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Health and safety issues relating to construction excavators and their attachments

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Abstract

Purpose – In striving to minimise downtime and optimise the productivity of construction excavators, very often, they employ a "quick-hitch" (Qh) as a means of changing attachments (like buckets) more quickly. Health and safety issues can relate to Qh use. The purpose of this paper is to observe these health and safety issues and consider their implications for stakeholders.

Design/methodology/approach – Triangulation, embracing a literature review; case studies; and the researchers' experiential knowledge, is employed to examine the nature and prevalence of Qh health and safety incidents.

Findings – It is confirmed that significant risks are associated with (inappropriate) Qh use, especially relating to "manual" and "semi-automatic" types. The main causes of Qh incidents are observed to be due to workers' acts or omissions, particularly, failure to properly implement safety mechanisms.

Practical implications – An identified emphasis on "people" and their actions, suggest a need for changes in construction working methods and management practice, as ways to help remove Qh risks. Accordingly, proffered solutions relate predominantly to improved worker training, combined with stricter site management. Mechanical solutions may involve possible changes to Qh design.

Originality/value – This specific area of academic plant management study is novel.

Keywords Construction industry, Health and safety, General management, Machine tools, Mechanical engineering

Paper type Research paper

Introduction

Fundamental economics demonstrate that the application of mechanisation to work can result in lower costs, controllable (e.g. consistent) output and higher productivity (see Edwards *et al.*, 1998, ch. 2). For these kinds of reason, the labour intensive construction sector relies heavily on mechanical plant and equipment (Harris and McCaffer, 2001, ch. 13; Edwards *et al.*, 2003) and one such commonly used type of construction plant, is excavators in their various configurations. For example, micro-excavators that are small enough to access the inside of buildings through doorways (Anon, 2007a); midi-excavators which are available with rubber tracks and an optional dozer blade (Anon, 2007b); and larger 360° turning machines that are used for a variety of high-volume excavating, earth-moving, demolition and other mechanised construction tasks.

To enhance their versatility, excavators employ a variety of attachments, these being appendages fixed to the machine's "excavating arm", otherwise known as its "dipper-arm". Examples include buckets of various types and sizes (e.g. trenching, dredging or rock buckets); rippers (designed to loosen consolidated materials); raw

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material handling grabs; hydraulically powered breakers; and specialist component handlers such as road kerb lifters.

These types of excavator attachments are "normally" fixed to the dipper arm with two steel pivot pins and to make an attachment change requires that: these pivot pins are temporarily removed; the "old" attachment is disengaged and safely released from the machine; the two sets of holes in the "new" attachment are lined up with two corresponding sets of holes on the dipper arm; and finally, the pivot pins be reinserted before being made secure with lynch pins or nuts and bolts. This process is very time consuming, taking as much as 45 minutes in some cases to perform (Berndtson, 2005) and normally requiring the machine operator to be helped by another worker.

Given this issue of time – and the fact that in any working day an excavator may undertake numerous attachment changes (Jackson, 2006) – resulting machine "downtime" can be unacceptable for the construction manager. For example, at only 10 minutes a change and with six changes in an eight hour shift this would represent 12.5 per cent machine downtime; whereas at 20 minutes a change and six changes, a quarter of the working shift would be unproductive.

This situation is economically intolerable to all involved in the execution of construction work. Resultantly, the quick-hitch has evolved to make these changes more efficient; with some types of quick-hitch allowing a machine operator to change an attachment unaided in less than a minute (Jackson, 2006). However, the Qh is not without problems and as this study confirms, several recent "high profile" accidents relating to their use have occurred.

Against this setting, the aim of this study is to investigate the nature of health and safety issues related to the use of excavator quick-hitches. Leading on from this, the following objectives apply and will be used to construct conclusions from the study:

- to understand the nature of Qh risks;
- to identify how and why these risks evolve; and
- to propose how the risks might be removed or mitigated (while highlighting the implications of such proposals on stakeholders, especially those who manage construction work).

Research method

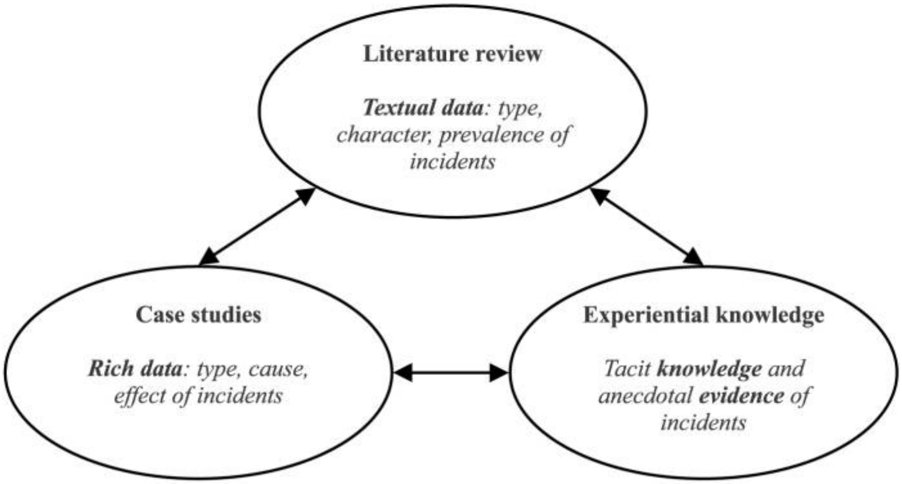
The research method employed triangulation, the doctrine of which is convergence to a point – a research conclusion for example – by at least three different routes (here, sub-methods). The triangulation metaphor emanates from navigation, where multiple reference points can pinpoint an object's exact position (Clark, 1951 cited in Jack and Raturi, 2006). The method is well entrenched within management research (Clark, 1951 cited in Jack and Raturi, 2006) and accepted as an appropriate scientific technique in social science *per se* (see Massey, 1999). Its specific applicability to construction management research has also been described (Love *et al.*, 2002).

The three aspects of triangulation in this work involved:

(1) a literature review;

(2) case-studies; and

(3) experiential knowledge and "anecdotal" evidence of the authors (see Figure 1).



Source: After Jack and Raturi (2006)

Figure 1.
Triangulated data and information sources underpinning this study

The literature revealed types, prevalence and "character" of Qh incidents, both in terms of accidents and "near misses". The case study Qh incidents were considered, for example, on the basis of cause and effect and contrasted with the findings of the review. Experiential and anecdotal knowledge from the authors' personal site experiences and relevant networks, was subjectively considered throughout and allowed to help steer the study's direction.

The subsequent discussion subjectively examines these data to develop a model, for stakeholders to address the hazards associated with quick-hitches, from design and manufacture of this equipment to its ultimate use at the job site.

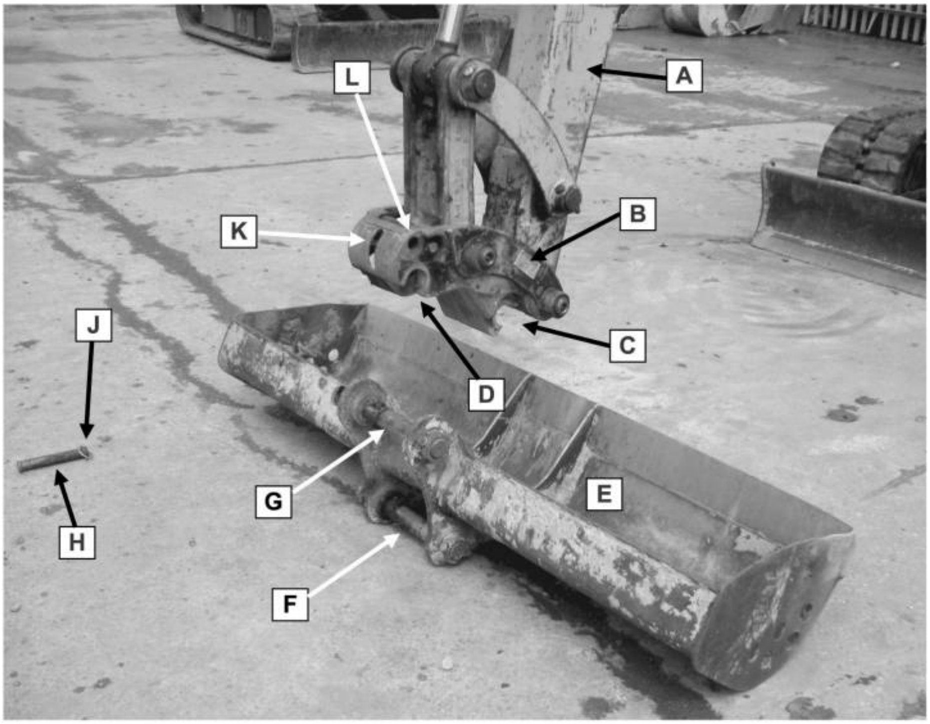
The literature review

Quick-hitches are typically produced by independent manufacturers (OSHA, 2005) and not normally supplied with a machine by the original equipment manufacturer (HSE, 2007a). Resultantly, they may have different names such as quick hitch coupler (JBS, 2007), quick coupler (Berndtson, 2005), or quick coupling attachment bracket (BSI, 2006), but essentially they are all the same thing. For simplicity, only "quick-hitch" and its acronym "Qh" will be used in this paper.

There are two fundamental classifications of Qh: "dedicated" and "pin" systems (HSE, 2007a, Section 5). The former type can only be used with corresponding attachments that have a dedicated receptive bracket fitted to those attachments. One purported advantage of this option is that because bucket geometry is not significantly changed, "break out" force (the force at the face of the bucket) is not reduced (Anon, 2007c). The downside is a reduction in versatility, because without such a receptive bracket fitted to it, an attachment cannot be used.

In contrast somewhat, the pin system Qh attaches to pivot pins of almost any attachment (although other constraints may exist such as maximum attachment weight or size for a given machine). This latter type of Qh is also sometimes able to accommodate pins of different diameters and of different centres, which again increases its versatility. It is for reasons such as these, that most quick hitches in use within construction, are of the pin system classification (see HSE, 2007a).

In broad terms, pin system quick-hitches are all similar in shape and form – being equipped with two "jaws" designed to accommodate the pivot pins on an attachment – see Figure 2. To connect with an attachment, a pin system Qh must undertake a three-stage procedure:



Key

A	Excavator dipper arm
B	Quick-hitch connected to machine's dipper arm
C	Front jaw of Qh – to engage with front pivot pin 'G'
D	Rear jaw of Qh – to engage with rear pivot pin 'F'
E	Excavating bucket
F	Bucket rear pivot pin
G	Bucket front pivot pin
H	Safety pin – to be inserted into hole 'L'
J	Lynch pin (through hole in end of safety pin)
K	Slot in Qh to allow insertion of 'tommy-bar'
L	Hole for safety pin

Figure 2.
Typical quick-hitch configuration (manual type)

(1) *engage* – the Qh engages with one of the attachment pivot pins by manoeuvring the receptive jaw around it;
(2) *retain* – the attachment is retained by placing the second jaw around the second pivot pin and retaining that pin in some mechanical way; and
(3) *make safe* – the connection is made safe, for example, by the excavator operator manually inserting a locking pin, to stop inadvertent attachment disconnection (Edwards and Holt, 2007).

The exact way in which a Qh performs the above three stages of connection place it into one of three further sub-classifications of type. These sub-classifications are: the manual Qh; the semi-automatic Qh; and the fully-automatic Qh. It is important to recognize these types because of their relationships to the prevalence of health and safety incidents (see later) and in the following description of them, letters in parentheses correspond with the letters annotated on Figure 2.

A typical manual Qh works by first engaging its front jaw (C) with the attachment's front pivot pin (G). The Qh is then "crowded" (turned mechanically) to allow the rear jaw (D) to engage with the rear pivot pin (F). The machine will then apply pressure onto the attachment in order to "click" the spring-loaded retaining mechanism of jaw (D) around the rear pivot pin; or alternatively, a steel bar (aka "tommy-bar") will be inserted into a slot (K) on the back of the Qh to temporarily release the spring mechanism and retain the pivot pin (F). Finally, a safety pin (H) is inserted into a hole on the Qh (L) so as to avoid any inadvertent release of the spring-loaded retaining mechanism (Anon, 2007d). Note that the safety pin is not a structural or load bearing component, it merely stops the retaining mechanism from opening inadvertently (HSE, 2007a, Section 6).

A semi-automatic Qh works in exactly the same way as to that just described, other than, the rear pivot pin is retained by a hydraulically operated latch mechanism (and not a manual one). Noteworthy here, is the important fact that a semi-automatic Qh does however still require the manual insertion of a safety pin at the point of connection (i.e. outside the machine) (HSE, 2007a). A fully-automatic type also works on similar connection principles to the semi-automatic, but the fully-automatic type does everything hydraulically, including the implementation of a safety device (which may incorporate a hydraulic non return valve and/or spring mechanism and/or gravity cam locks). Fully automatic types may therefore be operated entirely from within the machine cab (HSE, 2007a; Edwards and Holt, 2007) and not require the operator to get out and insert a safety pin. Obviously, all of the above are general descriptions only because Qh mechanical detail will vary somewhat between manufacturers.

Much health and safety (H&S) legislation applies to Qh use. Section 2 of The Health and Safety at Work etc. Act (1974) requires that employers ensure safe systems of work, while section 7 requires that employees take reasonable care of themselves and others who may be affected by their acts or omissions (HASWA, 1974) – which relates closely to the activation of Qh safety mechanisms for example. The Management of Health and Safety at Work Regulations (MHSWR, 1999) as amended, call for all risks relating to any type of work to be appropriately assessed; and mitigated or removed before work begins. Regulation 5 in particular, relates to adequate employee instruction in principles of accident prevention, which as will become clear, is particularly prudent in the present context. Being work equipment, quick-hitches are also regulated by The Provision and Use of Work Equipment Regulations (PUWER, 1998) as amended, along with The Supply of Machinery (Safety) Regulations (SMSR, 1992) as amended.

Where a quick-hitch has been manufactured to include a lifting or slinging eye (as is often the case), then for the purpose of relevant H&S law it becomes an item of "lifting equipment" and hence, *The Lifting Operations and Lifting Equipment Regulations* (LOLER, 1998) as amended have direct relevance. Finally, where a Qh is used on a construction site, the more recent *Construction Design and Management Regulations* (CDMR, 2007) will have general influence. Regarding common safety issues in plant and equipment, BS EN 474-1 (BSI, 2006) applies while part 5 of this series of standards relates specifically to excavators (BSI, 1996).

Health and safety literature relating to excavators, reveals that serious or fatal accidents involving them tend to include workers being:

- struck by a machine (or moving part of it); or
- being hit by an unintentionally disconnected excavator bucket (i.e. that has become disconnected from a Qh).

Indeed, the HSE recently identified that approximately 13 per cent of all accidents that they investigate involving excavators, can be attributed to the latter cause (HSE, 2007a) and in recognition of this, in December 2007, issued specific guidance to their construction inspectors to look out for these types of Qh hazard (HSE, 2007a). Statistics of fatal injuries at work for 2006-07 show that other than "falling from a height", being struck by a moving object; being trapped by something collapsing or overturning; and being struck by a moving vehicle, are the three most frequent causes of deaths within the construction sector (HSE, 2007b).

A press release from the HSE (2003a) reported on a worker who fell from a machine as a result of the bucket inadvertently disconnecting in the way described above. The worker suffered serious damage to his legs such that walking unaided was still not possible two years after the accident. Albeit the worker was employing an unsafe system of work at the time, the root cause of the accident was found to be that the safety pin had not been fitted to the Qh.

The HSE also provide details of prohibition notices (see Hughes and Ferret, 2003, p. 379) served on companies as a result of unsafe circumstances pertaining to quick-hitches. While the authors felt it inappropriate to give names and details in this paper, some of the descriptions reinforce this issue of unintentional release. For example: "…the safety bar [pin] was not fitted" and "notice served because measures were not taken to prevent uncontrolled release of excavator attachment from a Qh mechanism" (Anon, 2007e).

In an unspecified number of Qh incidents investigated by the Health and Safety Authority of Ireland, buckets had become unintentionally detached from excavator quick-hitches and had subsequently fell and struck workers (HSA, 2007). Meanwhile, Berndtson (2005) described where a bucket unintentionally detached from an excavator, hit two workers and killed one of them; while in another incident, an unintentionally detached excavator bucket fell onto a worker and broke both his legs. Elsewhere, the account was given of a 28 year old worker being killed after a bucket became detached from a Qh that was attempting to lift a manhole section while unloading materials on a construction site (NIOSH, 2003).

The US Department of Labor reported on one accident, where a worker was killed after an excavator bucket became inadvertently disconnected from a Qh due to the safety pin not having being fitted (the bucket fell onto that employee while they were in the excavation) (OSHA, 2005). Subsequent analysis of their H&S data relating to such incidents for the seven year period 1998-2005, identified an additional 15 similar accidents, from which a further eight workers had lost their lives under these kind of circumstances (OSHA, 2005). Similarly, the Health and Safety Executive confirmed four fatalities during 2007 relating to excavators fitted with Qh devices and that the "common theme" among these was missing safety pins (HSE, 2008).

The above examples of excavator quick-hitch incidents underline the seriousness of these in H&S terms, but the situation may be much worse than is apparent. This is because many incidents that do not lead to an injury but could have done – generally termed a "near miss" in health and safety parlance – will probably never be formally recorded. A "rule-of-thumb" regarding near misses is that for every 600 near misses a serious or disabling accident will actually occur (Hughes and Ferret, 2003); so an inverse proposition might state that the number of Qh near miss incidents is approximately 600 times greater than the number of serious accidents that have been reported.

The case studies

Three case studies were identified via the authors' personal network of plant and construction managers. Brief facts relating to these three Qh incidents were provided – but for reasons of commercial sensitivity – detail, place names and company names etc., cannot be included. Accordingly, these anonymous case studies are designated CS_1, CS_2 and CS_3 respectively. All three incidents occurred in Great Britain during 2006-07.

Case study CS_1 involved a large 360° excavator that was undertaking mass excavation work. In general, mass excavators are designed to provide power in contrast to "reach" or digging depth, in order that they can use the largest excavating buckets (that is, typically a large capacity, wide bucket). This machine was using such a bucket at the time of the incident that weighed in excess of 1 tonne; and this was attached to the machine's dipper arm by means of a semi-automatic Qh.

The bucket became disconnected from the machine while it was undertaking this excavation work and it resultantly fell to the ground. Fortunately, nobody was injured, but the incident represents a "near miss" that had the potential to have been fatal (should the bucket had fallen on a worker) and resultantly, was classified a "major incident" by health and safety managers of the company that operated the machine. Investigation by the safety managers identified the reason for disconnection to be because (following the most recent bucket change) the operator had not got out of the machine to insert the safety pin, before starting to use the attachment.

Case study CS_2 involved a machine on a construction site that was excavating a pit, with the excavated material being discharged by the machine into a dump truck for removal to another part of the site. There are similarities here to CS_1 as follows. First, this machine was using a bucket that was attached by way of a semi-automatic quick-hitch and while the machine was working, the bucket unexpectedly fell from the machine into the excavation (fortunately, no injuries were sustained by any workers).

Second, the reason for disconnection was also due to the operator not having fitted the safety pin to the Qh after last changing the bucket.

The seriousness of this "near miss" equally mirrors the previous case study. Subsequent investigation by the company of the circumstances underlying the incident revealed significant worker apathy; the "missing" safety pin was found being used by another dumper elsewhere on the site, as a "convenient" towing eye bar.

CS_3 concerned a machine that was fitted with a fully-automatic quick-hitch. This Qh was at some point changed for another fully-automatic type, as part of a fixed-time-to replacement maintenance regime. During this changeover of quick-hitches, the machine's hydraulic system (pressure) to the Qh was not checked and while the machine was subsequently using an excavation bucket to dig a trench, the bucket became detached from the Qh after making contact with the trench wall.

The lack of pressure within the hydraulic Qh retaining system, meant that the attachment was insecure and resultantly, the bucket detached and fell into the excavation (nobody was injured). The lack of pressure was discovered during near miss (company) investigation following the incident and points to failure of the hydraulic safety retaining mechanism within the Qh.

Discussion

Table I summarises the main issues relating to all incidents discussed above, as both identified from the literature review and the case studies. Clearly, the principal risk is shown to be unintentional attachment release from a Qh; with consequent risks of personal injury from the bucket striking (falling onto, sliding onto) a person and/or risk of entrapment/crushing. Despite there being other reasons in some cases (e.g. mechanical failure CS_3) and unspecified reasons in others (e.g. OSHA, 2005) – the common reason for detachment appears to be as a result of the Qh safety pin not having been fitted (see HSE, 2008) – which is also why the incidents are most frequently related to manual and semi-automatic types of Qh (that rely on this type of safety mechanism) (see HSE, 2007a, p. 8). Because safety pins require an operator to insert them manually it can be reasonably asserted that the majority of Qh incidents result from a human act, or more accurately, omission.

This observation is in keeping with other research studies that have equally attributed H&S incidents to the "human element". For example, the HSE (2003b) identified that worker actions or behaviour could in some way be attributed to 70 per cent of construction accidents, while BOMEL (2003) listed the human attributes of competence, awareness, perception (of risk) and compliance as being the most significant underlying causes related to falls from a height within construction. Similarly, Saurin *et al.* (2005) confirmed the relationship between human error and safety "failures" on construction sites whereas Wong *et al.* (2005) showed that almost one-fifth of construction accidents they studied were due to a "wrong" safety attitude in construction workers. Having confirmed this emphasis on human omission in Qh incidents, the next logical steps were to:

- consider why workers might not be inserting Qh safety pins; and
- suggest how such failure might be addressed.

Regarding the "why" question, Jackson (2006) inferred this was due to apathy on the part of machine operators going on to generalise that workers "would not bother" to

Table I. Summary analysis of literature and case study incidents

Source	Nature of incident	Outcome on worker(s)	Cause(s) of incident
HSE (2003a)	Worker fell while being lifted in machine bucket – bucket detached	Serious disabling injury to worker's legs	Safety pin had not been fitted to Qh
NIOSH (2003)	Bucket unintentionally disconnected from Qh while being used as lifting equipment	Bucket fell onto worker and killed them	Not stated
Berndtson (2005)	Unintentional bucket detachment from excavator Qh	Case no. 1: two workers struck, one killed Case no. 2: worker broke both legs	Not specifically stated but some reference to Qh safety mechanisms
OSHA (2005) (one case study)	Bucket detached from Qh and slid onto worker in the trench	Worker killed	Safety pin had not been fitted at last attachment changeover
OSHA (2005)	Sixteen no. cases of unanticipated attachment releases from Qh	Details on all incidents not given but eight worker fatalities in total	Unspecified reasons for unintentional release of attachment from Qh
Anon (2007e)	Two separate cases of HSE prohibition notice being served	n/a	Case no. 1: safety pin not fitted Case no. 2: uncontrollable release" measures not taken
HSA (2007)	Buckets becoming detached from Qh "in a number of cases"	Workers struck by the falling or detached bucket, no further details given	"… safety pin had not been inserted"
CS_1	Bucket detached from Qh during excavation	Bucket fell to ground, no injuries	Safety pin had not been fitted at last attachment changeover
CS_2	Ditto last	Bucket fell into the excavation, no injuries	Safety pin had not been fitted at last attachment changeover
CS_3	Bucket became detached from Qh upon contact with trench wall	Bucket fell into the excavation, no injuries	Failure of hydraulic retaining mechanism, hydraulic pressure was not checked when excavator's Qh was recently replaced

get out of a machine, for example in the cold weather, to look for a safety pin. Rameezdeen and Ratnasabapthy (2007) provided a useful discussion on workers' attitudes, with emphasis on the importance of how these can directly influence health and safety actions (or omissions in this case) at the workplace. They cite Lingard's (2002) model of attitudinal safety behaviour, this being: "beliefs" about the job; which impact "job attitudes"; which impact "behavioural intentions"; which finally impact "actual behaviour". We might relate this model to the present discussion as follows:

- *beliefs* – for example – "Safety is not important" . . . or . . . "The bucket cannot become detached";
- *attitudes* – for example – "There is no need [therefore] to bother about the safety pin";
- *intentions* – for example – [therefore] "I will not insert the safety pin"; and
- *behaviour* – resultantly, the safety pin is not inserted.

Other propositions might relate to the time pressures that are often placed on construction workers leading to apathy like that demonstrated, or simply that a lack of understanding of the risks is to blame.

Regarding the issue of "how" to address the human ("failure") element, one intuitively looks toward inadequate, or lack of training and instruction. This aspect of appropriate training, education and instruction being a pre-requisite to achieving human health and safety "compliance" appears frequently in the construction literature. For example, Teo *et al.* (2005) identified training (along with close supervision) as the most effective method of fostering safe construction worker behaviour; Smallwood (2006) stated that education and training can contribute to reducing scaffolding related accidents on construction works; and Edwards (2003) identified the importance of mandatory operator training as a tool to reduce plant related accidents on site.

Noteworthy here, at the time of writing existing plant certification schemes do not appear to include Qh training as an essential component of the syllabus; although a web search has identified at least one private training provider to recently introduce a basic Qh training "module" as an adjunct for existing certification schemes. Note also, that operator training needs may evolve; for example, if a new (alternative type of) Qh is to be used on a machine or as technologies underpinning Qh design advance.

While confirming that human actions are often a "fundamental factor" leading to H&S accidents, Suraji and Duff (2000) also discussed construction management deficiencies as a root cause. In a more specific context, Jackson (2006) made very clear the need for strict site management to ensure that operators insert safety pins, by stating that: "unless you stand over an operator, he's not going to do it" (i.e. insert the safety pin).

Based on the above discussion we may conclude that in addressing the risk of unintentional attachment disconnection from a quick-hitch – the problems of which relate predominantly to non-implementation of safety mechanisms – requires action by the three principal stakeholders:

(1) At organisational level construction managers need to set clear procedures and health and safety protocol, that in turn, is strictly enforced on site by supervisors.

(2) At site level, workers have a statutory duty to execute their work safely and comply with training and instruction in Qh use. This training should target new workers (e.g. at site induction); be reiterated on a cyclic basis (such as via toolbox talks); and be ad-hoc as required (such as when an operator is required to use a new model of Qh).

(3) Quick-hitch manufacturers have a duty to comply with manufacturing standards while also having a "moral" obligation to design and manufacture the safest possible equipment. Some might dispute that the latter – but there may be longer term commercial benefit – for those manufacturers that can demonstrate such.

A model indicating the relationships of these proffered solutions is shown graphically in Figure 3. Note that it is implicit in this model, that all parties will comply with their statutory duties, e.g. under HASWA (1974).

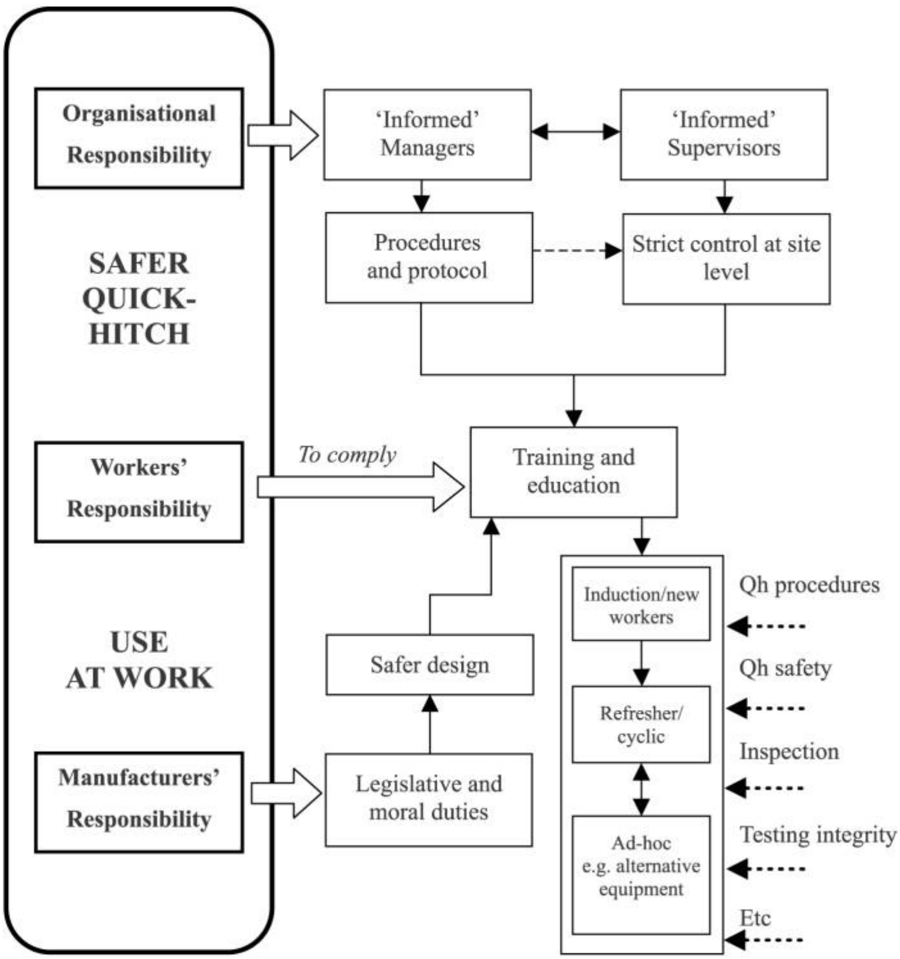


Figure 3.
A model of organisational, worker and manufacturer interrelationships for safer quick-hitch use

Conclusions

The construction sector relies considerably on the use of mechanical plant and equipment as a way of maximising output and exerting downward pressure on productivity costs. One such item of plant commonly used is the excavator in its various forms; which in turn tends to rely on a quick-hitch (Qh) as a way of changing a variety of machine attachments more efficiently and minimising plant "downtime".

However, over recent years several major incidents have been reported relating to Qh use and in one instance, accident data revealed that on average, one worker is killed for every two major Qh accidents. This study therefore set about investigating the nature of health and safety issues related to the use of excavator quick-hitches by considering the relevant literature and subsequently exploring three recent case studies of quick-hitch incidents. This was complemented by "anecdotal" evidence and informal discussions with plant owners, operators and managers; and from the authors' personal experiences.

Three objectives were linked to this aim: to understand the nature of Qh risks; to show how and why the risks evolve; and to suggest how risks might be removed or mitigated. The following conclusions are grouped in response to these three objectives.

Nature of the risk

The predominant health and safety risk related to quick-hitch use is that of unintentional attachment disconnection, in particular, excavating buckets that have had increased strain imposed on them such as when being used as lifting equipment, or as a result of contact with the sides of excavations. Such disconnection is inclined to result from human failure, that is, failure to appropriately implement Qh safety mechanisms. For example, manually inserted safety pins as are required on manual and semi-automatic Qh types.

How the risk evolves

A variety of reasons for safety pin omission have been proffered, including: worker apathy; ignorance (which in turn can result from inadequate or absence of training and instruction); pressure to get the job done as quickly as possible; and lack of supervision. This aspect of "human acts or omissions" and their relationship to health and safety failings generally in construction, is well documented in the literature.

Another possible contributory factor is that many Qh types have a safety pin which detaches completely during the changing of an attachment (refer to item "H" in Figure 2). In the harsh environment of a construction site, it is not difficult to envisage how this can easily become lost (for example, get dropped or trodden into mud).

Mitigating the risk

It has been concluded that to address the risk of unintentional attachment disconnection from a quick-hitch requires action by three stakeholders: construction managers (at organisational and site levels); operators (and other appropriate employees such as ground workers); and possibly Qh manufacturers. A model demonstrating the relationships of these proffered solutions has been offered whereby: managers must design appropriate systems and measures for safe working, compliance and training; workers must comply with safe work procedures and actively undertake initial and ongoing training as necessary; while manufacturers should strive to engineer the safest equipment.

How reliable are the findings of this study?

While this study was limited to a review of the literature and a small number of case studies, the authors are confident in the conclusions drawn from it. This is because of the convergence achieved within the triangle of:

- literature findings;
- case study observations; and
- the researchers' experiential/tacit knowledge.

There is clear commonality among the majority of incidents studied – for example – in terms of incident nature, the risks, the event, and the outcomes. Accordingly, conclusions drawn on these common observations are robust.

In summary therefore, it is concluded that in order to tackle this major health and safety hazard associated with construction plant and equipment, those charged with managing construction work must:

- be aware of the issues;
- be adequately informed of how to deal with them; and
- discharge their responsibilities by way of strict supervision where quick-hitch attachments are in use.

The latter is perhaps most important due to the prevalence of worker apathy highlighted.

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