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
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DESIGNING FOR HEALTH AND SAFETY IN CLADDING INSTALLATION - IMPLICATIONS FROM PRE-ASSEMBLY

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ABSTRACT

Europe has legislation that requires designers to take action to remove or reduce health and safety risks for construction workers. However, even without this legislation, it can be argued that there is a moral duty on designers to address these issues. Experience in Europe has not been completely satisfactory with surveys showing that many designers are not complying with the requirements to design for health and safety. Nevertheless, there are pockets of excellence.

This paper presents data and draws cladding case study exemplars from a number of Loughborough APaChE¹ projects including: D4h (Designing for Health), HASPREST² (Health and safety benefits and implications from pre-assembly) and Better, Safer, Easier Design via CDM (Greenstreet Berman – Wright et al, 2003). The paper argues that accidents and ill-health triggers can be reduced by designer action and explains cladding designers can take appropriate action to reduce the risks during installation, providing two exemplar case studies. Neither exemplar are particularly innovative in themselves, however, design decisions were made and health and safety risks were reduced in both cases.

CAN ACCIDENTS AND ILL-HEALTH TRIGGERS BE REDUCED BY DESIGNER ACTION?

The European Temporary and Mobile Construction Sites (TMCS 92/57/EEC) Directive has stimulated a change in design culture in many European states with designers being expected to explicitly acknowledge health and safety in their designs and seek to reduce or remove risk to construction workers. In the UK, the Directive has led to the Construction (Design and Management) Regulations (CDM). Research in the UK has supported this emphasis on design concluding that almost half of the 100 accidents studied in a recent Loughborough project for the Health and Safety Executive (HSE) could have been prevented by the permanent works designers (Haslam et al, 2003). This number is increased if the effect of action by temporary works and equipment designers is taken into account. Countries that have developed legislation on designers duties (mainly in Europe) have, understandably, been more active in this area. Nevertheless, the topic has been raised elsewhere, for example through the US Construction Industry Institute work (Hinze & Gambatese, 1996).

¹ APaChE is a partnership for construction health and safety between the Departments of Civil & Building Engineering and Human Sciences at Loughborough University, working in collaboration with industry and government to address health and safety challenges in the construction sector.

² The HASPREST and D4h CDs are available from the European Construction Institute – contact via www.apache4change.com

The Life-Cycle Safety (LCS) initiative in Oregon has also demonstrated that effective design intervention is feasible and beneficial, even where the legislation does not require it and custom, practice and even some legal opinion is against it (Gibbons et al, 2003). Australia has also been seeking to address these issues with the CHAIR initiative (Construction Hazard Assessment and Implication Review developed by NOHSC (National Occupational Health & Safety Commission) and NSW Government, Australia. CHAIR provides a series of keywords as prompts for multi-disciplinary design-review workshops both at the concept and design phases.

The argument is that the earlier in the design phase that action is taken to eliminate or reduce construction risk, the greater the benefit and the higher the chance of the benefit being realized (Figure 1 - Gambatese, 2003). A recent Health and Safety Commission paper (Smith 2003) has had to make the point that ‘hazards are introduced at the earliest stages in a project’s life through the processes of procurement and design. Hazards can often be eliminated and risks reduced through the design process, especially during the *first steps*’. It is also argued that such action, taken early in the design phase, will have less (if any) detrimental effect on the out-turn cost of the project.

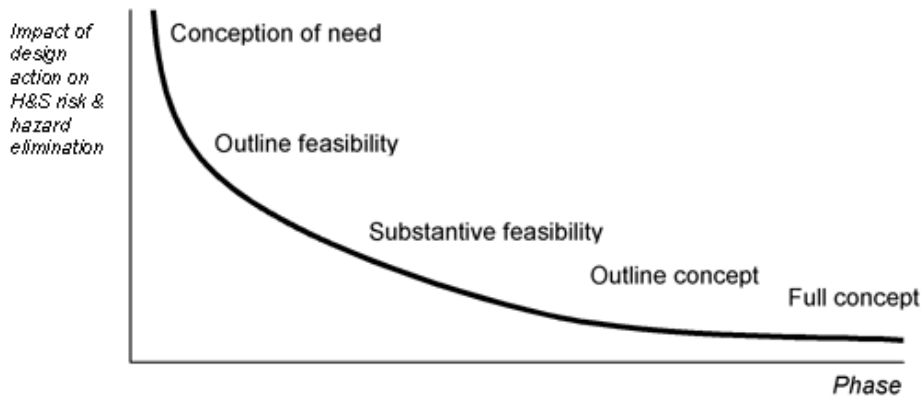


Figure 1 Impact of design action on health and safety risk and hazard elimination
Adapted from Gambatese (2003)

However, almost all the concentration so far has been on safety, to the exclusion of occupational health, except for issues surrounding hazardous substances. The case for more emphasis on Occupational Health has been made elsewhere (eg Smallwood et al 2000; Gibb et al 1999 & 2002). More recently the emphasis, at least within the UK, has been increasing with a series of high profile awareness campaigns. In UK construction, between 2001 and 2002, 79 people died and there were 3959 serious accidents. However, in addition to this a staggering 137 000 people in UK construction suffered from an illness they believed was caused or made worse by their jobs (Bray 2003) and this illustrates the extent of the occupational health challenge for construction.

D⁴h has confirmed the paucity of good design practice (Horne et al 2003). A D⁴h designer survey found that CDM had brought about little or no change to design practices. This lack of impact is emphasized by a recent survey by the UK’s Health and Safety Executive (Anon 2003) where they found that only a third of designers had sufficient knowledge of their duties under the Regulations (TMCS Directive – CDM in the UK). Furthermore, only 8% had received any training on the Regulations. When this sad state of affairs is combined with the poor regard for health compared to safety, the situation is desperate. The importance of designing-out risk still has to be emphasized, despite the Regulations being almost ten years old.

These facts have created a real challenge for the D⁴h team and their published response to the question: ‘What are designers doing for construction workers’ health?’ was ‘Not a lot!’ (Anon 2002). The challenge has been to produce practical guidance incorporating best practice exemplars when there have been so very few. What has been found however is that the supply-chain as a whole has been innovating to reduce both health and safety risk. Furthermore, they have been doing this in the ‘design stage’ in it’s fullest sense, in other words ‘prior to’ the construction work commencing. However, these initiatives have rarely been driven by the client’s design team and may even have been employed without their knowledge. There is still the culture in many organizations in Europe, despite the TMCS Directive, to say ‘Let’s leave that up to the contractor’. Notwithstanding the above, the supply chain has identified and developed a number of solutions that reduce occupational health and safety risk of construction workers and this paper presents some of these, concentrating on cladding operations.

The HASPREST project has demonstrated that one of the first considerations for designers should be: ‘Can we take work away from the site, into a factory where the risks can be controlled better?’. Simplistically, the manufacturing sector is between 4 and 6 times safer than construction (UK statistics on fatal and major accidents). Furthermore, although these statistics are heavily influenced by the large ‘non-construction’ manufacturing sector, there is still evidence that manufacturing for construction is still safer for a number of reasons, including:

- Risks are less as they are easier to control
- Training is easier to achieve
- There is less trade overlap
- There is a much lower workforce turnover
- People ‘look out’ for one another
- The adverse weather factor is removed (Gibb, 2003)

The main thing that happens to on-site risks by using pre-assembly is that the many, common-place, high-likelihood, low consequence risks are largely replaced by fewer, higher potential consequence risks, which are much less likely to occur as they tend to be easier to identify and control.

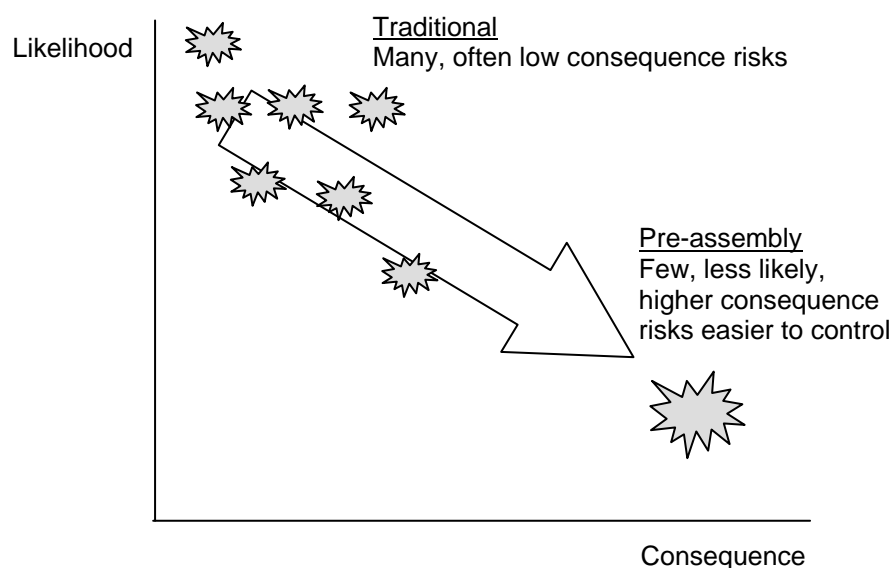


Figure 2 What happens to risk through increased use of pre-assembly (Gibb, 2003)

HOW CAN CLADDING DESIGNERS TAKE APPROPRIATE ACTION TO REDUCE THE RISKS DURING INSTALLATION? - CASE STUDIES

PRE-GLAZED WINDOWS IN PRECAST CONCRETE CLADDING PANELS

Windows are usually installed as building work proceeds and must be protected from damage. However, windows with factory-applied finishes are best installed into previously prepared openings. Once the window frames have been installed they are then always site glazed (McEvoy, 1994). Traditionally precast concrete cladding panels are installed on site first and then the windows are installed, usually from a standing scaffold or from mast climbers or scissor lifts, but this still involves working at height.

This exemplar comes from Whicheloe Macfarlane's St Margaret's hospital, Swindon, UK. This was an integrated team project as part of the UK's Private Finance Initiative (PFI). The precast panels were manufactured by Trent in the usual way. In normal practice the windows are installed on site after the precast panels are in place. However, in this project the windows were installed, by Broderick, in the panels at ground level at Trent's precast manufacturing yard before the panels were transported to site (Figure 3). The main benefits for this were:

- Reduced construction programme
- Improved quality of the window installation
- Elimination of the need for working at height
- Elimination of the need for site scaffolding



Figure 3 Factory glazing of precast panels at ground level

This action was agreed during early design meetings, where the integrated team including Principal Contractor, Carillion, and the specialist contractors identified that potential programme savings and reduced site health and safety risks could be achieved. "The idea was based around not using a standing scaffold at all, we identified this as a potential problem, and we wanted to cut accident rates. Therefore install the window at factory ground level, then bring them straight to site and install them with a crane and cherry picker" (Carillion design manager).

Table 1 shows the operations affected and the health and safety risks removed or reduced using this method of window and glazing installation.

Table 1

H&S risks removed or reduced by pre-installation of windows

Main operations affected	Relevant main H&S risks	What happens to the risk?
Delivery of window units and associated components (to factory rather than site)	Slips trips and falls	Easier to control Less site storage
	Manual handling	More options for mechanical handling
Installation of windows	Working at height	Eliminated
	Scaffolding risks	Eliminated
	Falling objects	Significantly reduced
	Manual handling	More options for mechanical handling in the factory
Sealing joint between windows and cladding	Work in exposed areas	Eliminated
	Working at height	Eliminated
	Falling objects	Significantly reduced
	Use of scissor lifts or cradles	Significantly reduced
	Work in exposed areas	Eliminated
	COSHH risks	Easier to control
Inspection/snagging of windows (done in factory rather than on site, at height)	Slips, trips & falls	Easier to achieve good housekeeping
	Working at height	Eliminated
	Use of scissor lifts or cradles	Significantly reduced

UNITISED CURTAIN WALLING

This exemplar is from a project in Paddington, London. Terry Farrell is the master planner and other signature architects are designing individual buildings. Reducing site operations is one of the key methods for reducing accidents and also of improving productivity as off-site operations are deemed to be both safer and more efficient. The design team developed numerous designs, methods and processes to facilitate a reduction in site operations, in collaboration with the supply-chain. Typically curtain wall is erected in 'stick' form, which is heavily reliant on site installation, however, wherever possible Bovis Lend Lease specify unitised systems. The *unitised system* comprises narrow storey height units of steel or aluminium framework, glazing and panels pre-assembled off-site in a factory environment. On site, mechanical handling is used to position, align and fix the units onto site fixed brackets which are attached to the floor slabs or the structural frame (CWCT, 2000). Figures 4 and 5 show a typical unitised panel by Felix being delivered and installed on site. Table 2 shows the operations affected and the health and safety risks removed or reduced using this method. The main benefits of unitised cladding over stick systems include:

- Reduced construction programme for the curtain walling work
- Improved health and safety for the facade work due to reduced site operations
- No site scaffolding

CONCLUSIONS

This paper has argued that designers can make a difference to the health and safety of construction workers. One of the main things that can be done is to increase the amount of work done off-site at low level, typically through pre-assembly. This may not be 'rocket science', but action by designers early in the design phase will help to eliminate certain hazards and transform the residual hazards so that they are more obvious and thus easier to control.



Figure 4 Delivery and distribution of units (Courtesy Bovis-Lendlease)

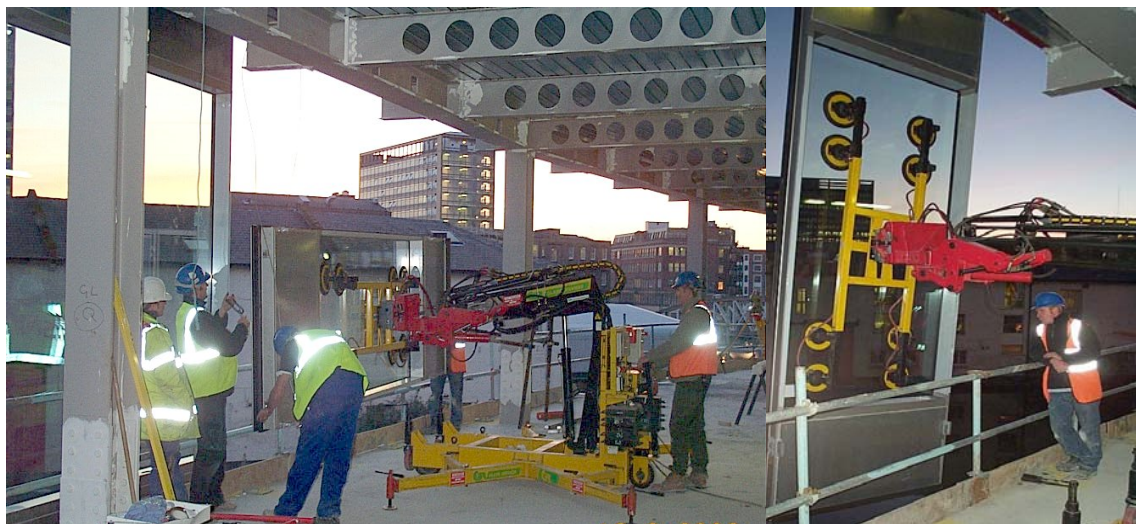


Figure 5 Installation of units using a tele-operated handler (Courtesy Bovis-Lendlease)
 (Note: Installers state that a safety back up system is always used in case the manipulator fails, but this is not clearly shown in the images provided here)

Table 2 H&S risks removed or reduced by unitised cladding (cf stick build)

Main operations affected	Relevant main H&S risks	What happens to the risk?
Unit installation	Work at height Falling objects Work in exposed areas Musculoskeletal disorders (MSDs)	Significantly reduced Significantly reduced Significantly reduced Units installed using tele-operated machines
Manual handling	Musculoskeletal disorders (MSDs)	Mechanical handling easier in factory
Glass handling	MSDs, cuts	Easier to control in factory
Scaffolding	Falls from heights, MSDs	Eliminated
Site storage and housekeeping	Slips, trips and falls	Less on site storage

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