Chapter 12.

Conclusions.

1 The identification of hazards is fundamental to their management. Hazard auditing is a formal systematic examination of a situation for the identification of hazards.

2 The development of a hierarchy of concepts that have the potential to provide evidence of proneness to failure, (chapter 2), is described in this thesis. The hierarchy is a structure that can be used in the design of hazard audits. Sections of the hierarchy are presented at appropriate positions in the thesis.

3 The construction industry has a particularly poor record for safety. The construction of a project provides the reference for the hierarchical structure developed in this thesis.

4 A search for hazards should not be restricted to an examination of a closed system. Hazards can exist and develop outside that system and manifest themselves within the system. There are no time constraints on the development of hazards. For a construction project hazards should be looked for in the larger systems of an overall project, industry, and society.

5 Continuing knowledge acquisition within a problem solving cycle is central to the methodology of this research. Many of the concepts included in the hierarchy arise out of knowledge that is qualitative and subjective to the extent that perceptions about influence on proneness to failure can be personal with no obvious basis for comparison. The influence and interaction of perception and worldview are intrinsic to the problems of this research that involve identifying and linking concepts in a structural form. A reflective practice loop, (Blockley, 1992), models this process.

Knowledge acquisition, as part of the reflective practice model of problem solving, may come from a variety of sources, including, but not restricted to, "experts". The interpretation of the researcher's own experience with knowledge acquired from experts is an importance part of the process.

6 Semi-structured interviews of experts is a useful means of acquiring knowledge from a domain that is primarily qualitative and not restricted to a well defined context.

7 A grounded theory approach, (Glaser and Strauss, 1967), to the elicitation of knowledge from interviews with experts, provides a method of generating theory.

8 Policy implementation can be considered in broad terms as being dependent upon a policy, a management framework, and culture.

9 Objectives are fundamental to any undertaking. Formulating objectives in a policy statement establishes them. They are then less prone to unnoticeable change, neglect, or abandonment.

10 A management framework of organisation, information arrangements, and planning arrangements, provides a basis for the development and control of all activities, systems, and procedures that are necessary for the achievement of objectives.

11 The characteristics of culture, (a set of beliefs, norms, attitudes, roles, and social and technical practices), are influential in stimulating and motivating the conception, development, and implementation of policy.

12 The state of the art of technology describes the extent of knowledge, products and processes that is available within a technology. This is a socio-technical system whose functioning is dependent upon the interaction of individuals, organisations, and technical knowledge, products and processes.

13 An investigation for evidence of proneness to failure in the state of the art of technology requires evaluation by experts. This means that evaluation of knowledge,

products, or processes should be based on the judgement of experts in the appropriate domain, (technology). Assessment requires comparison with standards, established by, or implicit to, experts in the appropriate technology.

14 There is a need to establish requirements for research and development in technology. This requires that the consequences of the development of technology be extensively researched to mitigate against failure and its consequences. An understanding of technology as a socio-technical system is inherent to this.

15 The expectations of society for safety, and the multi-disciplinary nature of hazards indicate a need to treat the identification and management of hazards as a separate, distinct discipline of hazard engineering.

16 The development of hazard engineering requires that relevant knowledge from domains such as sociology, psychology, philosophy, science, and engineering be gathered together as a distinct body of knowledge.

17 A hazard audit, for the identification of hazards is central to hazard engineering. Hazard auditors should be knowledgeable about the subject being audited as well as in the procedures used for auditing. It is envisaged that hazard auditing would be developed as a specialist activity.

18 Hazard audits and auditors need to be credible to both society and those whose decisions are influenced or dependent upon the results of an audit. This requires that there be confidence and trust in hazard auditors who therefore need to develop a reputation that is an assurance of competence, experience, integrity, and responsibility.

19 The use and development of reliability and risk assessment techniques is an activity of hazard engineering. Further research could be undertaken in the application of reliability and risk assessment techniques in the construction industry. This would involve the collection of data for both failed and successful structures. The influences

of human factors such as human error, workmanship, and supervision could be investigated.

20 There are no set rules for the assessment of concepts that relate primarily to human interactions. Character, personality, and circumstances influence these interactions. Assessment requires interpretation of the combination of judgement and knowledge in a given situation. Auditors need to possess a reputation such that there can be confidence in both their judgements and interpretations of situations.

21 Occurrences of incidents and manifestations of health hazards provide the opportunity to add to the knowledge domain of hazard engineering. The learning cycle should consist of: incident, reporting, investigation and analysis, dissemination of information from investigation and analysis, utilisation of this information, dissemination of knowledge gained from utilisation. The potential for development of knowledge is improved if the number of people having access to knowledge is increased; providing of course that the knowledge has some relevance to those in receipt of it. The dissemination of information/knowledge is of particular importance.

22 The development of a strong safety culture is central to the implementation of policy that has safety, (and consequently the minimising of hazards), as a main priority. A safety culture will have stronger roots if it is based on a moral obligation towards ensuring the safety of others; as distinct to a belief that safety can be profitable or a requirement to conform to legislation.

23 As evidence of proneness to failure on a construction project, the "state of society", can be considered in terms of its relationship with the construction industry, safety, and safety in the construction industry.

24 Recognition and understanding of the hazards that exist or develop in society and industry are important to the management of hazards in any context or situation. Considerable research and study of such influences is required to facilitate the

recognition and understanding of such hazards.

25 Assessment requires that there be standards with which comparisons can be made. There is a lack of standards associated with concepts that provide for an evaluation of the state of society for evidence of proneness to failure. Research is needed to determine standards. This involves establishing clear precise descriptions of the characteristics of evaluation and the relationships between them. Of particular significance, is the quality/safety/economic relationship that exists in society. Research will involve the elicitation of information from both experts and society. Properly conducted surveys of representative cross sections of society is probably the most effective means of gauging society's views. Having established the basis for comparison; the effort, commitment, and resources required for subsequent assessments will be similar to those needed for the initial research.

26 An industry represents the link between society, (a social environment), and projects associated with that industry. An industry influences both society and the individual members of that industry. The nature of that influence will be determined by those who possess the greatest power within the industry.

27 For the construction industry, the link between safety and profitability is not as obvious as in some other industries. The priorities of safety and profitability are likely to differ between corporate business interests and individuals working in the construction industry.

28 Representative organisations for individual members of the industry, such as professional institutions and unions, should have a self interest in the promotion of safety. Such organisations need to develop power if they are to be a position to promote these interests.

29 It is important to evaluate the implementation of overall policy for evidence of proneness to failure. Overall policy, for industry, project, and project phase, deals

with the quality/safety/economic relationship. Quality and safety should not be pursued at the expense of commercial viability. In the long term this may be self defeating because, in a UK type society, the availability of resources for the provision of quality and safety is linked to commercial success. Overall policy provides the framework for the implementation of policies relating to safety and the state of the art of technical engineering.

30 A standard needs to be established for the quality/safety/economic relationship in an industry. This provides a common base for assessments of culture relating to safety, the state of the art of technical engineering, and overall policy.

31 A project can be classified into phases that represent definable stages in the development, use, and withdrawal from use of a project. These phases are: feasibility and planning, conceptual design, design, construction, operation, decommissioning and demolition, post decommissioning and demolition.

32 Part of an examination of a project for evidence of proneness to failure can be focussed on the project as a closed system. An examination in this context needs to look for hazards within the system as a whole, (i.e. the project), in the separate subsystems, (i.e. the project phases), and in the inter-dependencies amongst the subsystems.

33 The development, use, and withdrawal from use of a project can be affected by society's reaction to it. Even if considered as a closed system, an examination for evidence of proneness to failure of a project, or project phase, should investigate the interaction between project and society, that is a consequence of a project's existence.

34 The perception of risk influences the identification of hazards. The perception of risk may be biased by heuristic processes, (Slovic, Fischoff and Lichtenstein, 1982). This may bias judgement about the presence of hazards or the extent to which they

represent evidence of proneness to failure. Similar biases due to attributional processes, (Dejoy, 1985), can influence judgement about the causality of an event. This may affect decision making based on the results of an audit. Auditors need to be aware of such processes and be able to take appropriate action to mitigate the effects.

35 An examination of the construction phase of a project as a closed system should be taken to include both off-site and site arrangements. It should cover the separate processes, organisations, and individuals and the inter-dependencies amongst them.

36 A disaster sequence describes the conditions and events associated with disaster. This sequence can be interpreted to cover all the conditions and events between the "normal situation" before, and the "normalised situation" after, a disaster, (Turner, 1978). Hazard audits may be described by their association with conditions and events in a disaster sequence. High level hazard audits cover the full extent of the disaster sequence. Low level hazard audits relate to particular positions within the disaster sequence. They are used to examine specific activities, systems and procedures. Audits that deal with activities, systems, and procedures associated with conditions and events later in the disaster sequence are of the lowest level.

37 The hierarchy presented in this thesis is a framework that can be used in the design of high level hazard audits, (chapter 2). Hazard auditing should be looked upon as a programme comprising low and high level audits to provide a structured examination of a project at different levels of detail. It should encompass the conditions that make up a disaster sequence. High level audits need to examine the use of low level audits for evidence of proneness to failure. An audit should also provide for a self examination of its own use.

38 Safety is integral to quality. Deficiencies in producing quality may be evidence of proneness to failure.

39 The hierarchy will, and should be subject to continual change. This will include

modifications, removal, and addition of concepts.

Chapter 13.

Suggestions for further work.

13.1 Objectives.

1 To outline the principal requirements for further work in the development of the hierarchy as a structure that can be used in the design of hazard audits.

2 To indicate areas of further study that need to be undertaken to facilitate audit assessments of particular elements of the hierarchy.

3 To suggest areas of research for the development of the hierarchy as a knowledge based system on a computer.

4 To outline the contractual and legal implications of the introduction of hazard auditing into the traditional contractual relationships of the construction industry.

5 To outline briefly, other problem domains, where the development of similar structures to that presented in this thesis may be of value.

13.2 Continuing development of the hierarchy.

The hierarchy presented in this thesis relates to the development, use and withdrawal from use of a project. It is focussed upon the construction phase of a project. The hierarchical developments of other project phases are obvious areas for further work.

Human factors engineering, as an influence on proneness to failure is an area of the hierarchy that could be refined. The current state of the art in human factors engineering should provide a sound basis for the hierarchical development of what is a specialist activity of the discipline of hazard engineering. Hazard auditing procedures and the skills associated with their use should, I would suggest, be continually developed as another specialist activity of hazard engineering. There is scope for study into the use of reliability and risk assessment techniques, (chapter 7), in construction. This could include studies into the influences of human factors, such as workmanship, supervision, and human error, on reliability in construction. This is linked to human factors engineering.

The absence of a credible base or yardstick, against which comparisons can be made, presents a basic problem for assessment. This situation exists to a large extent in concepts that relate to assessment of the "state of society" and "state of the industry" for evidence of proneness to failure. Open world problems, (Blockley, 1989), associated with social systems are particularly complex, and can be further complicated by the diversity and extent of the social environment. Considerable study and research are necessary if assessment of the "state of society, (chapter 8, fig. 8.1), in particular, is to be credible. It is necessary to establish the basis against which subsequent evaluations can be compared. This requires that systems, (concepts), be as clearly and precisely defined as is possible, in terms of characteristics and the relationships between them. For example, establishing a quality/safety/economic relationship and a standard for comparison is important in every context, (society, industry, project, and project phase), because of its relevance to evaluation of culture and policy implementation. Determining society's beliefs is especially difficult and will necessitate extensive research. An initial assessment produced through research will provide a basis for subsequent assessments. The work required for subsequent assessments of the state of society would require similar effort and resources to that of the initial research. This area of research, would be expected to generate further research into the recognition and understanding of hazards in society.

13.3 Utilisation of the hierarchy in future developments in hazard auditing.

At the present state of this research, the design of an audit from the hierarchy, and its analysis, would be, primarily, a manual process. Further research could investigate the development of this knowledge based-system on a computer. In practice, this could be a step by step development, beginning with those sections of the hierarchy that might prove most amenable to such development. The most amenable, being those sections in which inter-dependencies between concepts appear least complex. This would be situations where the interpretation of the combination of judgement and knowledge appears most straightforward. For example, assessment of the "state of the art of technical engineering" would appear to be less complicated than that of the "construction process" that involves judgement and interpretation of complex individual and organisational interactions that are dependent upon circumstances.

Presenting the concepts in an object data base, as described in chapter 2, clause 2.6, may be useful if an object orientated method of programming is used to implement the knowledge-based system on computer. This would not be a knowledge-based expert system in the sense that non-experts could use it to predict proneness to failure. It would be a knowledge-based support system, used by experts. The hierarchy presented in this thesis could provide the basis for this system. The potential and effectiveness of the system could be continually enhanced by adding concepts to the knowledge base and by obtaining further evidence to support the inclusion of concepts in the knowledge base. Elicitation of knowledge from experts can be used to add to the knowledge base. Another source of information is case histories. Developing a knowledge base of case histories is therefore another area that could benefit from further research, (Stone, 1989). The development of knowledge needs to address the problems linked to the maintenance of the learning cycle following an incident or manifestation of health hazard. This cycle, as described in chapter 7, (clauses 7.9 and 7.10), consists of: incident, reporting, investigation and analysis, dissemination of information from investigation and analysis, utilisation of information, dissemination of information from utilisation. Resources and access to information in the "incident learning cycle" are basic requirements for the development of the knowledge bases described here. It is envisaged that these requirements would be available within a very large organisation, (construction or otherwise), where the scale of operations provides the potential for data. The system could be expanded to cover a number of separate organisations operating similar systems. This would not preclude access to any other information.

To summarise, the development of knowledge-based systems linked to the identification of hazards, can be thought of as two complementing systems. These are:

- A knowledge-based support system for the investigation of evidence of proneness to failure. This would be based upon the hierarchy developed in this thesis. It is a tool for the expert.

- A knowledge-based system for learning from case histories of incidents. This would provide support for the inclusion of concepts in the "proneness to failure" hierarchy.

13.4 Legal Implications.

The implementation, as regulation, of the European Communities Commission Council Directives, (1989 and 1992), for safety and health in construction, may, according to some, (Anderson, 1992; Davies, 1992; New Civil Engineer, 1992b), affect the legal responsibilities associated with construction. The position will become clearer, after the introduction of regulation. However, new legislation will have little effect if it isn't used. Considerations about legal implications should address the issue of the use of existing legislation as well as the introduction of new legislation. Two cases, reported in the New Civil Engineer, (1990b and 1991), illustrate this. In the first, a client, Derby City Council, was fined for safety breaches that resulted in a fatal accident during work being carried out by a contractor. In the second case, a consulting engineer, Kenchington Little, was found guilty of breaching the Health and Safety at Work Act, 1974, with regard to protecting the public. In this incident, the consultants were supervising refurbishment when part of the building collapsed. According to the above mentioned reports these cases were unusual in that client and engineer respectively were held liable for incidents during construction. These rulings were not the results of new legislation; they were based on the use of existing legislation. I am not suggesting that new legislation will not produce changes, but it is use of legislation that will determine the extent of changes. In this respect, an increasing consciousness in society about the need to improve safety may influence the use of the law. The law may have to adapt if individuals and organisations adopt specialist roles to deal with safety related issues. For construction, this could be the introduction of hazard auditing as a specialist activity, involving the services of hazard engineers and hazard auditors. Traditional contractual arrangements for construction may need to be changed to accommodate this. In a high level hazard audit of a construction project, the auditor would require access to all processes and organisations involved in the project. This indicates that the auditor's role should be accommodated within contractual arrangements. There is a need to study the implications of this in terms of the legal responsibilities of the auditor and the possible effect on the responsibilities of other contracted parties.

13.5 Auditing within other domains.

Hierarchies that provide the structures for the design of audits could be applicable to other domains such as quality and environmental issues.

It was argued in chapter 10, that safety is integral to quality, (clauses 10.15.5 and 10.17), and it is reasonable to suggest that the framework of activities, systems, and procedures for the provision of safety and quality are similar. Because of this, the hierarchy developed in this thesis might serve as a starting point for the development of a structure that can be used in the design of quality audits.

The growth of knowledge, expanding population, and use of technology has determined that what happens in one part of the world or in particular societies cannot be contained. Hazards are created that impact on the environment, societies, and individuals in disparate and unexpected ways. This can affect the ways of life of separate human populations and the planet itself. There is a requirement to investigate and identify these environmental hazards. Environmental audits provide a tool for the identification of environmental hazards. A hierarchy of concepts that relate to the potential to provide evidence of proneness to failure in the environment could provide a structure that can be used in the design of environmental audits.

13.6 Summary and conclusions.

The hierarchy is not complete, and it is to be expected that concepts will be added, changed, and removed at different times. It could be said that there is scope for additional work in just about every concept of the hierarchy. It was an objective of this research to consider safety in as wide a context as possible so that the open world nature of the problems associated with safety were not reduced to convenient "models" of proneness to failure by ignoring those influences that appear most distant or the most difficult to deal with.

A few of the more obvious areas that could benefit from further work have been suggested. That relating to human factors engineering represents a refinement of the hierarchy in its present form. That for hierarchical development of the project phases, other than construction, is a natural extension of research to broaden the problem domain addressed by the hierarchy. The research suggested, relating to the state of society is necessary to facilitate assessment and add to the understanding of influences on proneness to failure that emanate from society. If this particular area of research is not pursued, assessments associated with these influences cannot be credible. Development of knowledge-based systems, on computer, will reduce the scale of the manual process required for auditing and analysis. They provide a tool for the expert, and a means of developing knowledge.

It has been argued that there is a need to develop hazard engineering as a discipline in its own right. It has also been argued that hazard auditing be developed as a specialist activity. For the construction industry, this may mean changes to traditional contractual arrangements. Consideration needs to be given to the possibility of such changes and the legal implications that may result.

The use of hazard audits, designed from the hierarchy, is essential if their effectiveness is to be tested and their value demonstrated. It is envisaged that the most appropriate context for use would be major construction projects which are of a scale that allows for the implementation of a properly designed programme of auditing.

If there is sufficient desire to mitigate failure, there is no reason why the continuing development of the hierarchy, the development of knowledge-based systems as support for experts, and the use of audits designed from the hierarchy, should not progress simultaneously. The cost of further development in comparison with the cost of failures, even in construction, is likely to be negligible, certainly in the long term. So called reasons for justifying existing efforts put into ensuring safety and health may be excuses for not making greater efforts. Quoting the introduction of new legislation as evidence of an improving attitude towards safety might even come into this category. The use of hazard audits is not a panacea for failure, but recognition of hazards is the first step in dealing with them. I would suggest that the development of hazard auditing, as an essential part of hazard engineering, is a worthwhile and potentially profitable area for further research.

References.

ABERCROMBIE, N., HILL, S. AND TURNER, B. S. (1984). *Dictionary of Sociology.* Penguin Books Ltd. London, UK.

ABERFAN DISASTER. (1966). *Report by the Tribunal appointed to inquire into the Disaster at Aberfan on October 21st 1966.* HC 553. 1967. HMSO. London, UK.

ADAMS, E. E. (1985). Accident investigation procedure. - Some guide-lines for classification. *Professional Safety.* Volume 30, No 8. August 1985. Pages 30 - 33.

ADAMS, J. G. U. (1985). *Risk and Freedom: The Record of Safety Regulation.* Transport Publishing Projects. London, UK.

ADAMS, J. G. U. (1988). Risk homeostasis and the purpose of safety regulation. *Ergonomics.* Volume 31, No 4. Pages 407 - 428.

ANDERSON, P. W. P. (1992). Paper Three. What the new duties and responsibilities may mean for major clients' organisations. *Construction Engineering Safety Conference.* 29 September, 1992. Institution of Civil Engineers. London, UK.

ASHBURN, J. H. AND MACDONALD, C. (1987). Implementation of the management safety audit system. *Canadian Institute of Mining and Metallurgy Bulletin.* Volume 80. December, 1987. Pages 25 - 28.

ASHFORD, J. L. (1989). *Quality management in construction. - Certification of product quality and quality management systems.* Special Publication 72. CIRIA. London, UK.

BAKER, M. J. (1986). Quality Assurance. - A critical review. *IABSE Symposium, Tokyo, 1986.* Reports of the working commissions (International Association for Bridge and Structural Engineering.) Volume 51. Safety and Quality Assurance of civil engineering. Published by: IABSE, Zurich, Switzerland, 1986. Pages 15 - 20.

BAYLEY, H. (1986). Developing a safety conscious approach to plant management and operation. *Transactions of the Institution of Diesel and Gas Turbine Engineers.* October 1986. Pages 1 - 8.

BBC2. (1988). *Construction Accidents.* Shown on 18-10-88. Brass Tacks Series.

BLOCKLEY, D. I. (1980). *The nature of structural design and safety.* Ellis Horwood Limited. Chichester, UK.

BLOCKLEY, D. I. (1989). Open World Problems in Structural Reliability. In: Ang, A. H-S., Shinozuka, M. and Schuëller. (Eds). *Structural Safety and Reliability. Proceedings of ICOSSAR '89, the 5th International Conference on Structural Safety and Reliability.* San Francisco. Aug 7-11, 1989. Volume 3. Pages 1659 - 1665.

BLOCKLEY, D. I. (1992). Engineering from reflective practice. *Research in Engineering design.* No 4. Pages 13 - 22.

BLOCKLEY, D. I. AND HENDERSON, J. R. (1980). Structural failures and the growth of engineering knowledge. *Proceedings of the Institution of Civil Engineers.* Part 1, November 1980. Volume 68. Pages 719 - 728.

BLOCKLEY, D. I., TURNER, B. A. AND PIDGEON, N. F. (1991). *Hazard Engineering.* (Unpublished Manuscript).

BRITISH CHEMICAL INDUSTRY SAFETY COUNCIL. (1969). *Safe and Sound. - Report on Safety Practices in the U.S. Chemical Industry.* Chemical Industries Association Ltd. London, UK.

BRITISH CHEMICAL INDUSTRY SAFETY COUNCIL. (1973). *Safety audits. - A guide for the chemical industry.* Chemical Industries Association Limited. London, UK.

BS 4778: Quality vocabulary. Part 1: 1987. International terms. British Standards Institution. London, UK.

BS 4778: Quality vocabulary. Part 2: 1979. National terms. British Standards Institution. London, UK.

BS 5750. Quality Systems. Part 0. Principal concepts and applications. Section 0.1, 1987. Guide to selection and use. Section 0.2, 1987. Guide to quality management and quality system elements. British Standards Institution. London, UK.

BSI HANDBOOK. (1990). *Quality Assurance.* British Standards Institution. London, UK.

BUCHER, R. (1957). Blame and hostility in disaster. *American Journal of Sociology.* 1957. Volume 62. Pages 467 - 475.

BUILDING ADVISORY SERVICE AND HEALTH AND SAFETY TECHNOLOGY AND MANAGEMENT LTD. (1990). *Construction Chase.* HASTAM Ltd & Building Advisory Service. London, UK.

BUILDING REGULATIONS. (1985). HMSO. London, UK.

BURGESS, R. G. (1984). *In the Field. An Introduction to Field Research.* Allen and Unwin. UK.

BUTLER, B. (1989). Safety first. - Profits last? *Quality and Reliability Engineering International.* Volume 5. 1988. Pages 95 - 100.

CASTI, J. L. (1989). *Paradigms lost. Images of man in the mirror of science.* Abacus. London, UK.

CBI. (1990). *Developing a Safety Culture.* London, UK.

CHAMBERS ENGLISH DICTIONARY. (1988). W & R Chambers Ltd and Cambridge University Press. Cambridge, UK.

CHECKLAND, P. (1981). *Systems Thinking, Systems Practice.* John Wiley and Sons. Chichester, UK.

CHEMICAL INDUSTRIES ASSOCIATION. (1991). *Guidance on safety, occupational health and environmental protection auditing.* Chemical Industries Association. London, UK.

CHILD, J. (1984). *Organization: A guide to problems and practice.* Harper and Row. London, UK.

CHURCHMAN, C. W. (1968). *The systems approach.* Dell Publishing Co. Inc. New York, USA.

CIMAH. (1984). *Control of Industrial Major Hazards (CIMAH) 1984 Regulations.* HMSO. London, UK.

CIRIA. Special Publication 55. (1988). *A clients guide to quality assurance in construction.* CIRIA. London, UK.

CIRIA. Technical Note 121. (1985). *Sample quality assurance documents.* CIRIA. London, UK.

COHEN, A. (1977). Factors in successful occupational safety programmes. *Journal of Safety Research.* Volume 9, No 4. December 1977. Pages 168 - 178.

COLLARD, R. (1989). *Total Quality. Success though people.* Institute of Personnel Management. London. UK.

COLLINGRIDGE, D. (1980). *The Social Control of Technology.* Open University Press. Milton Keynes. UK.

COMERFORD, J. B. AND BLOCKLEY, D. I. (1992). Managing Safety and Hazards through Dependability. *Journal of Structural Safety.* In Press.

CONSTRUCTION WEEKLY. (1990). *TML in race with time to implement safety rating.* 11th July. Page 6.

CONTRACT JOURNAL. (1991). *Civils "gets the dumbos".* 27th June 1991. Page 6.

COOPER, D AND CHAPMAN, C. (1987). *Risk Analysis for Large Projects. Models, Methods and Cases.* John Wiley and Sons Ltd. Chichester, UK.

COWAN, R. S. (1985). How the refrigerator got its hum. In: MacKenzie, D. and Wajcman, J. (1985). (Eds) *The social Shaping of technology.* Open University Press. Milton Keynes, UK.

CUI, W. AND BLOCKLEY, D. I. (1990). Interval Probability Theory for Evidential Support. *International Journal of Intelligent Systems.* Volume 5. Pages 183 - 192. John Wiley and Sons Inc.

CULLEN, W. G. (1990). *The Public Inquiry into the Piper Alpha Disaster.* (2 Volumes). Report by the Hon Lord Cullen. HMSO. London, UK.

DAVIES, V. J. (1992). Paper Four. What the new duties and responsibilities may mean for Professional advisors. *Construction Engineering Safety Conference.* 29 September, 1992. Institution of Civil Engineers. London, UK.

DAVIES, V. J. AND TOMASIN, K. (1990). *Construction Safety Handbook.* Thomas Telford. London, UK.

DEJOY, D. M. (1985) Attributional Processes and Hazard Control Management in Industry. *Journal of Safety Research.* Volume 16, No 2. Summer. Pages 61 - 71.

DHILLON, B. S. (1986). *Human Reliability. With Human Factors.* Pergamon Press. New York, USA.

DOUGLAS, M. (1982). *In the Active Voice.* Routledge and Kegan Paul. London, UK.

EISNER, H. (1991). Safety: the perils of self regulation. *New Scientist.* 12th January, 1991.

Page 22.

ERICSSON, K. A. AND SIMON, H. A. (1984). *Protocol Analysis: Verbal Reports as Data.* MIT Press. Cambridge, MA, USA.

EUROPEAN COMMUNITIES COMMISSION COUNCIL DIRECTIVES. (1989). Council Directive 89/391/EEC on the introduction of measures to encourage improvements in the safety and health of workers at work. 12 June 1989. *Official Journal of the European Communities. (No. L183).*

EUROPEAN COMMUNITIES COMMISSION COUNCIL DIRECTIVES. (1992). Council Directive 92/57/EEC on the implementation of minimum safety and health requirements at temporary or mobile construction sites. Original proposal. 24 June 1992. *Official Journal of the European Communities.*

FEYNMAN, R. P. (1989). *What do you care what other people think.* Unwin Paperbacks. London, UK.

FIDO, A. T. AND WOOD, D. O. (1989). *Safety management systems.* Further Education Unit. London, UK.

FREEMAN, R. A. (1985). The Use of Risk Assessment in the Chemical Industries. *Plant/Operations Progress.* Volume 4, No 2. April, 1985. Pages 85 - 89.

GAINES, B. R. AND SHAW, M. L. G. (1980). New directions in the analysis and interactive elicitation of personal construct systems. *International Journal of Man-Machine Studies.* Volume 13, 1980. Pages 81 - 116.

GAMMACK, J. G. AND YOUNG, R. M. (1985). Psychological techniques for eliciting expert knowledge. In: Bramer, M. A. (Ed). *Research and Development in Expert Systems.* Cambridge University Press. Cambridge, UK.

GAUNT. L. (89-2). Research Report. *The effect of the International Safety Rating System (I.S.R.S.) on organisational performance.* The Centre for Risk Management and Insurance Research. Georgia State University. U.S.A.

GIDDENS, A. (1989). *Sociology.* Polity Press. Cambridge, UK.

GITTUS, J. H. (1986). Risk Assessment. *Physics in Technology.* Volume 17, No 2. March 1986. Pages 75 - 82.

GLASER, B. G. AND STRAUSS, A. L. (1967). *The Discovery of Grounded Theory: Strategies for Qualitative Research.* Aldine de Gruyter. New York, USA.

GORDEN, R. L. (1975). *Interviewing: Strategy, Techniques, and Tactics.* The Dorsey Press. Homewood, Illinios, USA.

GROSS, J. G. (1986). Building Structural Failures. - Their Cause and Prevention. *Journal of Professional Issues in Engineering. A.S.C.E.* Volume 112. October, 1986. Pages 236 - 248.

HALE, R. A. AND GLENDON, A. I. (1987). *Individual behaviour in the control of danger.* Elsevier Science Publishers B. V. Amsterdam, The Netherlands.

HANDY, C. B. (1985). *Understanding Organisations.* Penguin Books Ltd. London, UK.

HEALTH AND SAFETY AT WORK ETC. ACT 1974. HMSO. London, UK.

HEALTH AND SAFETY EXECUTIVE. (1976). *Success and Failure in Accident Prevention.* HMSO. London, UK.

HEALTH AND SAFETY EXECUTIVE. (1980). *Effective policies for health and safety.* HMSO. London, UK.

HEALTH AND SAFETY EXECUTIVE. (1989). *Human factors in industrial safety.* HMSO. London, UK.

HEALTH AND SAFETY EXECUTIVE. (1991). *Successful Health and Safety Management.* HMSO. London, UK.

HEALTH AND SAFETY EXECUTIVE. (BIANNUAL, January and July). *Publications in series: List of HSC/HSE Publications.* Sheffield, UK.

HEIERMANN, H. (1988). Increasing safety consciousness as an employers task. *Giüehauf and Translation.* Volume 124, No 3. Feb 4, 1988. Pages 72 - 76. English translation. Pages 141 - 144.

HEINRICH, H. W., PETERSON, D. AND ROOS, N. (1980). *Industrial Accident Prevention: A Safety Management Approach.* McGraw-Hill Book Company. New York, USA.

HINZE, J. (1978). Turnover, New Workers, and Safety. *Proceedings of the American Society of Civil Engineers.* Volume 104. Division CO. December 1978. Pages 409 - 417.

HINZE, J. AND HARRISON, C. (1981). Safety Programs in Large Construction Firms. *Proceedings of the American Society of Civil Engineers.* Volume 107. Division CO. September 1981. Pages 455 - 465.

HINZE, J. AND PARKER, H. W. (1978). Safety: Productivity and Job Pressures. *Proceedings of the American Society of Civil Engineers.* Volume 104. Division CO. March 1978. Pages 27 - 34.

HOWARD, W. B. (1988). Process safety technology and the responsibility of industry. *Chemical Engineering Progress.* Volume 84. September 1988. Pages 25 - 33.

HSC CONSULTATIVE DOCUMENT. (1989). *Consultative document: Construction management: Proposals for regulations and an approved code of practice. 1989.* Health and Safety Executive. UK.

HSC. CONSULTATIVE DOCUMENT. (1992). *Consultative document: Proposals for Construction (Design and Management) Regulations and Approved Code of Practice.* 1992. Health and Safety Executive. UK.

HSC NEWSLETTER. (February 1992). *HSC Annual Report 1990/91.* No 81. Health and Safety Commission. Bootle, UK.

HSC. (1989/90). *Annual Report. 1989/90.* HMSO. London, UK.

HUGHES, T. P. (1985). Edison and electric light. In: MacKenzie, D. and Wajcman, J. (1985). (Eds) *The social Shaping of technology.* Open University Press. Milton Keynes, UK.

INTERNATIONAL ATOMIC ENERGY AGENCY. (1980). *Quality Assurance Auditing for Nuclear Power Plants: A Safety Guide.* International Atomic Energy Agency. Vienna, Austria.

INTERNATIONAL LOSS CONTROL INSTITUTE. (1988). *International Safety Rating System.* Institute Publishing. (Division of International Loss Control Institute). Loganville, GA,. U.S.A.

KALDOR, M. (1985). The armament process. In: MacKenzie, D. and Wajcman, J. (1985). (Eds) *The social Shaping of technology.* Open University Press. Milton Keynes, UK.

KAMINETZKY, D. (1991). *Design and Construction Failures. Lessons from Forensic Investigations.* McGraw-Hill, Inc. New York, USA.

KHARBANDA, O. P. AND STALLWORTHY, E. A. (1986). *Management disasters: and how to prevent them.* Gower Publishing Company. Aldershot, UK.

KLETZ, T. A. (1985a). *What went wrong? Case histories of process plant disasters.* Gulf Publishing Company. Houston, USA.

KLETZ, T. A. (1985b). *An engineer's view of human error.* Institution of Chemical Engineers. Rugby, UK.

KLETZ, T. A. (1985c). *Cheaper, safer Plants.* Institution of Chemical Engineers. Rugby, UK.

KLETZ, T. A. (1986). *HAZOP and HAZAN. Notes on the identification and assessment of hazards.* Institution of Chemical Engineers. Rugby, UK.

KLETZ, T. A. (1988). *Learning from Accidents in Industry.* Butterworths. London, UK.

KLETZ, T. A. (1990). *Critical Aspects of Safety and Loss Prevention.* Butterworths. London, UK.

KNOWLES, R. (1992). The Quality Professional in the 1990's. *Quality Forum.* Volume 18. Number 2. June 1992. Pages 63 - 68.

KOESTLER, A. (1967). *The Ghost in the Machine.* Picador. London, UK.

KRIPPENDORFF, K. (1975). *Information theory.* In: Hanneman, G. J. and McEwan, W. J. (Eds). *Communication and behaviour.* Addison-Wesley Publishing Company. USA. Pages 351 - 389.

LANGER, E. (1980). The Psychology of chance. In: Dowie, J. and Lefrere, P. (Eds). *Risk and Chance.* Open University Press. Milton Keynes, UK.

LAUFER, A. (1987). Construction Accident Cost and Management Safety Motivation. *Journal of Occupational Accidents.* Volume 8, No 4. April 1987. Pages 295 - 315.

LEOPOLD, E. AND LEONARD, S. (1987). Costs of construction accidents to employers. *Journal of Occupational Accidents.* Volume 8, No 4. April 1987. Pages 273 - 294.

LESSEM, R. (1991). *Total quality learning.* Basil Blackwell Ltd. Oxford, UK.

LEVITT, R. E. AND PARKER, H. W. (1976). Reducing Construction Accidents. - Top Management's Role. *Proceedings of the American Society of Civil Engineers.* Volume 102. Division CO. September 1976. Pages 465 - 478.

LITTLEJOHN, S. W. (1983). *Theories of Human Communication.* Wadsworth Publishing Company. California, USA.

LOWERY, R., MOORE, S. L., AND THOMAS, E. J. (1988). Safety performance: Results can be achieved. *Professional Safety.* Volume 33, No 8. August 1988. Pages 11 - 18.

MACKENZIE, D. AND WAJCMAN, J. (1985). (Eds) *The Social Shaping of Technology.* Open University Press. Milton Keynes, UK.

MAGEE, B. (1982). *Popper.* Fontana. London, UK.

MAGYAR JR., S. V. (1983). Measuring safety performance. A management guide. *Professional Safety.* November, 1983. Pages 18 - 25.

McCORMICK, N. J. (1981). *Reliability and Risk Analysis: methods and nuclear power applications.* Academic Press. Boston, USA.

McKENNA, F. P. (1987). Behavioural Compensation and Safety. *Journal of Occupational Accidents.* Volume 9, No 2. August 1987. Pages 107 - 121.

MELCHERS, R. E. (1987). *Structural Reliability. Analysis and Prediction.* Ellis Horwood Limited. Chichester, UK.

MENDEZ, S. R. (1987). Defining and developing and operating an effective safety and health programme. *Solar Cells. - Their source, technology, allocation and economics.* Volume 19, No 3-4. January 1987. From *Proceedings of the SERI Photovoltaics Safety Conference.* Lakewood, CO, USA. January 16 - 17, 1986. Pages 333 -336.

MERKHOFFER, M. W. (1987). Quantifying Judgemental Uncertainty: Methodology, experiences and insights. *IEEE Transactions on Systems, Man and Cybernetics.* SMC 17. Pages 741 - 752.

MINISTRY OF AGRICULTURE, FISHERIES AND FOOD. (1977). *Water for Irrigation.* HMSO. London, UK.

MONK, D. (1988). The Fine Art of Safety Audits. *Chemical Engineering Progress.* Volume 84, No 9. September 1988. Pages 34 - 37.

MOORE, G. (1988). Risk Assessment. - Black art or science? *IEE Review.* Volume 34, No 4. April 21, 1988. Pages 151 - 153.

MORTENSEN, C. D. (1972). *Communication: The study of human interactions.* McGraw-Hill. New York, USA.

MURRELL, K. F. H. (1965). *Ergonomics. Man in His Working Environment.* Chapman and Hall. London, UK.

NEW CIVIL ENGINEER. (1990a). *Policy on safety.* 24th May, 1990. Pages 25 - 26.

NEW CIVIL ENGINEER. (1990b). *Girls death prompts site safety rethink.* 15th February, 1990. Page 7.

NEW CIVIL ENGINEER. (1991). *Kenchington Little found guilty of endangering public.* (Page 8). *Legal Shock Waves.* Pages 10 and 11. 25th July, 1991.

NEW CIVIL ENGINEER. (1992a). *Active role for site safety.* 8th October, 1992. Page 28.

NEW CIVIL ENGINEER. (1992b). *Designer Safety.* 1st October, 1992. Page 15.

NEWELL, J. E. (1987). Human Factors in the Attainment of Quality and Safety in Design.

The Nuclear Engineer. Volume 28, No 3. May-June, 1987. Pages 66 - 73, and 85.

NOVEGNO, A. AND ASCULAI, E. (1987). In Perspective: The role of safety assessment and risk management. *International Atomic Agency Bulletin.* Volume 29, No 2. Vienna, Austria. Pages 33 - 38.

O'HEAR, A. (1989). *Introduction to the Philosophy of Science.* Oxford University Press. New York, USA.

OBORNE, D. J. (1987). *Ergonomics at Work.* John Wiley and Sons Ltd. Chichester, UK.

OLIVER, G. B. M. (1990). *Quality management in construction. - Interpretations of BS 5750. (1987). - "Quality Systems" for the construction Industry.* Special Publication 74. CIRIA. London, UK.

PEARCE, F. (1992). Sitting on a toxic time bomb. *New Scientist.* 15th August, 1992. Pages 12 - 13.

PERROW, C. (1984). *Normal Accidents: Living with High-Risk Technologies.* Basic Books. New York, USA.

PIDGEON, N. F., TURNER, B. A. AND BLOCKLEY, D. I. (1991). The use of Grounded Theory for conceptual analysis in knowledge elicitation. *International Journal of Man-Machine Studies.* Volume 35. 1991. Pages 151 - 173.

PIDGEON, N. F., TURNER, B., BLOCKLEY, D. I. AND TOFT, B. (1991). Corporate Safety Culture: Improving the Management Contribution To System Reliability. In: Matthews, R. H. (Ed), *Proceedings of European Reliability 1991 Conference.* (1991). Pages 682 - 690. Elsevier Applied Science. London, UK.

PIÉSOLD, D. (1991). *Civil Engineering Practice: Engineering success by analysis of failure.* McGraw-Hill Book Company (UK) Limited. Maidenhead, UK.

POPPER, K. R. (1972). *Conjectures and Refutations. The Growth of Scientific Knowledge.* Routledge and Kegan Paul. London, UK.

POWER, R. D. (1985). *Quality assurance in civil engineering.* Report 109. CIRIA. London, UK.

PUGSLEY, A. P. (1969). The engineering climatology of structural accidents. In: Freudenthal, A. M. (Ed), *Proceedings of International Conference on Structural Safety and Reliability.* Smithsonian Institute of History and Technology, Constitution Avenue, Washington, D. C. April 9, 10 and 11, 1969. Pergamon. New York, USA.

RAMSEY, J. D., BURFORD, C. L. AND BESHIR, M. Y. (1986). Systematic classification of unsafe worker behaviour. *The International Journal of Industrial Ergonomics.* Volume 1, No 1. August 1986. Pages 21 - 28.

RASMUSSEN, J. (1986). *Information Processing and Human-Machine Interaction. An Approach to Cognitive Engineering.* Series Volume 12. North-Holland, Elsevier Science Publishing Co., Inc. New York, USA.

REASON, J. (1990). *Human Error.* Cambridge University Press. Cambridge, UK.

REED, D. A. AND HINZE, J. (1986). A study of Construction Safety in Washington State, USA. *Reports of the working commission (International Association for Bridge and Structural Engineering). Volume 51. IABSE Symposium. Tokyo. 1986. Safety and quality assurance in civil engineering structures. Preliminary report.* Pages 345 -

350.

RIDDOR. (1985). *The reporting of injuries, diseases and dangerous occurrences regulations 1985.* HMSO. London, UK.

ROBENS, LORD. (1972). *Safety and Health at Work Cmnd 5034.* 1972. (Robens Report) Para. 28. HMSO. London, UK.

RUSSELL, M. AND GRUBER, M. (1987). Risk Assessment in Environmental Policy-Making. *Science.* Volume 236. 17 April, 1987. Pages 286 - 290.

RYBCZYNSKI, W. (1983). *Taming the Tiger. The Struggle to Control Technology.* Penguin Books. New York, USA.

SAMELSON, N. M. AND LEVITT, R. E. (1982). Owner's Guidelines for Selecting Safe Contractors. *Proceedings of the American Society of Civil Engineers.* Volume 108. Division CO. December 1982. Pages 617 - 623.

SANDERS, M. S. AND McCORMICK, E. J. (1987). *Human Factors in Engineering and Design.* McGraw-Hill Book Company. New York, USA.

SHANNON, C. AND WEAVER, W. (1963) *The Mathematical Theory of Communication.* University of Illinois Press. Urbana, USA.

SIBLEY, P. G. AND WALKER, A. C. (1977). Structural accidents and their causes. *Proceedings of the Institution of Civil Engineers.* Part 1. Volume 62. May 1977. Pages 191 - 208.

SLOVIC, P. (1987). Perception of risk. *Science.* Volume 236. 17 April, 1987. Pages 280 - 285.

SLOVIC, P., FISCHOFF, B. AND LICHTENSTEIN, S. (1982). Facts versus fears: Understanding perceived risk. In: Kahneman, D., Slovic, P. and Tversky. (Eds). (1982). *Judgement under uncertainty: Heuristics and biases.* Cambridge University Press. Cambridge, UK.

STEINER, V. (1987). Assessing the Safety Climate of a Plant Yields Long Term Benefits. *Plant Engineering.* (Barrington, Illinois). Volume 41, No 8. April 23, 1987. Pages 26 - 29.

STONE, J. R. (1989). *Expert System Learning from Structural Failures.* Ph. D. Thesis. University of Bristol. UK.

STRAUSS, A. L. (1987). *Qualitative Analysis For Social Scientists.* Cambridge University Press. Cambridge, UK.

TAYLOR, P. (1990). *The Hillsborough Stadium Disaster. 15th April, 1989.* Inquiry by the Rt Hon Lord Justice Taylor. Final Report. HMSO. London, UK.

THE ROYAL SOCIETY. (1983). *Risk Assessment. A Study Group Report.* The Royal Society. London, UK.

THOFT-CHRISTENSEN, P. AND BAKER, M. J. (1982). *Structural Reliability Theory and Its Applications.* Springer-Verlag. Berlin, Germany.

THOMPSON, M., ELLIS, R., AND WILDAVSKY, A. (1990). *Cultural Theory.* Westview Press. Colorado, USA.

TOFT, B. (1990). *The failure of hindsight.* Ph.D. Thesis. University of Exeter. UK.

TOMLINSON, M. J. (1986). *Foundation Design and Construction.* Longman Scientific and Technical. Harlow, UK.

TURNER, B. (1978). *Man Made Disasters.* Wykeham. London, UK.

TUSA, W. (1986). Risk Assessment: Engineering Tool. *Civil Engineering (New York).* Volume 56, No 2. February, 1986. Pages 59 - 61.

TVERSKY, A. AND KAHNEMAN, D. (1974). Judgement under Uncertainty: Heuristics and Biases. *Science.* Volume 185. 1974. Pages 1124 - 1130.

VARADARAJAN. S. (1986). Safety and quality in chemical industry. *Chemical Age of India.* Volume 37, No 1. January 1986. Pages 25 - 29.

VICKERS, G. (1970). *Freedom in a Rocking Boat.* Penguin Books Ltd. London, UK.

VICKERS, G. (1983). *The art of judgement: A study of policy making.* Harper and Row Limited. London, UK.

VINCK, W. F., GILBY, E. V. AND CHICKEN, J. C. (1987). Quantified Safety objectives in High Technology: Meaning and Demonstration. *Nuclear Safety.* Volume 28, No 4. October-December, 1987. Pages 461 - 471.

WALSTER, E. (1966). Assignment of responsibility for an accident. *Journal of Personality and Social Psychology.* 1966. Volume 3, No 1. Pages 73 - 79.

WILDE, G. J. S. (1982). The Theory of Risk Homeostasis: Implications for Safety and Health. *Risk Analysis.* Volume 2, No 4. Pages 209 - 225.

WILSON, B. (1990). *Systems: Concepts, Methodologies and Applications.* John Wiley and Sons. Chichester, UK.

APPENDIX A.

CONCEPTS FROM LITERATURE SURVEY

DIRECTLY RELATED TO SAFETY.

1.1 ACCIDENT RECORDS.
1.2 NEAR MISS AND MINOR ACCIDENT REPORTING.
1.3 INVESTIGATION OF ACCIDENTS.
1.4 ANALYSIS OF ACCIDENTS AND INCIDENTS.
1.5 CONSTRUCTION ACCIDENTS.
1.6 ACCIDENT INVESTIGATION AND ANALYSIS AS A WHOLE OR IN GROUPS.
1.7 INDEPENDENT INVESTIGATION OF ACCIDENTS.
1.8 ACCIDENT COSTS PUT AGAINST PROJECT.
1.9 ACCIDENT COSTS SHOULD BE CIRCULATED.
1.10 ACCIDENTS ARE MULTI-CAUSAL.

2.1 DESIGN INTENTION.
2.2 LAYOUT AND LOCATION OF PROJECT.
2.3 DESIGN PROCESS. EXPERIENCE, WORKING ENVIRONMENT, SOCIAL INFLUENCES, ECONOMIC INFLUENCES, DESIGN METHODS, USE OF EQUIPMENT, ETC.
2.4 STRUCTURAL SAFETY.
2.5 DESIGN INFLUENCE ON SAFETY DURING CONSTRUCTION.
2.6 DESIGN INFLUENCE ON SAFETY DURING OPERATION.
2.7 DESIGN CONSTRUCTION OPERATION INTERACTION.
2.8 PRE DESIGN, CONCEPT DESIGN.
2.9 THE APPROPRIATENESS OF THE CODES BEING USED IN DESIGN.
2.10 VARIATIONS IN DESIGN.

3.1 UNSAFE ACTS.

4.1 UNSAFE CONDITIONS.

5.1 MANAGEMENT COMMITMENT AND INVOLVEMENT.
5.2 MANAGEMENT COMFORTABLE WITH AUDIT.
5.3 AUDIT OF MANAGEMENT SYSTEMS. - SEE THE ISRS METHODOLOGY.

6.1 DETAILED PLANNING, PROGRAMMING OF CONSTRUCTION INCLUDING METHOD STATEMENTS, PROCEDURES, SAFETY IMPLICATIONS ETC.
6.2 CONSTRUCTION PROCESS. EXPERIENCE, WORKING ENVIRONMENT, SOCIAL INFLUENCES, ECONOMIC INFLUENCES, CONSTRUCTION METHODS, USE OF EQUIPMENT. ETC.
6.3 THE INFLUENCE OF CONSTRUCTION ON DESIGN.

7.1 SAFETY CULTURE.
7.2 ORGANISATIONAL INFLUENCES.
7.3 INDIVIDUAL INFLUENCES.
7.4 THE DEVELOPMENT OF SAFETY CULTURE, BY: LEARNING, FOSTERING, PROMOTION, DISCUSSION, DESIRE, NOT COMPROMISING PRODUCTION.

7.5 ASSESSMENT OF SAFETY CULTURE.

8.1 STORAGE DURING CONSTRUCTION AND OPERATION.

9.1 MAINTENANCE ON THE COMPLETED PROJECT.

10.1 HOUSEKEEPING.

11.1 LIST OF QUESTIONS FROM "THE NATURE OF STRUCTURAL DESIGN AND SAFETY" BY D BLOCKLEY.

12.1 LIST OF QUESTIONS FROM "BUILDING FAILURES" BY T. McKAIG.

13.1 PATTERNS FROM PAST FAILURES.
13.2 LEARNING FROM PAST EXPERIENCE.

14.1 COMMUNICATION ACROSS HIERARCHY. MANAGEMENT - SUPERVISION - WORK-FORCE.
14.2 INFORMATION ON RISKS MADE KNOWN ACROSS THE ORGANISATION.
14.3 COMMUNICATION REQUIRED TO BALANCE PERCEPTIONS.
14.4 COMMUNICATION OF ACCIDENT RECOMMENDATIONS.

15.1 THE EFFECT OF WORK-FORCE TURNOVER.
15.2 WORK-FORCE TURNOVER IS INEVITABLE. MEASURES ARE REQUIRED TO COUNTER THE EFFECTS.
15.2 MARITAL STATUS AND AGE OF WORK-FORCE.
15.3 LENGTH OF SERVICE OF THE INDIVIDUALS IN THE WORK-FORCE.
15.4 APPROPRIATENESS FOR PARTICULAR WORK.
15.5 JOB ASSESSMENT, JOB PLACEMENT AND JOB ADVANCEMENT.
15.6 EMPLOYEE SUPPORT SERVICES.
15.7 EMPLOYEE ACTIONS.
15.8 PRESSURE ON LABOUR FORCE FROM SUPERVISORS.

16.1 PRESSURE ON SUPERVISORS FROM MANAGEMENT.

17.1 WORKING ENVIRONMENT.

18.1 TRAINING IN SAFETY PROCEDURES.
18.2 ONGOING INSTRUCTION IN SAFETY PROCEDURES.

19.1 TRAINING IN JOB SKILLS.
19.2 FOLLOW UP INSTRUCTION IN JOB SKILLS.

20.1 EQUIPMENT AND PROCESS DESIGN.

21.1 HAZARDS OF MATERIALS.

22.1 SAFETY CENTRES.
22.2 SAFETY COMMITTEES.

23.1 EMERGENCY PROCEDURES.

24.1 MANAGEMENT MUST BE GIVEN ACCIDENT RATE INFORMATION.
24.2 MANAGEMENT AND SUPERVISOR SALARIES SHOULD BE INFLUENCED BY THEIR SAFETY RECORDS.
24.3 ACCIDENT RATE INFORMATION SHOULD BE MADE KNOWN THROUGHOUT THE ENTIRE ORGANISATION.

25.1 SAFETY TREATED THE SAME AS PRODUCTION AND QUALITY.

26.1 SAFETY EQUIPMENT NOT CHARGED TO PROJECT?

27.1 INSURANCE COSTS.

28.1 SAFETY PROGRAMMES.

29.1 INCENTIVES.
29.2 PUNITIVE ACTION.

30.1 RESPONSIBILITY.
30.2 ACCOUNTABILITY.
30.3 AUTHORITY.
30.4 RELATIONSHIP BETWEEN RESPONSIBILITY, ACCOUNTABILITY AND AUTHORITY.
31.1 STATUS OF SAFETY PERSONNEL.

32.1 IS THE COMPANY HIERARCHY SHALLOW OR DEEP?

33.1 GEOGRAPHIC DISPERSION OF PROJECT.

34.1 COST v. BENEFIT OF SAFETY AUDIT.
34.2 COST v. BENEFIT OF SAFETY MEASURES.

35.1 RELATIONSHIP BETWEEN SAFETY PERFORMANCE AND SITE PERFORMANCE?

36.1 SAFETY IS AN "OPEN WORLD" SITUATION.

37.1 DECOMMISSIONING.
37.2 DEMOLITION.

38.1 QUALITY ASSURANCE CHECKS. - QUALITY AUDIT.

39.1 THE EFFECT OF THE AVAILABILITY HEURISTIC.
39.2 THE EFFECT OF OVER-CONFIDENCE OF JUDGEMENTS BASED ON HEURISTICS. - MIND SET, OVER-CONFIDENCE IN CURRENT KNOWLEDGE, FAILURE TO CONSIDER TECHNOLOGICAL SYSTEMS AS A WHOLE, SLOWNESS TO DETECT CUMULATIVE EFFECTS, FAILURE TO ANTICIPATE HUMAN RESPONSE TO SAFETY MEASURES i.e. A FALSE SENSE OF SECURITY IN A SAFETY MEASURE, FAILURE TO ANTICIPATE COMMON MODE FAILURES e.g. COMMON LOCATION OF SERVICE LINES.

40.1 THE INFLUENCE OF ATTRIBUTIONAL PROCESSES.

40.2 EDUCATION REQUIRED AS TO HOW ATTRIBUTIONAL PROCESSES INFLUENCE RESPONSES.

41.1 SAFETY AUDITING IS AN AID TO IMPROVING SAFETY.

42.1 INCREASING LITIGATION INFLUENCING INVOLVEMENT OF ENGINEERS IN CONSTRUCTION.
42.2 STRICT LIABILITY.

43.1 CONTRACTUAL ARRANGEMENTS.
43.2 DISSATISFACTION WITH CONTRACTUAL ARRANGEMENTS.

44.1 FINANCIAL PRESSURES.
44.2 TEMPORAL PRESSURES.
44.3 POLITICAL PRESSURES.
44.4 PROFESSIONAL PRESSURES.

45.1 RISK ASSESSMENT ANALYSIS.

46.1 INDOCTRINATION INTO SAFETY.

47.1 SAFETY SURVEYS.

48.1 MORALE.

49.1 FORMAL POLICY STATEMENT.

50.1 SYSTEMS CONSIDERED BOTH AS A WHOLE AND AS CONSTITUENT PARTS.

51.1 EMPLOYEE, MANAGEMENT RELATIONS.

<u>RELATED TO AUDIT.</u>

100.1 MANAGEMENT COMFORTABLE WITH AUDIT.

101.1 AUDIT IS AN OBJECTIVE EXAMINATION.

102.1 AUDIT EASILY COMMUNICATED AND UNDERSTOOD.

103.1 AUDIT PROVIDES THE BASIS FOR OBJECTIVES AND MEASURES REAL PROGRESS.

104.1 AUDIT CAN BE USED AS A BASIS FOR BONUS OR INCENTIVES.

105.1 AUDIT GENERATES OBSERVABLE IMPROVEMENTS.