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# The use and non-use of seat belts in the operation of forward tipping dumpers

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# The use and non-use of seat belts in the operation of forward tipping dumpers

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In the event of a forward tipping dumper (FTD) overturning, the operator will be protected from death and serious injury by wearing their seat belt. The seat belt works in combination with the roll over protection system (ROPS) to keep the operator in their seat, preventing them being crushed by the machine. Unfortunately, a proportion of operators choose to operate FTDs without wearing a seat belt and thus increasing their risk of death or serious injury should the machine overturn. Using semi-structured interviews to gauge the opinions of trainers, original equipment manufacturers, seat and seat belt manufacturers and FTD operators, this research aimed to better understand the reasons why FTD operators choose not to wear their seat belt when operating their machines. The research also explored potential solutions that would encourage operators to wear their seat belt more, including possible design control measures such as immobilisation technology, alternative designs of seats and seat belts, and of the overall FTD machine.

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# KEY MESSAGES

1. The reasons why operators of forward tipping dumpers (FTDs) may not wear their seat belts are multifactorial, with important factors being:

   - Low levels of trust in the combined seat belt/roll over protection system (ROPS)
   - Wearing the seat belt is seen as inconvenient and uncomfortable
   - The basic nature of the typical seat belt design results in belts becoming dirty and easily damaged.

2. Manufacturers could improve the wearing of seatbelts by making changes to aspects of the design of FTDs. Manufacturers should consider, **in priority order**, the following design changes:

   - Fitting integral cabs
   - Changing the seat/ROPS design to allow the fitting of three or four point seat restraint systems, equipped with sophisticated interlock/immobilisation technology
   - Fitting robust, retractable lap seat belts instead of the more damage susceptible non-retractable variety and also equipped with sophisticated interlock/immobilisation technology.

3. Manufacturers of FTDs could do more to involve end-users in the design process.

4. Groups, organisations and stakeholders representing the Construction Industry should drive a change process by actively encouraging the use of higher specification FTD designs on site. FTDs are operated in all weather conditions all year round. Current designs take little account of operator comfort and welfare and this is likely to impact negatively on productivity and safety.

5. Construction companies could do more at site level to monitor and enforce the wearing of seat-belts.

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# EXECUTIVE SUMMARY


## Study aims

This qualitative study aimed to:

- Generate insight into the reasons why forward tipping dumper (FTD) operators choose not to wear their seat belt when operating their machines.
- Identify possible design control measures that would encourage operators to wear their seat belt more.
- Seek the opinions of FTD manufacturers, and seat, seat belt and immobiliser manufacturers, with regard to the design specification of FTD seats, seat belts and immobilisation technology.

## Methodology

The study used semi-structured interviews to gauge the opinions of subject matter experts (particularly FTD original equipment manufacturers (OEM)), seat and seat belt manufacturers and FTD operators with regard to a range of issues around the non-use of seat belts.

## Main findings

Key reasons why operators may not want to wear their seat belt included:

- Low levels of trust in the combined seat belt/roll over protection system (ROPS)
- Wearing the seat belt is seen as inconvenient
- The basic nature of the typical seat belt design results in belts becoming dirty and easily damaged.

FTD manufacturers:

- Tend to take a passive role as regards FTD seat and seat belt design and specification
- Appear to be heavily influenced by the need to keep production costs as low as possible
- Do not solicit post product development feedback directly from the FTD operator community with regard to satisfaction with their product, and the need for design improvements. Feedback is, however, sought from dealers and end customers.

Potential design control measures that may encourage operators to wear their seat belts more include:

- Fitting robust, retractable lap seat belts instead of the more damage susceptible non-retractable variety
- Fitting integral cabs
- Changing seat/ROPS design to allow the fitting of three or four point seat restraint systems such as those used on skid-steer loaders and
- Fitting more sophisticated interlock/immobilisation technology.

## Key conclusions

1. The FTD original equipment manufacturer (OEM) community are potentially **key players** in terms of promoting change.
2. There is clearly much more that the FTD (OEM) community could do, particularly around improving the design of FTDs.
3. Given that hire companies purchase a large proportion of FTDs, and that many machines in use are hired rather than purchased, the Plant Hire Association may be in a position to influence OEMs to improve the design seat belt systems and the overall design of the FTD machine.

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# 1. INTRODUCTION

## 1.1 BACKGROUND

The forward tipping dumper (FTD) is a piece of construction plant designed exclusively to move bulk material (usually spoil). Available in a range of sizes, typically from one to ten tonnes, FTDs are used extensively on all types of UK construction sites as the primary means of transporting excavated spoil material between different locations on site. FTDs are wheeled or tracked machines, and are commonly operated on rough, uneven terrain, including slopes. Given that the vast majority of FTDs operating in the UK are designed without a cab, their operators have less protection in the event of an overturn compared to other types of construction plant.

To mitigate this vulnerability in the event of an overturn, FTD manufacturers are required to incorporate a safety system comprised of:

- A roll over protection structure (ROPS) and
- A seat belt to restrain the operator in their seat in the event of an overturn.

The ROPS typically comprises a structural frame that functions to physically prevent the operator being crushed by the machine in the event of an overturn (see Figure 1). The ROPS creates a protective safety zone by physically preventing contact between the ground and the operator’s seat area. Importantly, the ROPS only works effectively in conjunction with the operator’s seat belt. Should an overturn occur, the seat belt functions to keep the operator in their seat, and crucially within the protective safety envelope zone provided by the ROPS. The combination of the ROPS and seat belt will henceforth be described as the ROPS system. The ROPS/ Seatbelt combination are likely to prevent fatalities but are unable to prevent some injuries occurring. All FTDs currently manufactured for use in the UK are fitted with a ROPS/seat belt combination in order to comply with BS EN474-6[1] and BS EN ISO 3471[2], although the exact type of seat belt may differ depending on manufacturer preference.


**Figure 1** Typical forward tipping Dumper

[1] *Earth-moving machinery. Safety. Requirements for dumpers*
[2] *Earth-moving machinery. Roll-over protective structures. Laboratory tests and performance requirements*

## 1.2 RESEARCH AND POLICY CONTEXT

The interdependency between the ROPS and seat belt in the ROPS system throws up a potential vulnerability; in order for the system to function effectively if the machine overturns, the operator must be wearing their seat belt. The anecdotal experience of Health and Safety Executive (HSE) inspectors carrying out field inspections of construction sites is that many operators of FTDs do not consistently wear their seat belts. Figure 2 is a graphical analysis of RIDDOR[3] dumper/dump truck accident data held by HSE for the period April 2005 and March 2010. The chart shows that, in terms of the number of incidents that resulted in either a fatality or a major injury (e.g. an amputation), the "trapped by something collapsing/overturns" category is the most likely type of accident involving a fatality. In all of the five fatal accidents which involved the dumper overturning the operator was not wearing a seatbelt. To the best of HSE's knowledge, there have been no reported fatalities in incidents where a FTD has overturned and the operator has been wearing their seat belt.

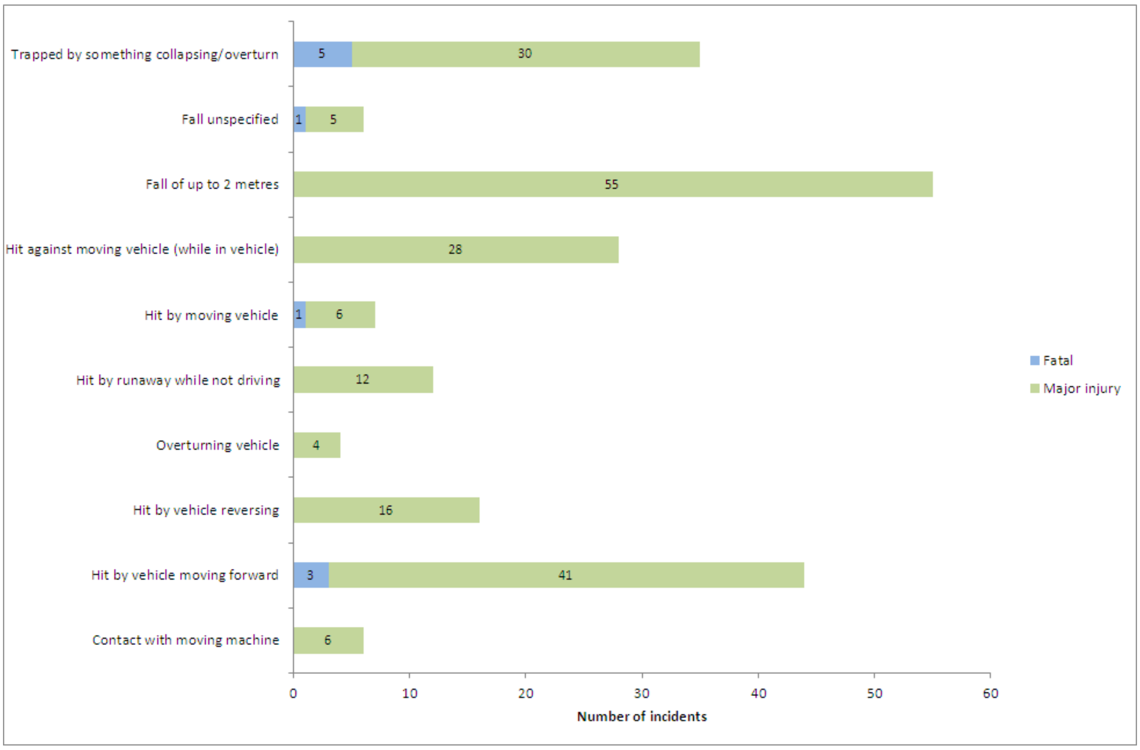


**Figure 2** Dumper/dump truck fatalities and major injuries April 2005 to March 2010 based on HSE RIDDOR data

If, as is suspected by HSE inspectors from their field experience, there is a proportion of FTD operators who, for whatever reason, choose not to wear their seat belt during normal operation, then this group could be regarded as exposed to an elevated level of risk should their machine overturn.

[3] *Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 2013*

## 1.3 STUDY AIMS

To better help HSE understand why some FTD operators choose not to wear their seat belt, the Health and Safety Laboratory (HSL) have been commissioned to undertake a research study that aims to:

- Gain detailed insight into full range of reasons why some FTD operators do not wear their seat belts

- Identify a range of design control measures (that can be fitted to new machines or retro fitted to older ones) that could assist to significantly increase the wearing of seat belts by FTD operators.

- Seek expert opinion as to the likely efficacy of various design control measures

- Seek the opinions of seat, seat belt and immobiliser manufacturers with regard to design specification of FTD seats, seat belts and immobilisation technology.

# 2. METHODOLOGY

## 2.1 RESEARCH DESIGN

The research utilised qualitative methodology in three separate stages:

- **Stage 1**: Five semi-structured face-to-face interviews with "subject matter experts" comprising UK original equipment (OEM) FTD manufacturers and FTD operator trainers

- **Stage 2**: 19 semi-structured face-to-face interviews with FTD operators

- **Stage 3**: Five semi-structured telephone interviews with seat, seat belt and immobiliser system manufacturers.

A qualitative methodology was preferred over a quantitative approach (e.g. a questionnaire survey) in order to gain detailed insight into opinions and perceptions. Employing semi-structured interviews offered opportunities for in-depth exploration of the knowledge, attitudes and experiences of subject experts and operators around a set of specific themes deemed relevant to the research. These themes included:

- FTD design and its impact on seat belt wearing

- FTD seat belt design

- Design control measures to encourage the wearing of seat belts

- Operator seat belt use

- Specification of FTD seats and seat belts

- Incorporation of safety interlock technology systems into FTD seat and/or seat belt installations.

## 2.2 QUESTION SET DESIGN

Five semi-structured interview question sets were designed in close consultation with HSE colleagues. Combinations of open and closed questions (some with appropriate follow-up items) were developed in order to explore the themes listed above. All five question sets are available for inspection in Appendix 1.

## 2.3 SAMPLE SELECTION AND RECRUITMENT PROCEDURES

### 2.3.1 Subject experts

A purposive sample[4] of five respondents were selected so as to reflect the views of two distinct groups of subject matter experts deemed to have in-depth experience of key topics of interest: operator trainers and employees of three UK based FTD manufacturing companies. Employees of FTD manufacturers were interviewed to obtain an engineering design perspective on seat and seat belt installations. By contrast, trainers were interviewed in order to obtain a well-informed, but less technical perspective on seat belt design and use.

[4] *A sample selected to represent participants with particular characteristics.*

The five respondents were recruited by making use of existing known contacts, and from contacts provided by HSE Construction Division. Individuals were contacted by telephone by an HSL researcher to explain the purpose of the research and to request their participation. All subject matter experts were interviewed by HSL researchers in their place of work.

#### 2.3.2 FTD operators

A total of 19 construction industry operators were recruited by approaching health, safety and environment professionals from three house building construction companies and a ground works company. Individual interviews were arranged at construction sites with the assistance of site management personnel. Site managers or supervisors selected individuals for interview. This approach resulted in a diverse sample of operators who had a wide range of FTD experience.

#### 2.3.3 Seat, seat belt and immobiliser manufacturers

Purposive samples of five respondents were recruited using contacts supplied by FTD manufacturers and by colleagues in HSE. Representatives of one seat manufacturer, two seat belt manufacturers and one immobiliser manufacturer took part in a short semi-structured telephone interview.

### 2.4 INTERVIEW PROTOCOL

All interviews were audio recorded using a digital recorder and then transcribed. To ensure that the data analysis process was reliable and consistent, interviews were conducted by two researchers, and utilised a "cross checking" procedure. The latter involved the assistant researcher checking the coding of the primary researcher to ensure consistency in data interpretation.

### 2.5 DATA MANAGEMENT AND ANALYSIS

The qualitative data in this study were analysed using a variant of Framework[5], an analytical approach devised by researchers at the National Centre for Social Research[6] (NatCen). The variant of Framework used in this study involved the following steps:

- A thorough reading of the transcripts to allow identification of the more relevant information provided by the respondents
- Extraction of this relevant information into a matrix format with columns containing topic areas and rows containing cases (interviewees)
- The data for each topic area was then summarised into relevant themes, based specifically on the accounts of respondents, and, finally
- A cross checking (inter-rater reliability) procedure was undertaken.

The final matrix provided a summarised themed record of interviewee responses to questions around specific topics of interest. These emerging themes provided a basis for the research team to examine and understand interviewee perspectives on overturn related human factors issues.

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[5] *Richie, J. and Lewis, J. (2003) Qualitative Research Practice: A Guide for Social Science Students and Researchers, Sage Publications*

[6] *http://www.natcen.ac.uk*

### 2.5.1 Limitations of the employed methodology

A degree of social desirability response bias cannot be ruled out given the circumstances in which the data were collected i.e. that interviewees may have, in some situations, provide responses that they perceive to be “correct” based on the status of the interviewer rather than providing their honest opinion or a true account of the facts.

# 3. FINDINGS

## 3.1 SUBJECT MATTER EXPERTS

### 3.1.1 Sample characteristics

The three interviewees representing manufacturing companies had an engineering background. All three reported extensive experience of the processes involved in the design and production of FTDs in the UK. Two interviewees were with companies supplying the main UK FTD market, the third interviewee was with a company that now only manufactures for export to markets outside of the European Union.

The two training interviewees were both with independent training organisations. These interviews reported much more limited levels of engineering and design expertise compared to the manufacturer representatives. This was, however, offset by extensive "hands-on" FTD operating experience in a wide range of situations and environments.

All interviewees were able to answer the questions asked of them, providing good levels of detail based on in-depth levels of knowledge and expertise.

### 3.1.2 Seat belt wearing and forward tipping dumper design

#### *Main perceived factors influencing forward tipping dumper design*

A range of factors impacting on the design of FTDs were mentioned by respondents (not in any order of importance):

- The safety of operators when using the machine;
- Stability of the machine;
- Performance and machine functionality (e.g. load carrying capacity, all-terrain capability);
- Ease of manufacture and
- Keeping costs as low as possible.

The manufacturer interviewees emphasised market-related factors (e.g. cost-related issues) in contrast to the trainers, with the latter focusing more on the importance of machine functionality.

#### *Perceived reasons for use of the lap/waist fitting seat belt design on FTDs*

Respondents offered a range of reasons for the use of the lap/waist fitting seat belt design:

- Tradition/custom and practice – the design has been used a long time
- The low cost of the design
- It is convenient to use
- It is easy to install given the design of the seats used
- It is a standard design supplied by seat manufacturers and
- Operator comfort.

### *Perceived reasons why operators choose not to wear seat belts*

A range of reasons were identified and discussed by the experts, including:

- Seat belts are seen as inconvenient
- Operators forget to wear their seat belt
- Operators are frequently getting on and off machines
- A fear of being crushed if the machine overturns
- A lack of basic foundation training
- Poor site management
- No legal requirement to wear a seat belt
- Seat belts are easily damaged (and therefore may not be usable)
- Impact of use on rough terrain (e.g. operator discomfort due to seat belt pressure on abdomen)
- Lack of comfort during use and
- Operators having no or little perception of risk.

## 3.1.3 Design control measures aimed at increasing seat belt use

### *Practicality of design control measures*

The experts were asked about the practicality of a number of design control measures aimed at increasing seat belt use. The measures, along with a summary of the experts' assessment of their practicality are summarised in Table 1:

**Table 1** Subject matter expert opinions on design measure control options

| Design control measure | Opinions about practicality |
|---|---|
| Auditory or visual alarm systems which alert the operator and others | Very practical - could improve seat belt use |
| Better designed seat belt systems | Practical – could improve seat belt use |
| More comprehensive training | Practical – could improve seat belt use |
| Better designed Roll Over Protection System (ROPS) bars | None mentioned |
| More "visually substantial" ROPS bars | None mentioned |
| Side restraints which provide more protection to the operator in the event of a sideways overturn | Mixed views expressed |

Clearly, the experts expressed a preference for auditory/visual alarms and better designed seat belt systems. Unfortunately, the experts could or would not offer ideas or examples of what feasible solutions may look like in practice.

### *Opinions about how design control measures could be defeated by operators*

Respondents mentioned two ways in which operators may defeat control measures:

- Deliberate vandalism and
- Interlocked seatbelts could potentially be defeated by the operator permanently fastening the seat belt behind him and then sitting on top of it.

When asked about how the design of forward tipping dumpers could be changed to prevent operators using the machines without wearing their seat belt, respondents offered no suggestions or solutions.

## 3.2 OPERATORS

### 3.2.1 Sample characteristics

The majority of respondents reported their job title as either ground workers or dumper operators, although the sample included a site supervisor and a safety director, both of whom had operated dumpers in previous roles. There was a wide range in the length of time respondents had operated dumpers, ranging from 2 to 32 years.

Many reported operating FTDs on most days while working on site, with time of operation ranging from a few minutes to all day depending on the job. In terms of size of machines operated, the range was from four to ten tonnes, with the most usual size operated around nine tonnes. Respondents reported operating FTDs on both housing and civil engineering sites.

Most respondents reported that they had been formally trained with most holding Construction Plant Competence Scheme (CPCS) licences; however a small number did not hold any formal proof of competence as they had gained their experience on the job. A good understanding was shown of the function of the ROPS/seat belt system as a means of remaining safe in the event of an overturn.

### 3.2.2 Seat belt use on FTDs

Although some operators said they always wore their seat belt, the majority said they only wore their seat belt some or none of the time. The latter were in the minority. The circumstances where operators said they did not wear their seat belt included:

- When driving up and down slopes and/or on bumpy/uneven ground (as there is a greater perceived risk of tipping, and certain operators would like to preserve the option of jumping clear of the machine in the event of a tip)
- When driving short distances (less perceived risk of tipping the machine)
- Good weather conditions e.g. dry (less perceived risk of tipping the machine)
- When driving on level ground (less perceived risk of tipping the machine)
- If the seat belt is difficult to adjust (seen as inconvenient)
- When getting on and off frequently (putting belt on and off is seen as inconvenient)
- If the seat belt is uncomfortable (avoidance of discomfort)
- On smaller machines (e.g. one tonne) (as these are perceived to be more at risk of tipping).

Emerging themes around the reasons for non-use of seat belts included:

- Inconvenience
- Certain situations perceived as being less risky
- Feeling uncomfortable
- Doubts about the safety benefits of wearing seat belts – several respondents expressed the view that they would rather preserve the option of jumping clear in the event of the dumper overturning.

The majority of respondents thought that wearing a seat belt did not make reversing more difficult.

In terms of what would need to change to encourage greater use of seat belts on FTDs, respondents made a number of varied suggestions, including:

- Stricter site rules penalising seat belt non-use
- Interlocked immobiliser systems
- Better ROPS
- Adding a cab to FTD design
- A three point of contact restraint system
- Making seat belts easier to use and
- High visibility seat belts.

These suggestions can be summarised into the following themes:

- Improved FTD design
- Improved seat belt design and
- Stricter site rules.

### 3.2.3 Operator perceptions around the current FTD seat belt design

In terms of opinions around the current design of the seat belts on FTDs the response pattern was mixed, with some saying the design was acceptable and others regarding the design as poor. Operators taking the latter stance gave a number of reasons for poor design, including being perceived as:

- "Flimsy" i.e. potentially may not completely restrain the operator in the seat and
- Vulnerable to getting dirty, particularly the non-retractable designs

The operators thought that seat belts on FTDs were easy to use and adjust.

The picture was, however, more mixed with regard to the potential for damage, with some, but not all operators, perceiving the current seat belt design as being vulnerable to damage and/or suffering the impact of dirt. This mixed response pattern was also reflected in responses to the question about the proportion of seat belts that are defective, the range of responses varying from "a small proportion" to "80 per cent". There was also a mixed set of responses from the operators when they were asked if the ROPS and the seat belt would protect them in the event of an overturn. The majority of respondents said that they thought that the ROPS would protect them. However, a proportion of respondents expressed the opposite view, due to concerns about:

- Getting trapped under the ROPS
- Their head hitting the ROPS and
- The upper torso being vulnerable to being tossed about violently during the overturn.

The operators were asked for their opinions on the advantages and disadvantages of current FTD seat belt design. The range of opinions offered are summarised in Table 2.

**Table 2** Operator opinions on the advantages and disadvantages of current FTD seat belt design

| Advantages | Disadvantages |
|---|---|
| • It is a safety feature<br>• Simple to use | • It "locks you in"<br>• Poorly designed<br>• Inconvenient to use if getting on and off the machine frequently<br>• Difficult to see if the seat belt is being used<br>• Perceived low level of protection<br>• Tend to be poorly maintained<br>• Has poor usability<br>• Uncomfortable to wear/use<br>• Poor adjustability |

Table 2 shows a mixed response pattern, consistent with the mixed range of opinions around the efficacy of current FTD seat belt design. There is, however, a noticeable contrast between the two categories i.e. the disadvantages opinions displaying a greater range and depth of insight. Perceived low levels of protection are well explained and summarised using the following quote from an operator:

*"It doesn't make you... you don't feel it's going to save you in the event of an overturn"*

The operators were also asked to give their opinions on how FTD seat belt design could be improved. Not all respondents offered suggestions but ideas included seat belts designed to:

- Go across chest/shoulder as this would be more comfortable
- Restrain the whole body
- Have multiple points of contact with the operator's body
- Get less dirty
- Be protected from the elements
- Be simpler to use

These suggestions reflect several themes, including restraining the user more robustly, being less exposed to dirt and simplicity of use, all of which would require fundamental changes to the current design principles.

Finally, the operators were asked whether they had ever seen a FTD with a cab design. Again, the response pattern was mixed with some operators aware of a cab design, others not.

### 3.2.4 Seat belt wearing on sites where the operators had previously worked

There was no consistent response pattern to the question "On previous sites where you have worked, did FTD operators usually wear their seat belts?", suggesting a mixed picture in terms of the seat belt wearing habits of FTD operators. This mixed picture was substantiated by inconsistent responses to the follow-up question about the regularity of seat belt wearing on sites previously worked on.

### 3.2.5 Site management on sites where previously worked

The operators were asked a number of questions about their perceptions around safety management on the sites where they had worked in the past. Most of the operators reported that they were told to wear their seat belt as part of the company's/site's health and safety policy, although some reported that they were not explicitly told to wear their seat belt. Again, variability was observed in the response pattern to the follow-up question about how strongly seat belt wearing policies were enforced, and also to the question as to whether seat belt wearing was discussed as part of FTD risk assessments. Finally, this variable picture extended both to the behaviour of site managers in their enforcing, or checking up on, seat belt non-use. There was also variability regarding the training of FTD operators i.e. some longer serving and more experienced operators had not received formal training through the exercising of "grandfather rights" due to the depth and extent of their on the job experience.

### 3.2.6 Design control measures

The operators offered a number of suggestions as to how FTD design would need to change in order to encourage operators to wear their seat belt more, including:

- Being able to get on and off a FTD more quickly
- A cab
- A shut off if the seat belt is not engaged
- A dead-man's switch
- A three point seat belt system.

The operators were asked to give their opinions on the efficacy of the following two design control measures to enforce seat belt wearing:

a) Engine immobiliser switch i.e. engine would not start unless the seat belt was connected
b) Combination of engine immobiliser switch and seat switch.

Most respondents thought that both ideas were reasonable, but the balance of opinion was that option b) would more effective than option a), with some citing concerns about the potential for defeatability of option a).

The operators saw defeatability as an attribute of both suggested design control measures. Suggested techniques for defeating the control measures included:

- Putting hand pressure on the seat and turning the [starting] key
- Seat belt being clipped behind the operator (however, if the interlock circuitry worked in sequence such that the operator seat switch had to be activated first, having the seatbelt permanently fastened would not work when the operator sat down on the seat since the seatbelt was already fastened)
- Putting knee in/on the seat, clipping the seat belt together and starting the engine
- Disarming the seat by joining wires together.

In answer to a question inviting the operators to provide their own ideas for a safety system that would encourage seat belt wearing on FTDs, a number of suggestions were made:

- Audible alarms
- Green flashing light when the seat belt was clipped in
- A harness instead of a seat belt
- An ID card to plug into the seat belt so know which operator is on it and will only start when seat belt on - when card removed then engine cuts out.

## 3.3 SEAT, SEAT BELT AND IMMOBILISER MANUFACTURERS

### 3.3.1 Sample characteristics

The information was provided by five manufacturing companies. Respondents had mainly technical backgrounds.

### 3.3.2 Seat manufacturer

The seat manufacturer reported that there are three models of seat (including a compact seat) that are typically supplied to FTD OEMs. The FTD OEMs do not specify the seat design features as the design is typically specified by the seat manufacturer. The seats supplied are typically generic in basic design. Lap seat belts are most typically fitted to FTD machines.

There are a number of variations on the lap type seat belt design that can be fitted to all types of FTD seats:

- Static lap
- Retractor lap - automatic locking
- Retractor lap - emergency locking.

The FTD OEMs do not specify the type of seat belt design fitted to FTD seats. The company routinely supplies products incorporating safety interlock technology, but not routinely for FTDs (this technology is typically supplied to fork lift truck manufacturers). These interlock technology systems are based on linking seat occupancy switches and warnings lights on the dashboard with interlock circuitry to prevent the FLT being operated without an operator sat in the seat, although the seat belts tend not to part of these systems. The seat manufacturer has never discussed interlock technology with FTD OEMs.

### 3.3.3 Seat belt manufacturers

The static lap belt is the main type of seat belt supplied to FTD OEMs. This is the standard and cheapest offering. Although the design of seat belts meet minimum standards (ISO 6683), the FTD OEMs do not specify the designs supplied. Costs are seen as a key driver of the procurement process.

Both seat belt manufacturers can supply products incorporating safety interlock technology (typically using micro-switches on the buckles). The interlock technology utilises a micro-switch inside the buckle which is connected to a wire harness that has a connector on the end. When the tongue of the opposite side of the seatbelt is engaged into the buckle, the micro-switch sends a signal to the vehicle's control system that the seat belt has been engaged.

Both companies reported discussing safety interlock technology with FTD OEMs, but with minimal uptake. The reported additional costs of the technology are between £5 and £25 per unit.

Both manufacturers offer products that incorporate high visibility webbing but only one company reports involving end users in the design process. The company that does not consult end users relies on the standards process in specifying their designs. Neither manufacturer solicits feedback from end users regarding their products (only from OEMs) and were unaware of the views of operators concerning the lap belt design. One manufacturer reported an awareness of accidents on FTDs and, therefore, tried to understand all of the potential risks.

Views were mixed on the issue of whether the design of FTD seat belts could be improved. One manufacturer suggested designs with an improved comfort factor, the other thought that FTD OEMs needed to drive the improvement process. Cost was the main perceived barrier to achieving design improvements.

### 3.3.4 Immobiliser manufacturer

Plant immobilisation products rely mainly on keypads for operation but radio frequency identification (RFID) tag recognition systems are also available. The systems are manufactured for a range of plant including fork lift trucks, telescopic handlers, excavators etc.

Supplied keypads can include technology designed to prevent users defeating the interlock e.g. seat belt sensing which they say is not easily defeatable but offer nothing as yet that will deal with the issue of operators sitting on seat belts to override the interlock.

# 4. DISCUSSION

The experts cited a range of possible reasons for why operators choose not to wear their seat belts when using FTDs. Some of these reasons link to cultural factors (e.g. site and peer group culture, organisational/safety culture influencing management practices on sites), and some to operator perceptions of what is and is not safe practice. However, the opinions expressed by the experts appeared to be somewhat inconsistent. This latter observation is illustrated by the experts citing both the "safety of operators" and "keeping costs as low as possible" as factors impacting on the current design of FTDs.

The views of the OEM expert respondents must be regarded as crucial here, given their potential influence over the design process. The views expressed by OEM respondents suggest that their companies adopt a somewhat conservative and passive position with regard to the design of seat belt systems on FTDs. For example, the interviews with seat and seat belt manufacturers suggested a lack of OEM pro-activity in specifying seat and seat belt designs. Typical seat belt designs fitted by OEMs vary little from the basic lap seat belt design, implying that they are content to fit seats and seat belts specified by the seat manufacturers, as long as these meet basic standards. This influence of a passive "custom and practice" attitude seems to be reinforced by commercial pressures to keep the costs of production as low as possible. Continuing to produce machines fitted with basic, low cost non-retractable lap seat belt systems illustrates how cost pressures can impact on design decisions. Furthermore, seat and seat belt design decisions continue to be taken by the OEM community in the absence of feedback from, and consultation with, the user/operator community. By contrast, the OEMs do solicit feedback from their dealer network and the companies that purchase FTDs.

The information provided by the FTD operators implies that the practice of not wearing seat belts when operating the machines is commonplace and, in some instances, not enforced by site management. Although the responses of the operators lacked consistency and coherence (indicating some diversity of opinion), the information they provided shows clearly that there is a proportion of users who, for a variety of reasons, choose not to wear a seat belt, despite the increased risk of injury or death should the machine overturn. This finding shows clearly that, despite the theoretical soundness of the ROPS/seat belt safety system, in practice many users are unlikely to comply with its use. The net result of this situation is likely to be user behaviours that result in consistent non-compliance with the safety systems built into the design of FTDs. Furthermore, the relatively negative views expressed by the FTD operators around current seat belt design suggest that there is much room for improvement. Possibilities include basic options such as providing retractable lap seat belts to help reduce the potential of the belt being damaged) or more ambitious initiatives around changes to fundamental machine design such as machines with integral cabs. The opinions of the operators suggest that the way forward lies in improved design, both of the seat/seat belt systems and of the FTD overall. These suggestions by the operators should be seen as complimentary to other influential factors, in particular the application of consistent safety enforcement practices at site level.

The interviews with the specialist manufacturers highlighted a lack of OEM pro-activity with regard to seat and seat belt design and compliance with minimum standards. Thus, the OEMs are in a strong position to drive change should they choose to do so. Encouragement could be taken by the potential of technology transport from the fork lift truck sector, where the use of interlock/immobilisation technology is at a more advanced stage compared to the technology used on FTDs.

When considered together, the views of the OEMs and the operators are not consistent. There appears to be a gap between theory (i.e. that the ROPS/seat belt safety system will be trusted and used by operators) and practice (i.e. a proportion of operators do not consistently wear their seat belt). This suggests, therefore, there is considerable scope for change. Operators suggest design changes as the most effective way of driving change in user compliance. This suggests that there are opportunities for FTD OEMs to reconsider their position in relation to current seat/seat belt design. Possibilities include FTD OEMs:

- Acknowledging the safety issues associated with current FTD seat/seat belt design
- Adopting a more pro-active role with respect to alternative design options, including the more fundamental options such as including a cab and
- Consulting the end user community about all aspects of FTD design, and in particular listening to their views about the ROPS/seat belt restraint system.

# 5. CONCLUSIONS

- There are potential design solutions that, if adopted, may encourage seat belt use. These design changes could, in the short term, be quite basic (e.g. fitting robust, retractable lap seat belts instead of the more damage susceptible non-retractable variety).

- Over the longer term, more fundamental design changes (e.g. fitting integral cabs, changing seat/ROPS design to allow the fitting of three or four point seat restraint systems such as those used on skid-steer loaders, fitting more sophisticated interlock/immobilisation technology etc.) could also be introduced to encourage seat belt use.

- The OEM community are potentially **key players** in terms of promoting change.

- There is clearly much more that the FTD OEM community could do, particularly around improving the design of FTDs. Influencing the FTD OEM community to depart from the “status quo” must be regarded as key to effecting change, particularly with regard to:
    - Improving the general overall design of the machines e.g. incorporating an integral cab that would allow alternative seat design formats (as well as significantly improving operator comfort), so providing more options with regard to the seat and seat belt design.
    - Improving current seat and seat belt design so as to encourage operators to want to use it e.g. fitting retractable lap belts as standard, changing the seat design to allow the fitting of multi-point restraint systems (see point above).
    - Being less concerned about keeping production costs as low as possible.
    - Taking steps to consult the FTD operator community in addition to end customers and dealers with regard to product satisfaction.

- Given that hire companies purchase a large proportion of FTDs, and that many machines in use are hired rather than purchased, the Plant Hire Association may be in a position to influence OEMs to improve the design seat belt systems and the overall design of the FTD machine.

- Site managers/supervisors could also help to influence practice by:
    - actively monitoring and insisting on the wearing of seat belts and
    - encouraging the use of higher specification machines on their sites e.g. machines with cabs, retractable seatbelts, interlocked seatbelts

# 6. APPENDIX 1 SUBJECT MATTER EXPERT QUESTION SET

**About you**

1. What does your job role consist of?
2. What experience do you have in relation to forward tipping site dumpers?
    - Probe: have you had any forward tipping dumper related training / driving experience? How extensive is your experience

3. What experience and/or training do you have in relation to forward tipping dumper design and/or control design for other equipment?
4. In your opinion, what are the main factors that influence forward tipping dumper designs?
5. FOR MANUFACTURERS ONLY: As part of your role, do you establish if there are (or are you aware of any) deficiencies in current forward tipping dumper models?
6. FOR TRAINERS ONLY: Are you aware of any design deficiencies in current forward tipping dumper models?

**Seatbelt wearing and current forward tipping dumper design**

7. HSE incident analysis and field observation suggests that some forward tipping dumper operators prefer not to use their seatbelts when operating their machine. In your opinion, what could be the reasons for this?
    - Seatbelts are uncomfortable
    - Seatbelts are inconvenient
    - Macho culture
    - Frequently getting on and off the machine
    - Able to get away with it
    - A perception that the risk is greater when wearing the SB?
    - Seatbelt broken/ damaged etc.
    - The size and/ or stability of the machine will prevent it from overturning?
    - A lack of training or misconceptions regarding the purpose of the seatbelt
8. Do you think that there are specific forward tipping dumper design features that encourage operators not to wear seatbelts?
9. What do you think are the main safety functions of the seatbelt on forward tipping dumpers?
10. The seatbelt design on a typical forward tipping dumper is of the traditional lap/waist-fitting type. In your opinion, what are the main reasons for using this type of seatbelt design?
    - Design reasons?
    - Technical reasons - Does it come as part of the package with the seat or is it sourced separately
    - Design standards
    - Custom and practice?
    - Cost
    - Operator expectations? (lack of operator input?)

11. Are there any other type of seatbelts in addition to the waist/ lap type:
    - If yes,  how common/ rare are they

12. Has forward tipping dumper seatbelt/seat design has changed over the years?

    - If so why

13. Do side-tipping and hi-lift site dumpers have the same design of seat belt as the forward tipping models?

14. Feedback from some forward tipping dumper operators is that the traditional lap/waist-fitting type of seatbelt can:
    - Overly restrict movement such as turning around while reversing the machine
    - Cut into the operator's waist as the machine is driven over rough ground

    Could the design of forward tipping dumper seatbelts be improved to prevent these problems?
15. Forward tipping dumper seatbelts are intended to be used in conjunction with a roll-over protection bar (ROP). Do you think that the ROP does offer protection in the event of a forward tipping dumper overturning? If not yes or no then why?
16. How effective do you think the ROPs-seatbelt combination is at:

    a) preventing death
    b) preventing injury
17. Do you think it possible to improve on the current design and/or appearance of ROPs?

FOR MANUFACTURERS ONLY:

18. Does your company actively specify the seat restraint system design on a forward tipping dumper or do you acquire ready-made solutions from third party suppliers?
19. Would your company be responsive to design changes in the forward tipping dumper restraint system or would this depend on competitors introducing modifications in the first instance?
20. Considering the overall forward tipping dumper design process, what factors influence the type/style of seatbelt to install?

**Possible design control measures preventing forward tipping dumper operation if an operator is not wearing a seatbelt**

21. In your opinion, how practical are the following control measures aimed at increasing seatbelt use?
    a. Interlocked seat switches (how would these work?)
    b. Interlocked switches incorporated into the seatbelt
    c. Interlocked over shoulder restraint bars (as used in Skidsteer loaders)

Ask specifically for opinions about:

- Feasibility
- Usability
- Comfort
- Defeatability

22. How could operators circumvent these prevention design control measures? (Try and obtain an answer for each solution)
23. How else could the design of forward tipping dumpers be changed so as to **prevent** operators using the machine unless they wear their seatbelt or alternative restraint system?

**Possible design control measures aimed at increasing seatbelt usage**

24. In your opinion, how practical are the following design control measures aimed at encouraging increased seatbelt use?
    - Better designed ROP bars
    - More "visually substantial" ROP bars
    - Side restraints which provide more protection to the operator in the event of a sideways overturn
    - Better designed seatbelt systems
    - Auditory or visual alarm systems which alert the operator and others
    - More comprehensive training (i.e. presenting a risk based case?)

25. What additional design control measures could be introduced so as to **encourage** operators to wear their seatbelts?

**Question for Manufacturers Only**

26. Do you have a system in place to collect operator feedback
    a) when designing machines
    b) for legacy machines?
27. Have you sought or received operator/ contractor feedback regarding the seat/ seatbelt/ ROPs combination for new or legacy machines - what did this feedback say?
28. Has there been any consideration given to radically changing the design (e.g. with the addition of a cab)?

**Question for Trainers Only**

29. In your opinion what would improve the wearing of seat belts
30. From your experience what are the main reasons why trainees don't wear seat belts For example is it
    - forgetfulness
    - failure to appreciate the purpose of the seatbelt
    - slows down productivity
    - restricts their movement
    - prevents escape in the event of a sideways overturn

# 7. APPENDIX 2 OPERATOR QUESTION SET

**About you**

1. What does your job involve?
2. How long have you been operating forward tipping dumpers (FTDs)?
3. How frequently do you operate FTDs on any specific day? How long for each time?
4. What sizes of FTD have you operated?
5. What types of site have you operated FTDs on?
6. What training have you undergone to operate FTDs? e.g. CPCS and what did this say about the wearing of seat belts?
7. What is the function of the seatbelt in relation to the Roll Over protection System (ROPS) system

**Your Seatbelt Use on FTDs**

8. Do you wear your seatbelt when operating a FTD?

   If yes, do you wear it either :
   - always – if so, what makes you wear it? **OR**
   - some of the time/occasionally ? if so, under which conditions would you wear it?

   Prompt – level of site supervision, site conditions, size of machine

9. What are the reasons for not wearing your SB?

   Prompt: Has this to do with the frequency of getting on and off the machine?
   Prompt: seatbelt difficult to adjust or not functioning?
   Prompt: Do you experience any sort of discomfort? If yes could you explain what happens please?
   Prompt: do you feel safer wearing it or not wearing it?
   Does size of dumper have any bearing on whether you decide to wear a seatbelt or not

10. Does wearing your seatbelt make turning around while reversing difficult? How?
11. What other obstacles prevent you from wearing the seatbelt?
12. What would need to change to encourage you to wear your seatbelt more?

**FTD Seatbelt Design**

13. Is the current (lap fitting) seatbelt design easy to use?

    **If not, why not?**

14. From your experience, what proportion of dumpers you have operated have defective seatbelts?
15. How easy is it to damage the seatbelt on a FTD?
16. How easy is it to adjust the seatbelt on a FTD?
17. What do you think of the current seatbelt design?

18. Do you think the ROPS/seatbelt combination would protect you in the event of an overturn?
19. In your opinion, what are the advantages and disadvantages of current dumper seatbelt design?
20. Could FTD seatbelt design be improved?

    **If yes**: How and would this encourage operators to wear their seatbelts more?

21. Have you ever seen a dumper with a cab? If no, show a picture to check opinions – what would be the advantages?

**Site Culture and Management**

22. On previous sites where you have worked, did FTD operators usually wear their seatbelts?
    - If not, why not?
23. On previous sites where you have worked, were there colleagues who regularly wore their seatbelts?
    - If yes, why do you think they did this?

24. On previous sites where you have worked, would you say that most FTD operators wore their seatbelts or most didn't ?

    **Why is that?**

25. On previous sites where you have worked, were you told to wear you SB? Was there typically a written/verbal policy on this?

    **If yes, how strongly was the policy enforced?**

26. On previous sites where you have worked, was seatbelt wearing discussed as part of the risk assessment when assessing the risk of operating dumpers?

27. On previous sites where you have worked, was there a significant number of operators using forward tipping site dumpers who had not been trained?

28. On previous sites where you have worked, did site managers enforce and / or check up on seatbelt use?
    - If yes, what did they do next? If not, what is your view on this?

**Design Control Measures**

**29.** How would the design of FTDs need to change to encourage operators to wear the seatbelt?

30. What do think of these design control measures?

- **An engine immobiliser switch (interlock)** in the seatbelt so that the seatbelt would need to be fastened before the dumper engine would start.
- **A combination of engine immobiliser switch and seat switch** i.e. you would need to in your seat with the seatbelt fastened before the dumper engine would start.

31. Could these safety systems be defeated? If so how?

    Prompt: How could you prevent an operator from simply fastening the seat belt permanently behind them?
    Prompt: Would an audible alarm help if it was configured such that it sounded if the seatbelt was fastened with no operator on the seat?

32. Do you have any ideas for a safety system that would encourage operators to wear their seatbelts?
33. What is your opinion on the advantages or disadvantages of having side restraint bars or handhold grips fitted to the dumper to help prevent injury during an overturn?

# 8. APPENDIX 3 SEAT, SEAT BELT AND IMMOBILISER MANUFACTURER QUESTION SETS

**Seat Manufacturers**

1. What is the range of seats supplied to OEM dumper manufacturers or manufacturers of other mobile plant e.g. lift trucks.
2. How is the design of dumper seats specified?
    a. Does the OEM specify the design?
    b. If yes, how detailed is the OEM involvement?
3. What sort of seat belt designs can be fitted on the seats you supply to dumper OEMs?
    a. Do dumper OEMs specify specific types seat belt design or manufacturer?
4. Has your company ever supplied seat/seat belt products that incorporate safety interlock technology that would prevent use of the machine unless the seat belt is fastened?
    a. If yes, please provide more details of how the system works.
    b. If no, why not? Has the company ever considered such technology? What would be the additional cost implications?
5. Has the company ever discussed seat/seatbelt safety interlock technology with dumper OEMs?

**Seat Belt Manufacturers**

1. What is the range of seat belt types supplied to seat and/or OEM dumper manufacturers, or manufacturers of other mobile plant e.g. lift trucks.
2. How is the design of dumper seat belts specified?
    a. Does the OEM specify the design?
    b. Does the seat manufacturer specify the design?
    c. If yes, how detailed is the OEM/ seat manufacturer involvement?
3. What sort of seat belt designs do you supply to that are suitable for dumpers?
    a. Do dumper OEMs/ seat manufacturers specify specific types seat belt design?
4. Has your company ever supplied seat/seat belt products that incorporate safety interlock technology that would prevent use of the machine unless the seat belt is fastened?
    a. If yes, please provide more details of how the system works.
    b. If no, why not? Has the company ever considered such technology?
5. Has the company ever discussed seat/seatbelt safety interlock technology with dumper OEMs or seat manufacturers? What are the additional costs associated with providing interlocked or other solutions?
6. Specifically have you considered integrated warning systems, high visibility seatbelts or other methods to encourage the wearing of seat belts
7. How do you take account of human factors and ergonomics in design/ manufacture of seatbelts
8. Do you involve end users in the design process - if so, how?
9. Do you solicit/ receive feedback from end-users using your products on dumpers
10. Are you aware of operator views on the lap belts typically provided on site dumpers

11. Are you aware of accidents on dumpers and does this influence your design process or considerations in any way
12. In what ways do you think seatbelts could be improved on dumpers
13. What do you see as the main challenges to achieving such improvements

**Immobiliser Manufacturers**

1. What immobilisation technology do you produce for mobile plant?
2. Does the technology include methods for ensuring operators wear seat belts on mobile plant which cannot be readily defeated (for example interlocked seat belts which can be permanently fastened behind the operator?)
3. What sort of plant is you immobiliser technology currently used in?
4. What are the key features of the technology and how does it work to make machines safer?
5. Could the technology be ported or adapted for use on FT dumper vehicles?
6. What would be the additional costs for the various technologies your company offer?

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# The use and non-use of seat belts in the operation of forward tipping dumpers

In the event of a forward tipping dumper (FTD) overturning, the operator will be protected from death and serious injury by wearing their seat belt. The seat belt works in combination with the roll over protection system (ROPS) to keep the operator in their seat, preventing them being crushed by the machine. Unfortunately, a proportion of operators choose to operate FTDs without wearing a seat belt and thus increasing their risk of death or serious injury should the machine overturn. Using semi-structured interviews to gauge the opinions of trainers, original equipment manufacturers, seat and seat belt manufacturers and FTD operators, this research aimed to better understand the reasons why FTD operators choose not to wear their seat belt when operating their machines. The research also explored potential solutions that would encourage operators to wear their seat belt more, including possible design control measures such as immobilisation technology, alternative designs of seats and seat belts, and of the overall FTD machine.

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