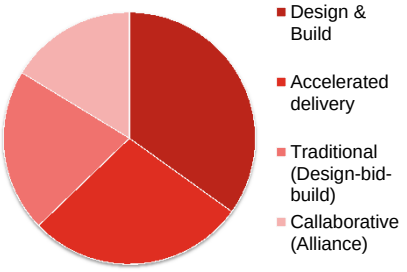
- To examine the relationship between consideration of health and safety (pre-construction) stages of projects and the **quality** of health and safety solutions realised
- Propositions:
  - better H&S solutions (i.e, above the line safety) will be realised when construction workers' H&S are considered early in project decision-making, and/or
  - better H&S solutions (i.e, above the line safety) will be realised when construction process knowledge is integrated into early project decision-making
- ***Does earlier consideration of H&S produce better outcomes?***

US and Australian case studies

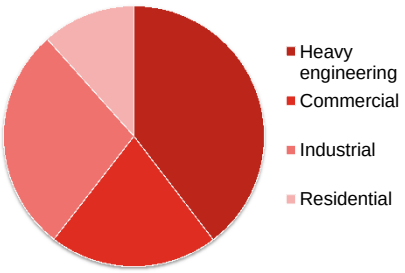
- Detailed data collected from 23 construction projects (10 in Australia and 13 in US)
- The total number of features of work in the analysis was 43
- The number of features of work from each project ranged between 1 and 4 (the average was 1.9)
- 288 interviews were conducted (185 in Australia and 103 in the USA)
- Research "mapped" pre-construction decision-making and looked at the impact of decisions on H&S solutions realised in the construction stage

The sample

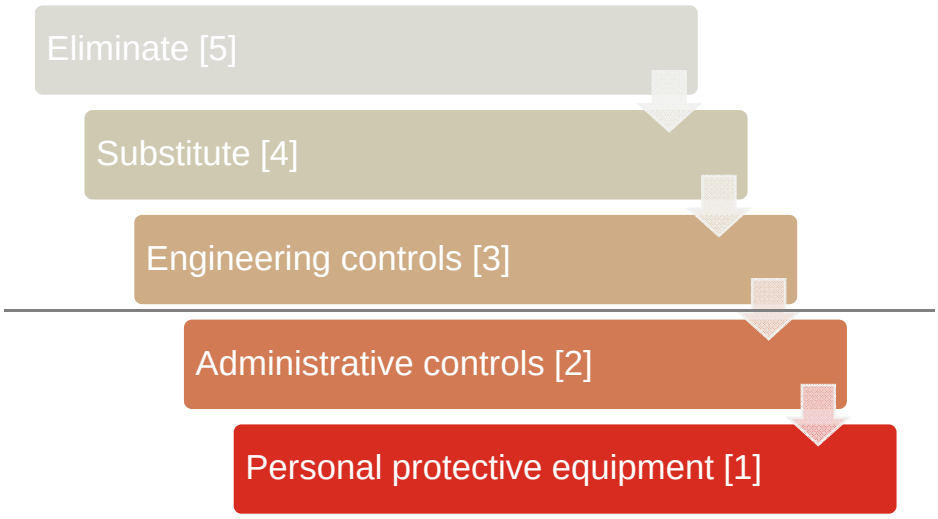
Delivery Methods



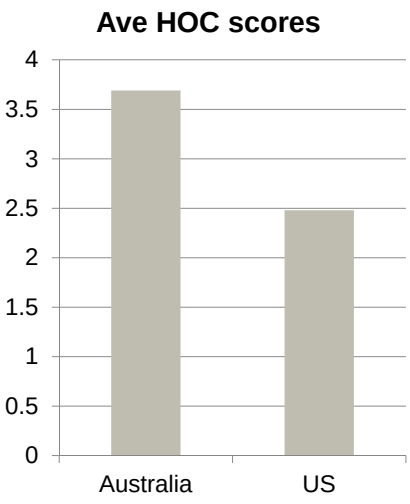
Industry Sectors



Quality of H&S outcome

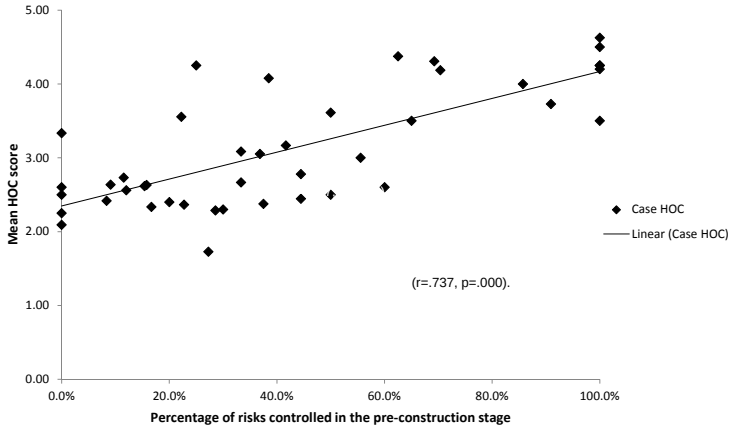


Findings

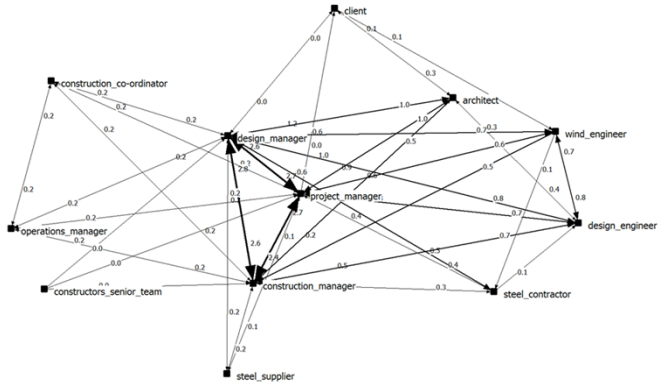


- Commercial and residential sector had lower mean HOC scores than those drawn from the engineering and industrial sectors.
  - (not statistically significant)
- Collaborative or design and build projects had slightly higher HOC scores than those drawn from accelerated (fast track) or design-bid-build projects
  - (not statistically significant)

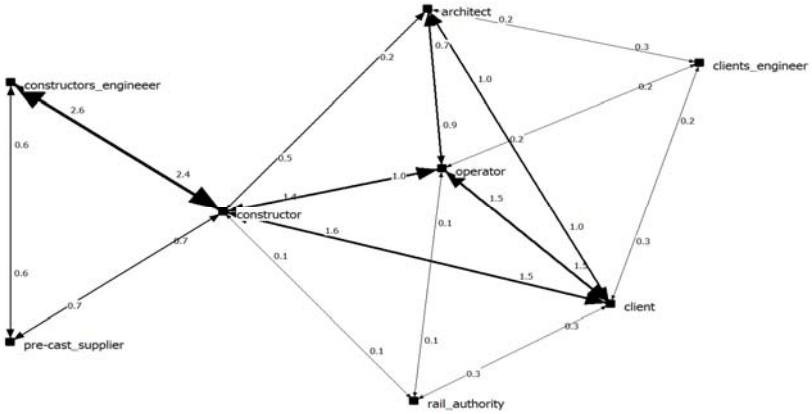
Timing of risk control decisions and quality of risk control (US and Australian data)



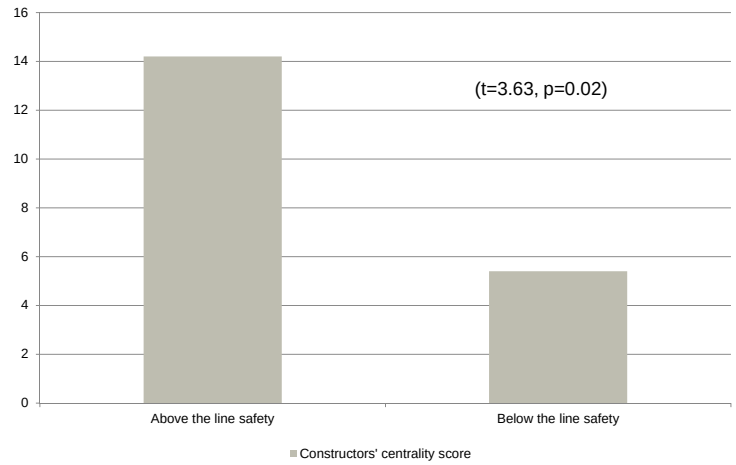
Case example 1: Re-design of high rise façade system



Case example 2: Footbridge support system



Above the line or below the line safety?



Conclusions

- The research supports the time-safety influence curve
  - cases in which the constructor had input into decision-making at the early project stages were more likely to realise “above the line” safety outcomes.
    - i.e, hazards were eliminated or engineered out of construction activities
  - cases in which construction workers’ health and safety were considered early in the life-cycle were more likely to realise “above the line” safety outcomes.
- The research also shows how the hierarchy of risk control can be used to measure and benchmark health and safety effectiveness in construction projects.
  - How well do projects achieve “above the line” safety?

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RESEARCH-TO-PRACTICE

Tools

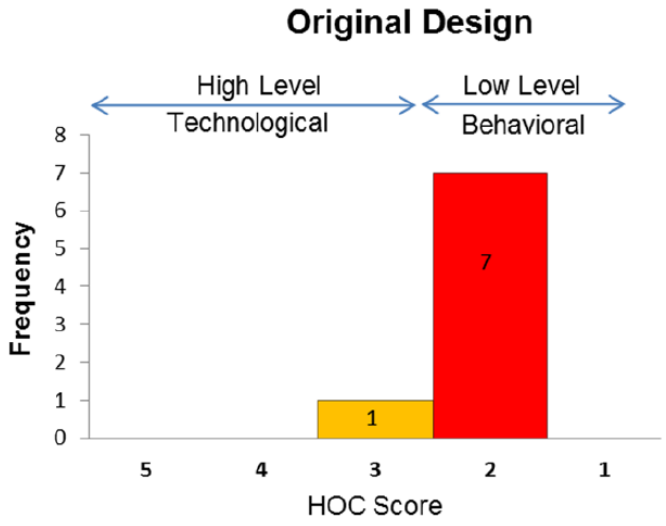
1. Hierarchy of Controls Evaluation Tool
2. Image-based tool for encouraging OSH risk communication
   - "Do you see what I see?"

Tool 1 – Hierarchy of Controls Evaluation Tool (Façade system)

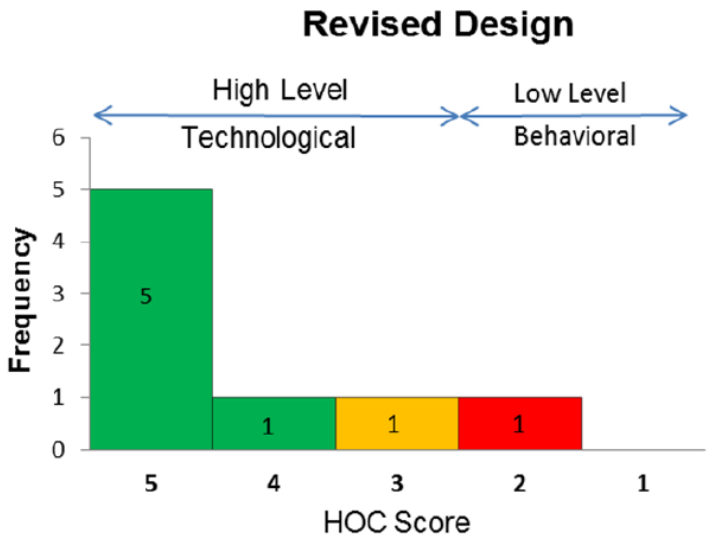
Table 4.2: Assessing the quality of risk controls for construction of a high rise building façade system

Activity	Work Task	Safety Challenge	Response to Safety Challenge	HOC Level	HOC Score	HOC Average
Material handling and construction activities for the WRAP façade	Installation of horizontal frame elements for the façade structure	Overexertion in holding, carrying, or wielding Struck, caught, or crushed in collapsing structure, equipment, or material	Using light-weight material to build frame elements	Substitution	4	4.07
Installation of frame elements for the WRAP structure (façade)	Connecting the frame elements back to the slab	Overexertion bending, crawling, reaching, twisting, climbing, stepping	Using rolled steel in place of GRC and reducing the number of connections required	Substitution	4	
Building WRAP frame elements	Building façade frame elements from rolled steel folded into rectangular shape	Contact with objects and equipment Overexertion in holding, carrying, or wielding	Off-site manufacturing	Elimination	5	
Installation of steel elements	Lifting large sections to position using crane	Struck by object or equipment	Training, safe work method statement, work sequence	Administrative	2	
Installation of façade frame	Positioning and connecting frame elements to each other and to the slab	Falls to lower level	Installing the façade elements floor by floor, accessing the work area from finished floors	Elimination	5	
Installation of façade frame	Installation of façade frame elements at each floor without permanent exterior walls	Falls to lower level	Protection by safety screens	Engineering Control	3	
Installation of façade frame elements	Connecting the intersecting elements together	Overexertion bending, crawling, reaching, twisting, climbing, stepping	Fabricating the intersecting sections as a single section off site to reduce the number of connections	Substitution	4	
Fixing façade frame to the slab	Connecting the frame back to the slab to fix the façade	Contact with objects and equipment	Cast ferrules into the precast slab to eliminate the need for drilling into the concrete	Elimination	5	
Beam connections	Connecting the beams to the intersecting sections using connection arms	Overexertion bending, crawling, reaching, twisting, climbing, stepping	Attaching connection arms to the beams in factory to eliminate the need to weld or bolt the connection arms on site	Elimination	5	

Tool 1 – Hierarchy of Controls Evaluation Tool (Façade system)



Tool 1 – Hierarchy of Controls Evaluation Tool (Façade system)



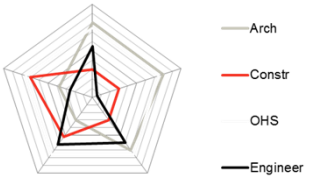
Tool 2 – "Do you see what I see?"

Safest	Safer	Safe	Unsafe	Least safe
				
				
				

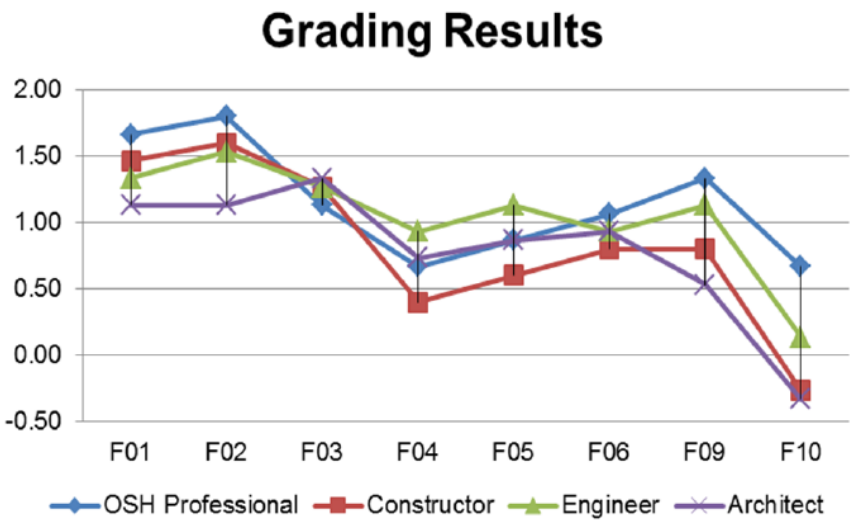
Tool 2 – “Do you see what I see?”




Architect | Constructor | Engineers | OHS Professional



Tool 2 – “Do you see what I see?”



How can we consider health and safety earlier?

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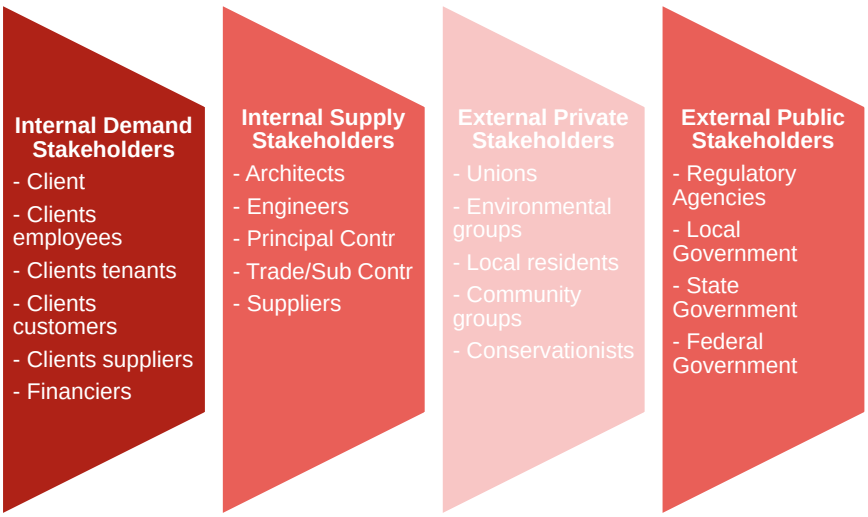
THE CHALLENGES

The Challenges

- Implementation issues for 'Safety in Design'
  - Capability
  - Supply chain fragmentation
  - Project complexity
  - Dynamic nature of design
  - Defining and differentiating design

Project Stakeholders



(adapted from Winch, 2010)

Dynamic nature of design

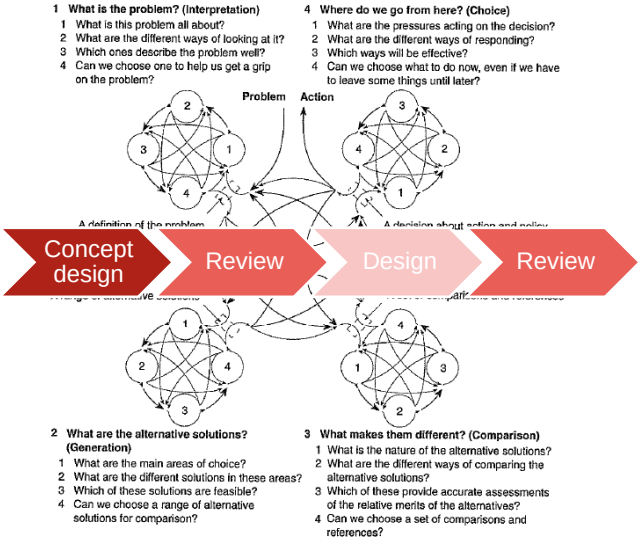


Fig. 5. The continuous whirling process of design thinking.

Gray & Hughes (2001)

Product or Process Design?

Product design

- Safety in use of the product
- Safety in maintaining the product
- Safety in the structural/operational integrity of the product
- Traditional designers more comfortable with product design

Process design

- Safety in the manufacture, transport, installation and commissioning of the product
- Constructors (traditional controllers of risk) can control 'any' risk!
- **Requires 'construction process knowledge'**

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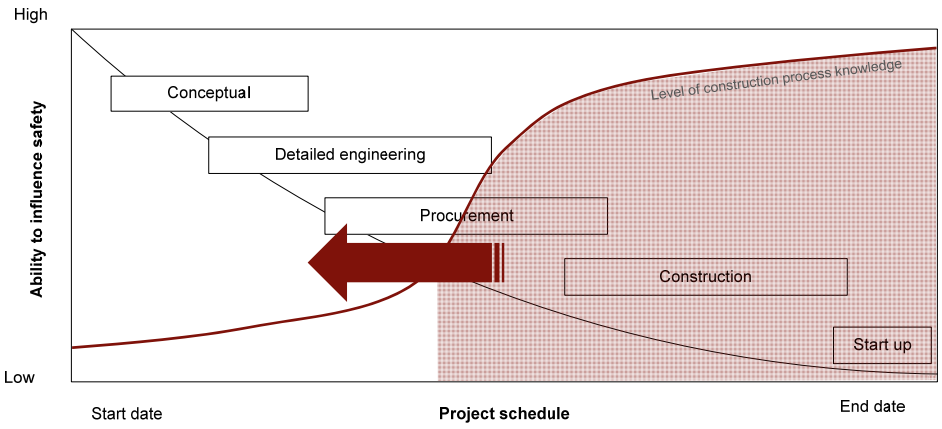
ADOPTING A KNOWLEDGE-BASED APPROACH

Time-process knowledge influence curve

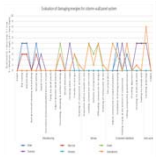


Adapted from Szymberski (1997)

Safe design tools using knowledge-based approaches

Decision trees [Product]

Risk profiling [Process]



Visual Information [Product & Process]

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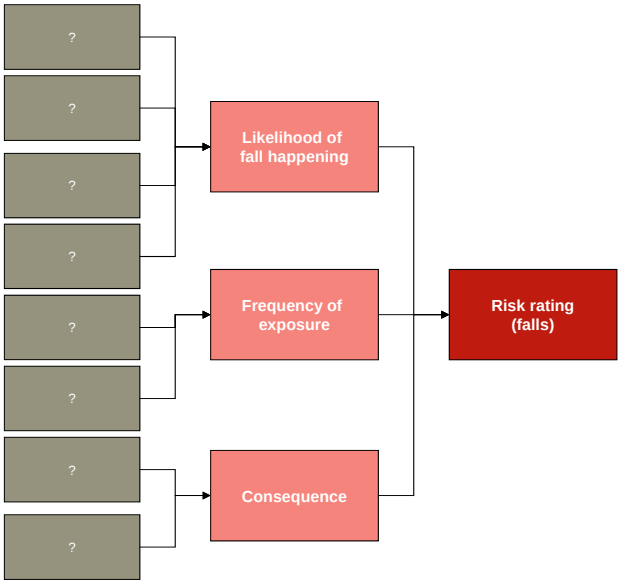
DECISION TREES

Argument trees – template for reasoning in complex situations



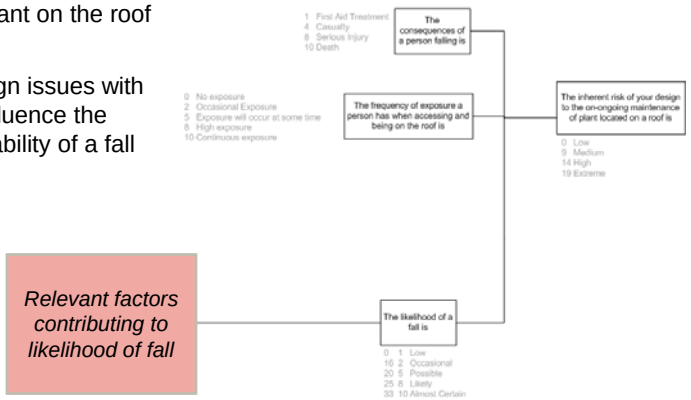
Knowledge acquisition

- Ascertain design factors contributing to fall
- Panel and secondary data
  - OHS expert
  - Facilities Manager
  - Architect
  - Structural engineer
  - Constructor
  - Building Surveyor
- Consensus
  - Factors
  - Relevance
  - Relationships
  - Degree of influence

Knowledge acquisition

Identifying relevant factors

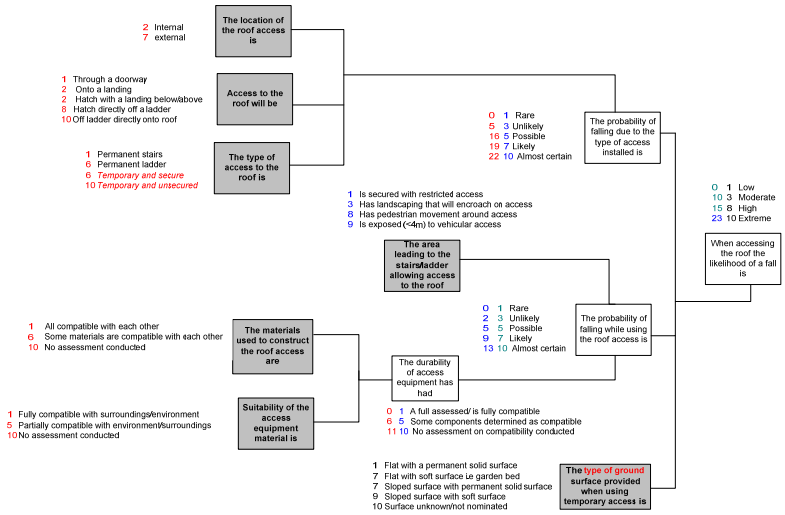
- Identify design features with the potential to impact upon the risk of falls from heights during maintenance of plant on the roof of a building
- Consider the design issues with the potential to influence the likelihood or probability of a fall happening



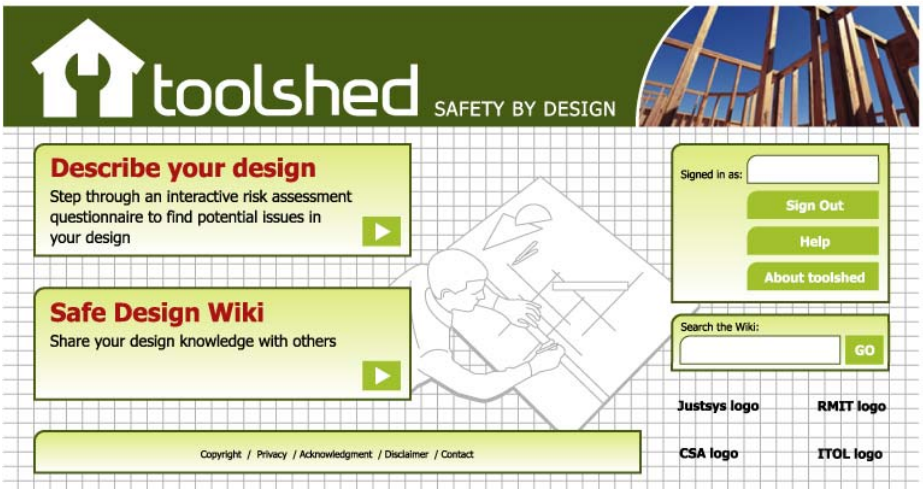
Knowledge acquisition

Likelihood argument trees groupings	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 arrest systems	10
Skylights	15
Pitch of roof	6
Roof coverings	4
	101

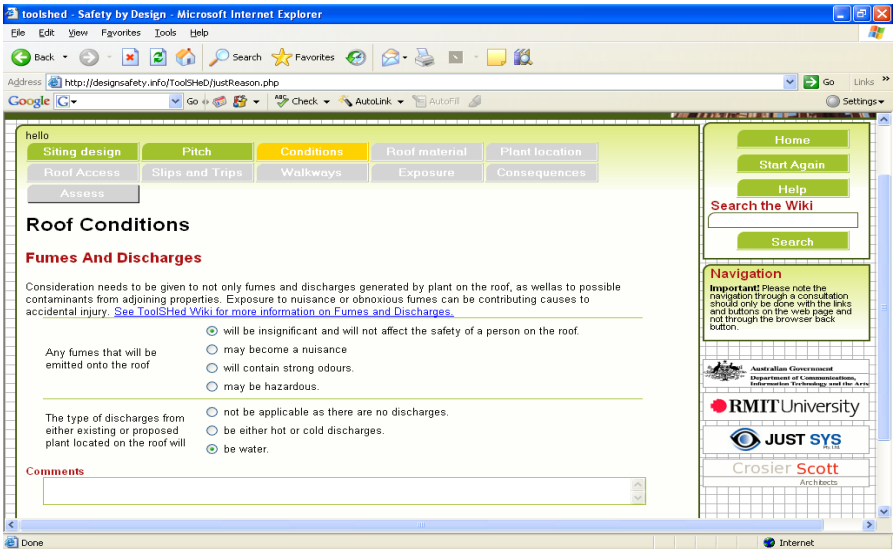
Argument tree



Prototype Decision Support Tool



Prototype Decision Support Tool



Outcome

- Possible uses of Knowledge models using decision trees
  - Consultation tool – practical on-line decision support
  - Educational tool
    - Evidence of intrinsic learning of both technical content and process (OHS risk management)
    - Steeper learning curves
    - Bridging the knowledge gap between novice decision-makers and experts
  - Corporate knowledge management tool to capture expertise
- Challenges
  - Creating trees become very complex
  - Weightings system difficult to check and maintain
  - Does it work?

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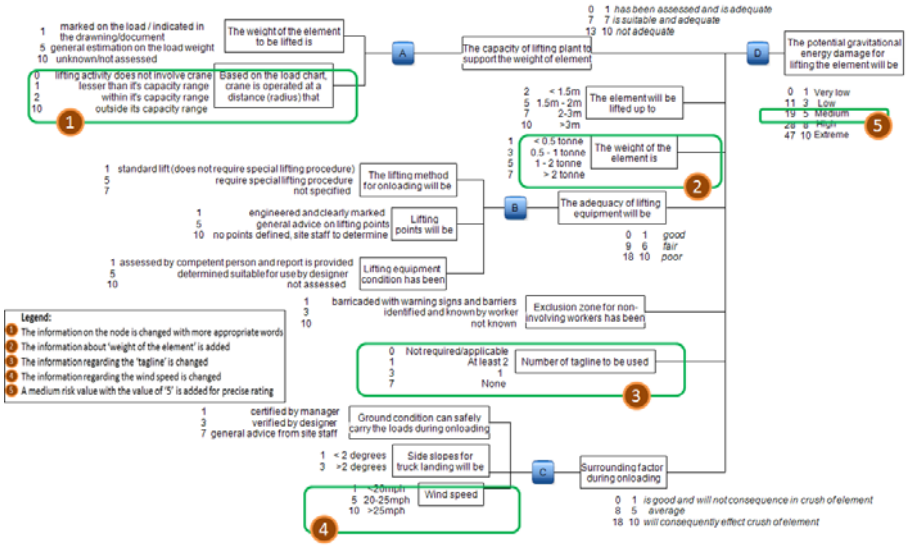
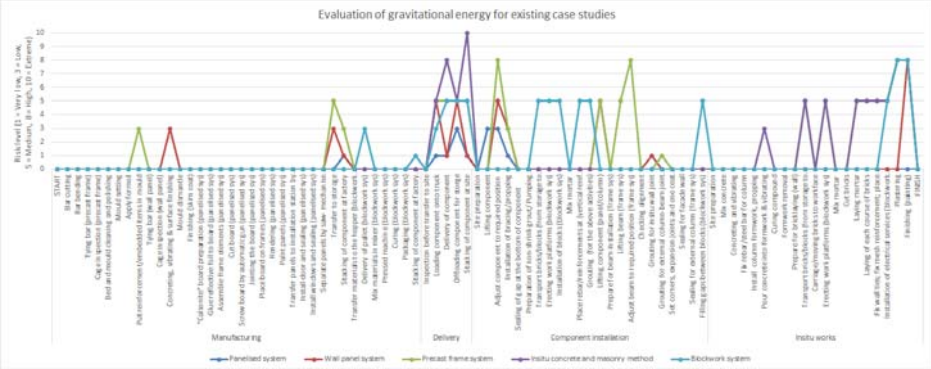
RISK PROFILING

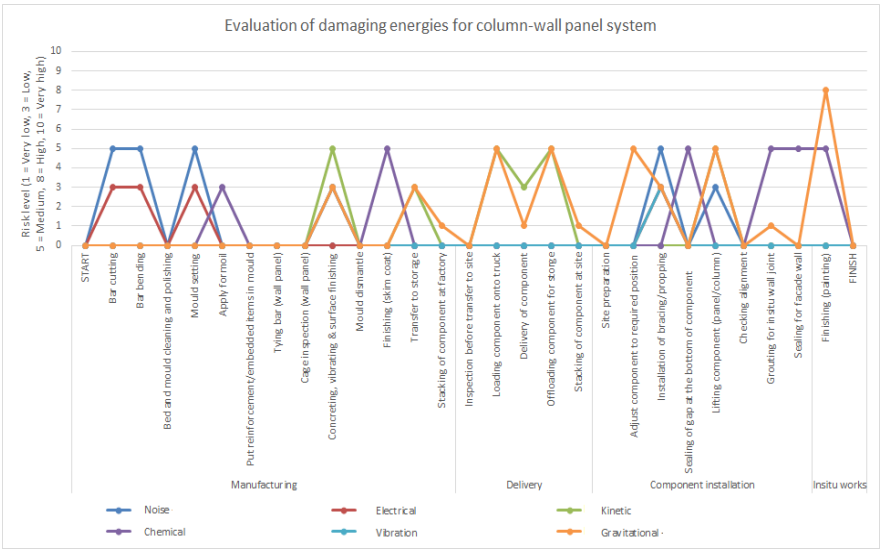
Is precast safer?



Is precast safer?



Is precast safer?



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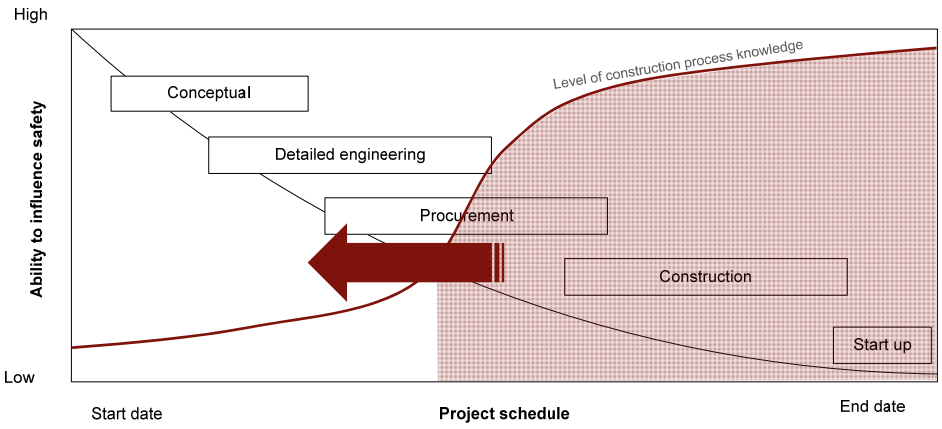
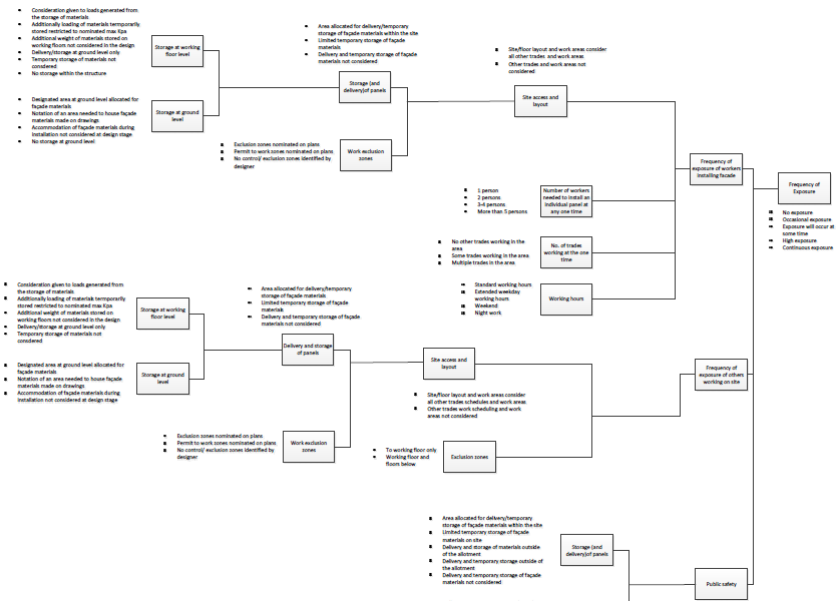
VISUAL KNOWLEDGE

Time-process knowledge influence curve

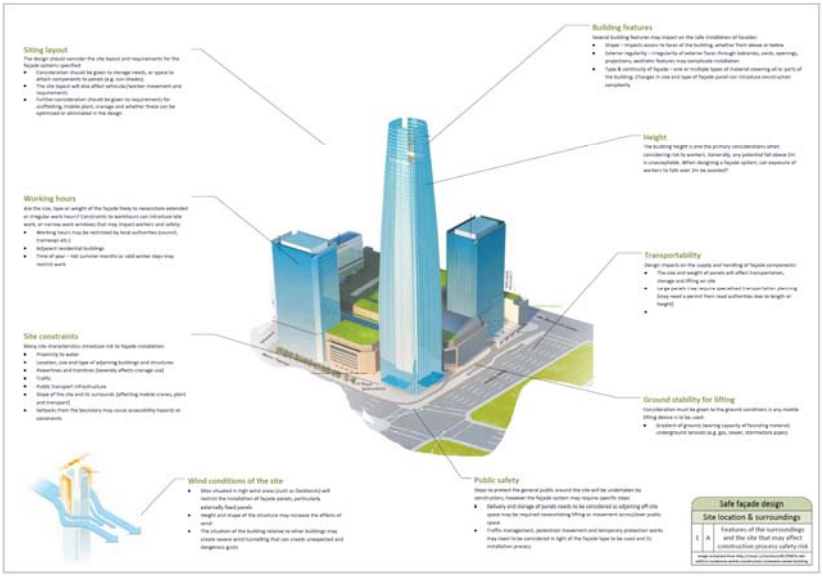


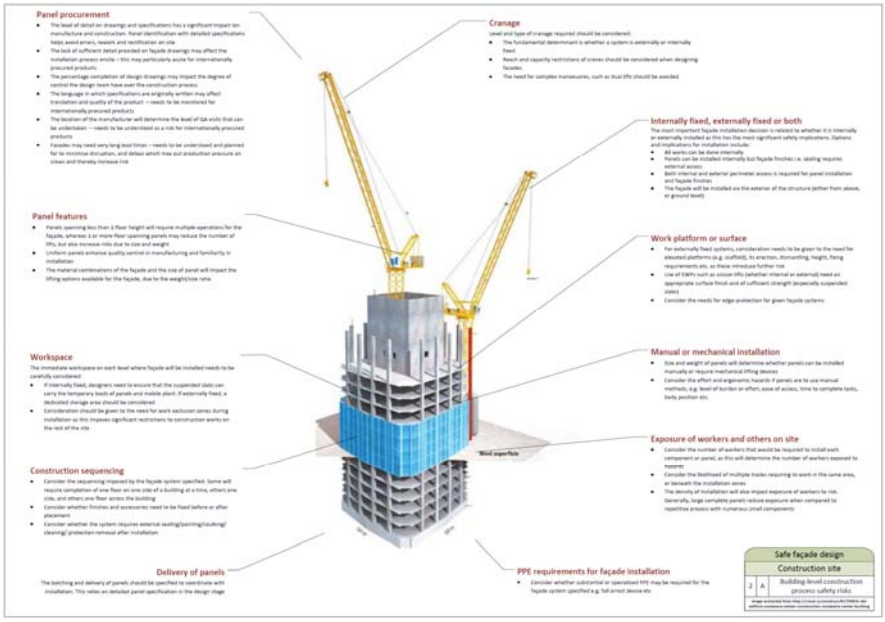
Adapted from Szymberski (1997)

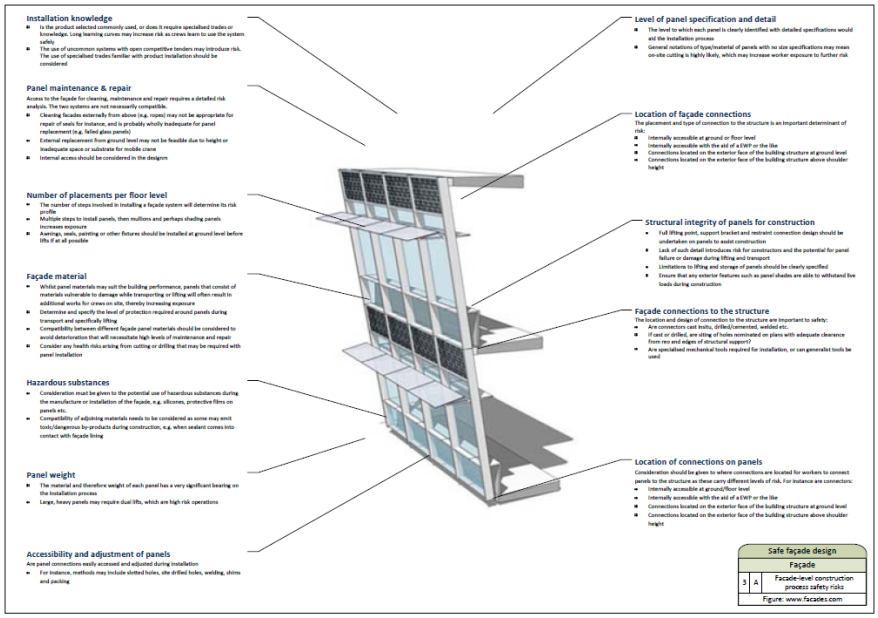
Process knowledge trees for façade construction



Infographics







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