This Peer Review is a free standing document representing work undertaken by the Inquiry into the Underlying Causes of Construction Fatal Accidents. The Peer Review has informed Rita Donaghy's Report[a] but the contents are not necessarily endorsed by the Inquiry nor necessarily reflected in Rita Donaghy's recommendations. It represents useful background work, with sources clearly identified, to inform discussion.

Secretary of State for Work and Pensions
Inquiry into the Underlying Causes of Construction Fatal Accidents

Independent Review of the Phase 2 Analysis of Fatal Accident Cases[b]

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Introduction

As part of Phase 2 of the Inquiry into the underlying causes of construction fatal accidents conducted for the Secretary of State for Work and Pensions, it was agreed that there should be a detailed analysis of approximately 25 fatal accidents in the construction industry. The objective was to enrich the understanding of the Inquiry about the deeper causal factors and influences. Although 25 accidents is a relatively small sample of the over 200 fatalities over the period 2005/06 to 2007/08, it was felt that such an analysis would highlight commonly occurring issues and allow a semi-quantitative comparison with the issues raised in the research and literature survey and the perceptions of the important issues raised in the interviews with and submissions from key players in the construction system. This could highlight issues where perceptions were strongly backed up by accident analysis, but also those where there appears to be a discrepancy in either direction between those sources of evidence.

The Phase 2 Analysis of Fatal Accident Cases has represented an important element in the Inquiry. The peer reviewers have viewed their tasks in relation to the Phase 2 report as two-fold: to review the processes themselves; and to comment on the outputs of these processes. This report therefore involves an account of the process of selection of the 28 fatalities; a critical review of the process together with suggestions as to how it might be adapted or improved in the future. Our comments on the content of earlier drafts of the report have already been conveyed to its authors with a commitment to address these in the final versions of the report.

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[a] Rita Donaghy's Report to the Secretary of State for Work and Pensions. 'One Death is too Many: Inquiry into the Underlying Causes of Construction Fatal Accidents', July 2009. www.dwp.gov.uk/publications/policy-publications/fatal-accidents-inquiry.shtml

[b] Health and Safety Executive. Phase 2 Report: 'Inquiry into the Underlying Causes of Construction Fatal Accidents – Review and sample analysis of recent construction fatal accidents', 2009. http://www.hse.gov.uk/construction/inquiry.htm

This Phase of the Inquiry provided a unique opportunity to the three peer reviewers both to oversee elements of the inquiry and to understand more of the processes and situational events, which lead to a fatality. While all three peer reviewers were engaged in this process, it was agreed that one of our number, Professor Andrew Hale should play a close role on behalf of the three peer reviewers and the Inquiry Chair in advising on, monitoring and reviewing the process of, and tools and methods used for this analysis and for the drawing of conclusions from it. The process and results of the analysis are described in the report[a] "Phase 2: Underlying causes of construction fatalities – Review and sample analysis of recent construction fatal accidents" prepared by HSE for the Inquiry. The role of the Chair and independent peer reviewers is briefly described in that report, within the whole context of the study, but is explained in more detail here.

Critical Review of the Study

1. Case selection

It was considered important that the choice of the 25 cases to be analysed should be done by the Chair and peer reviewers, in order to avoid any possible bias in a selection by the regulator. The selection of the fatalities was conducted in an open manner, with inquiry chair and peer reviewers having complete discretion over the selection of the cases, based on our existing knowledge of fatalities in the sector. Rather than employing a random selection strategy, the Chair and peer reviewers decided to select accidents that would illustrate as wide a range of these characteristics as possible. Eventually 26 cases with 28 fatalities were chosen for analysis. A choice of 28 from 211 is only 13.3% of the fatalities in the three-year period chosen to represent recent fatalities. The sample is a small one. But it is illustrative of a range of circumstances leading to fatal incidents in construction. It is clearly not comprehensive nor in the view of the peer reviewers should it be regarded as 'representative' in scientific terms. It is nevertheless sufficient for the purpose of qualitative investigation, bearing in mind time and resource constraints of the Inquiry, and has provided a rich seam of individual case study detail. Although the choice should therefore never be considered as fully, statistically representative of all categories of construction activity or scenarios of accidents, the statistical data produced in Annex C to the Phase 2 report show that the accidents chosen are reasonably spread over the categories mentioned. Hence, the most commonly occurring factors involved in them will also be illustrated in the case studies selected.

In order to facilitate the choice by the Chair and peer reviewers, brief descriptions of all accidents over the period were provided from HSE records, together with key classifiers, such as the sector of work (public / private / domestic), size of project / site, type of construction work (refurbishment / new build / civil engineering / etc), accident type (fall / electricity / collapse / etc), age, employment status and nationality of victim, etc. and the numbers of fatalities falling into each of these categories over those three years. The Chair and peer reviewers then chose the fatalities to be studied in depth. As well as the range of factors mentioned, the choice of accidents to be studied was also influenced by the richness of data potentially available. A decision was also made to include a small number of 'live' cases, where prosecutions were still to be decided or were in process, despite the disadvantage that no information could be published in any Inquiry reports in the short term over those accidents, because of concerns over influence on those decisions and proceedings. The data could, however, be suitably anonymised and included in the analysis. This ensured that enough of the more recent, but relatively complex cases could be included.

2. The methodology

There are many methods available in the academic and professional literature for in-depth analysis of accidents. The essential requirements for such a method are that it clarifies the processes leading up to the accident, tracing them back from the proximal errors and failures into the processes of provision of the risk control measures that failed, and further into the risk analysis and planning of work, and the design, purchase/hire, installation and maintenance of any hardware and software and the equivalent selection, training, motivation and appraisal of people doing safety-related tasks, and finally into the influences of regulatory, market, societal and environmental issues framing such processes. The categories should clearly link to an explicit model of how potential and actual risk controls work to block or control negative influences in all of those processes.

A shortlist of appropriate methods was made, which included Events and Causal Factors Analysis (ECFA) (DOE 2002), Tripod (Groeneweg 1998), Storybuilder (Bellamy et al 2007), Accimaps (Rasmussen & Svedung 2000) and HFACS (e.g. Dekker 2002). All of these methods require significant levels of competence in the analyst to extract the information from available sources and categorise it into the form of the method. Given the very short timescale of the project, this was the major constraint on the choice of a method, and led to the choice of HFACS as primary method, since the Human Factors trained analyst available in HSE to do the work had received adequate training in this method and not in the others on the shortlist. An added advantage was that the same method had been used in studies reported in the Phase 1 report to the Inquiry, offering easy links between those two sources of information.

However, the reviewers did express a degree of concern that the HFACS method, stemming as it does from aviation, with a major focus on proximal errors and failures to control complex technology, did not provide a full enough coverage to extract all of the underlying causal factors and influences which were of interest to the Inquiry. As a consequence of this concern it was therefore agreed to extend the HFACS classification with categories drawn from the underlying safety management models also used in studies reported in Phase 1, particularly those carried out by Bomel (2001, 2003a and b, 2004. These filled in the organisational and 'system level' (regulatory/market/ societal) levels and produced the modified HFACS classification method, which was used to elicit the information about all of the accidents studied.

As a check on the coverage and applicability of the chosen classifications, one of the peer reviewers, Professor Andrew Hale, subsequently carried out a mapping exercise to compare this extended HFACS classification with the Bomel management model, HS(G)65, the requirements in both the CDM regulations and the ACOP based on them, with a generic safety management model developed in a European Union project (ARAMIS – Hale & Guldenmund 2004), which is specifically designed to show the management processes needed to ensure risk control. That model also formed the basis for Storybuilder. The mapping (see Annex 1) showed that the ARAMIS model had a clearer categorisation of the safety management level than HFACS, and one which led more directly to recommendations about where in the safety management system improvements would be necessary to combat the accident processes. Therefore it was used to recode the information elicited using HFACS in the final analysis reported in the HSE Phase 2 report.

Finally, during the analysis process, which Professor Hale monitored and gave advice on, the lowest system level of the classification of HFACS, that of the human errors, was also found to generate some confusion among those involved in the data elicitation and classification. By returning to the original texts by James Reason (1990) on which the method is based, it was possible to arrive at a more transparent grouping of error types for final use in the analysis.

3. Data elicitation and analysis

The information for the analysis was elicited from the inspectors responsible for the fatalities selected, and was done by one analyst, ensuring continuity and comparability. The Chair and peer reviewers were able to sit in on almost half of the elicitation sessions, which were conducted either in person, or over video-conference links. It was clear that these sessions were conducted in a constructive and open sphere and that the data collected was suitably free of bias. Inspectors were able to add very considerably to the formal reports, based on their broader knowledge of the accidents, producing a much more nuanced view of causal factors than the relative black and white required for legal proceedings. This allowed for a classification of factors on a scale of quality of proof that they were actually causal. Any gaps in data were practically unavoidable, due to key knowledge-holders having been the victims, or refusing to cooperate with the investigations, or to issues being outside the area of interest of the original investigations, which were conducted with a different objective to the one the Inquiry has, and so were not studied. In a small minority of cases the process operated less satisfactorily, generally in those cases where the original HSE inspector was no longer available and the documentation on the case was not easily available.

While, as we indicate above, the method of investigatory interview, with one investigator conducting all of the interviews, had great value in terms of continuity, it does also contain some weaknesses. This style of investigation places heavy reliance on following a set procedure of investigation, a highly structured interview schedule in this case, to uncover ‘underlying causes’. It is well established in social science fieldwork that there is a danger that with repetition and the imposition of tight time constraints such set procedures may develop into routines that operate for their own sake rather than as devices to elicit quality information for analytical purposes. Such is the case for example where interviewers attempt to interview too many subjects too quickly and when, in an effort to follow the interview schedule, interviewers ask leading questions and/or direct interviewees in ways that emphasise their own biases, sometimes at the expense of those of the interviewee. It was, perhaps, inevitable with so many hearings, over such a wide geography, being held over a relatively short period, that we did observe a few instances when questions could have been interpreted as leading or when it appeared that the HSE inspector being interviewed was being 'hurried on'.

The ‘unit of analysis’ for each accident was the individual errors which the investigating inspectors believed were the proximal causes or contributors to the fatality. These were then traced back one by one into the underlying factors in the four system levels. There were therefore potentially a number of errors per accident. The HFACS tool, as modified, seemed to be quite successful in eliciting these errors as starting points, and the inspectors had no difficulty in identifying several. However, there are two criticisms which could be levelled at this approach. It relies on the inspectors’ memories and mental models of what are errors, and it does not give space for technical failures as proximal factors. The latter had therefore to be rephrased as underlying errors leading to the technical failures where appropriate. In practice these shortcomings did not seriously limit the coverage and quality of the information elicited. However, use of a formal tool such as ECFA to clarify the sequence of events and causal factors before starting on the error and failure analysis would improve this step in future use of the technique.

At the same time it needs to be clearly stated that none of the peer reviewers experienced barriers to their involvement and any interventions that we made or questions that we raised were welcomed and taken on board unreservedly. We in no way felt that our observations were ignored or were not properly dealt with. The issues that we raise are directed towards improving the method used in future, a course of action we strongly recommend to HSE, due to the rich material following from such an analysis. They relate to:

- an inevitable lack of knowledge where, due to the passage of time, the HSE inspector who had conducted the initial enquiry was not available and another inspector with a more limited knowledge of the case had to step in;
- a consequent greater degree of speculation, particularly where the documentation held on the case was reactively sparse; and
- an element of fatigue on the part of the individual conducting the hearings, due to their sheer number and the relatively short period of time.

In addition, there are some areas included in the HFACS-C template where the absence of information directly from the DP made it impossible to draw clear conclusions. This was particularly so when trying to assess whether underestimation of risk, fatigue and stress had had a role in the accident, since there is always a large degree of subjectivity in these assessment. For this reason we favoured a more cautious drawing of conclusions in these areas.

If the HSE was to decide that this process of gathering and analysing data had longer term uses and our collective view is that there is much to be gained by adopting a consistent analytical method to investigate fatalities, then these criticisms could be overcome by investigatory hearings taking place much sooner and without the pressure to complete so many over such a short period of time.

Professor Hale was able to monitor the analysis of the accidents using the finally developed methods described above, by participating in the analysis of the first few, and then sampling and checking the analysis of the remainder. The quality of this analysis was very high.

In the view of the three peer reviewers, the report provides an extremely useful analysis of the underlying causes of fatalities in the cases examined. With the suggestions for elaboration of the method described above it has even greater value for future use.

Reflection

Reflecting on the development of this data collection and analysis method, it is clear that it suffers from a number of limitations. In ideal circumstances the development work on the data collection tool and the analysis classifications would have been done on a small sample of accidents before the main body of data collection started. The short deadlines for the Inquiry did not allow for this. This gave rise to considerable recoding in the analysis stage, requiring extensive listening to the tapes of the elicitation processes. However the end result was of high enough quality to be of considerable use to the Inquiry in its further deliberations. It also satisfies the criteria of scientific rigour to the extent that is possible with this sort of data.

It is recommended that HSE consider using the tool finally developed to conduct studies of more fatal and high potential accidents, to extract a more robust picture of underlying causes than is possible from a sample of 25. Instruction of field inspectors, who conduct the initial investigations, in the tool would ensure that they collect the necessary data for all levels and categories whilst the accident is recent. Use of the tool on a more routine basis would provide HSE with a much richer picture of underlying causes for use in policy and strategic and tactical decisions. The results of the analyses, suitably anonymised, would also be useful to other players in the industry.

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Annex 1. Mapping of extended HFACS classification with the Bomel management model, HS(G)65, CDM regulations and CDM ACOP, with ARAMIS model (Hale & Guldenmund 2004)

Combined model	Bomel	HFACS	Loughborough	CDM regs	CDM ACOP	HSG65 App 5	HSG65 Text
Output of delivery system - Modified Delft	**Human/technology**	**Preconditions for unsafe acts**	**Immediate accident circumstances**	**Not needed, as can map to next level**	**As CDM Regs**	**Immediate causes**	
Availability (manpower planning)	Fatigue, alertness	C.2.2.1, 3.3.1, 3.3.2	Fatigue			People	
Competence, suitability	Competence, situation awareness, health, lifestyle, suitable human resources	C.2.2.2-5, 2.3 (all), 2.4.4, 3.1.2	Capabilities, actions, Knowledge, skills, health			People	
Communication, cooperation	Teamworking, communication (D7)	C.2.4.1, 3.1.1	Work team, communication			People	
Goals & Procedures	Information, advice					Procedures	
Planning + Risk Assessment & Risk Control Selection	Risk perception	C.2.1.5, 3.1.3, 3.3.5					
Participation, motivation & conflict resolution	Motivation/morale, compliance, teamworking (peer pressure), alertness	C.2.1 (all), 2.4.2, 2.4.3, 3.1.4, 3.3.3, 3.3.4	Behaviour, actions			People	
Hardware functioning	Plant/equipment operability, safety equipment, access	C.1.2.3	Material/equipment condition, suitability			Premises, plant & substances	
Hardware & workplace ergonomics/ usability/hazard	External & internal work environment, plant/ equipment operability, safety equipment	C.1.1.1, 1.1.2, 1.1.3, 1.1.4, 3.2 (all)	Materials, equipment, workplace, usability, layout, space, lighting, noise, local hazards, cold, hot, wet			Premises, plant & substances	
Delivery systems - Modified Delft	**Management**	**Organisational influences**	**Shaping factors**				**Management cycle minus policy**
Availability (manpower planning)			Work scheduling	10.2.c, 22.1.f+i		Competence	
Competence: selection, training, information	Recruitment/selection, training. communication (O7)	B.2.2.1, 2.2.2, 2.2.3, 5.1, 5.2, 5.3		13.4.a-c, 13.5, 22.2, 39.3, 41.5-6	150o, 173, 174, 179.b+e, 182-185, 189, 191, 193-246, 252	Competence	Communication, competence, training
Communication, cooperation	Safety culture	B4.4.2		5, 24.a	24.c+e, 43.c-d, 44, 50.c, 92, 151-153, 179.h, 187.e241, 242, 249, 250, 251,		Cooperation, communication
Goals & Procedures	Procedures,	B.4.1 (all)		13.4.d-f, 19.2.c, 22.1.d-e, 39.1-2	44-46, 150.k, 167, 168	Planning, cooperation, communication	Risk control systems
Planning, Risk Assessment & Risk Control Selection	Planning, management & supervision	B.2.1.4, 4.2		6, 7, 10, 13.2, 15, 16, 17, 19, 20, 22.1(esp. A-e+j), 23, 29.2	20-23, 27, 43.b, 44-46, 50, 55-60, 62.c-d, 65, 66, 72-74, 77-82, 93, 94, 103-107, 119.c, 120, 124-128, 132-134, 148, 150(esp.c,-e+g+l), 156-166, 179(esp.c-e), 180, 181, 188, 189, 246, 251, 252, 256-268	Planning, assessing risks, cooperation	Control, planning, risk assessment, hazard identification, risk control, prioritising H&S activities
Participation, motivation & conflict resolution	Safety culture, (?pay & conditions)	B.3.5	Safety culture		24.c, 45, 241, 242, 246, 249, 250	Control	Cooperation, communication
Design for constructability	design for safe construction, buildability	B.4.5		7, 10, 11, 12, 15, 17, 18, 20.1.c, 20.2.b-d, 28	23, 27, 44, 47, 48, 50d, 55-57, 65-67, 87, 93, 94, 98-102, 106, 107, 109-145, 150.m, 179.f, 192, 256-268	Planning	
Hardware design, purchase & installation	Equipment purchase, equipment design, process design,	B.2.1.2, C.1.2.1	Design, specification, supply availability, construction processes, works design, site constraints, housekeeping	7, 10, 13.6, 15, 17, 20.1.c, 20.2.b+d+f, 22.1.b+l, 25, 26, 27, 29, 30, 31.1-3, 32.1, 34, 35, 36, 37, 38, 40, 41, 42, 43	20, 23, 27, 65-67, 93, 150.j+m, 170-172, 179.f, 192, 256-268	Planning	Workplace precautions, risk control systems
Hardware inspection & maintenance	Inspection & maintenance	B.2.1.3, C.1.2.2		31.4, 32.2-3, 33, 35.1.c, 41.3		Planning	Risk control systems
Monitoring & correction, supervision	Supervision, safety culture	B4.4.1, 4.4.3, C.3.1.2	Supervision	13.2, 22.1a, 23.1b	50f, 51, 52, 61d, 90d, 96j, 98-102, 105, 135, 137f, 150g, 158, 164-166, 179c, 180, 181, 220, 251, 252f, 253.	Monitoring	Supervision, performance standards, measuring performance, active & reactive monitoring
Monitoring & improvement + System Review	Incident management & feedback, safety culture	B.4.3		19.2.a+d	52, 53, 164-166, 172, 186, 187c+f+g, 190, 252, 253.	Monitoring, review	Information management & systems, performance standards, measuring performance, active & reactive monitoring, investigation, auditing & review
Corporate - modified Bomel	**Corporate**	**Organisational influences**	**Originating influences**				**Policy**
Organisational structure, roles & responsibilities	Organisational structure	B.1.2		8, 13.1-13.3, 14	20, 23-42, 49-54, 83, 108, 143-145, 175,	Control	Control
Ownership/control/leadership top management	Ownership & control	B.3.1				Communication	
Company (safety) culture	Company culture	B.3.3, 3.5	Safety culture				Corporate strategy & social responsibility, manufacturing & operating policy
Contracting strategy	Contracting strategy	B.1.1 (all), 4.4.1, 4.4.2		4, 8, 13.1-13.3, 14, 19.2b	10, 11, 24, 26, 33-42, 43.a, 47, 49-60, 62a+b, 63, 64, 69-75, 83, 86, 88, 89, 91, 108, 114, 146-149, 150.h, 154,155, 176-178, 187.d		
Labour relations, consultation	Labour relations	B.3.2, 3.4		24.b-c	150.p, 179.i, 247, 248, 251, 252, 254-255		Human resources
Safety Management & Learning system, incl. professional safety advice	Safety management		Risk management, project management	7, 9, 10, 13.1-13.3, 14, 20, 22.1a	49-54, 64-75, 84, 85, 90, 95-97, 108, 143, 156-159, 175, 179.j, 187.a+b		QEHS management, H&S advisors
Company profitability/resources	Company profitability	B2.1.1, 2.1.5					Finance
Environment - modified Bomel	**Environmental**	**Environmental influences**					
Political	Political	A.1					
Regulatory	Regulatory	A.2		1, 2, 3, 21, 45-48	1-9, 12-19,		
Market, incl. financial	Market	A.3	Economic climate, client requirements				Marketing
Societal, incl. image	Societal	A.4			28-32		Corporate strategy & social responsibility