CONSTRUCTION MANAGEMENT ACTIONS: A STIMULANT OF CONSTRUCTION ACCIDENT CAUSATION

Akhmad Suraji and A Roy Duff

Department of Building Engineering, UMIST, Manchester M60 1QD, UK

Human actions are believed to be a fundamental factor leading to accident causation. However, such failures are often ascribed to operatives rather than management. It is necessary to investigate how people in an upstream boundary of project organisation stimulate situations or conditions, which are likely to increase the risk of accident. This will be helpful for developing comprehensive prevention strategies. A study of management actions by all participants in construction projects, in relation to accident causation, is currently being undertaken by the authors at UMIST. As part of this work, this paper introduces construction management actions by builders: contractor or subcontractor, which may induce deficient procedures during the construction phase of a project. Construction management action is defined as constraints and responses by the construction manager or site manager, which may generate deficiencies in planning, control, operation, site condition and operative action. Using the constraint-response model of construction accident causation developed by authors, the detail of these deficiencies is described. Thus, a variety of construction management actions generating these deficiencies are identified as root causes of construction accidents.

Keywords: construction accident, construction management

INTRODUCTION

Human error is believed to be a fundamental factor leading to accident (Rasmussen, 1990). In the past, human error was often perceived to be operatives' error rather than management failure. Since the early 90s, most researchers into industrial accident (Reason, 1990; Groeneweg, 1994) and construction accident causation (Bellamy and Geyer, 1992; Whittington, et al, 1992, Atkinson, 1998) have considered managerial or organisational errors as latent failures, or underlying factors of an accident. However, the issue still remains unclear as to why and how those management and organisational factors stimulate accidents and no attempt has been made to integrate them, in a systematic way, into a model for effective accident investigation and prevention. These factors are a major issue in tracing root causes of an accident (Rowlinson, 1997), but their causal mechanism is, crucially, still not well understood.

The major problem is difficulty in mapping potential stimulants leading to deficiencies in the construction process, by which the risk of accident is increased. It is still not clear how project participants contribute to accident causation. In the fragmented organisation of construction projects, the stimulant may come from the client, client's team, designers, or builders (contractors or subcontractors) including operatives. This method of organising a construction project ensures that participants will have a different view of project (Walker, 1989). Each participant will have its

Suraji, A and Duff, A R (2000) Construction management actions: a stimulant of construction accident causation. *In:* Akintoye, A (Ed.), *16th Annual ARCOM Conference*, 6-8 September 2000, Glasgow Caledonian University. Association of Researchers in Construction Management, Vol. 2, 733-42.

own project, business or environmental constraints and will make a different response concerning these constraints, during the implementation of the project. In this way, the sources of stimulants in accident causation are scattered through every stage of the construction project: conception, design and construction. Tackling the root causes of accidents will mean controlling the management actions, which stimulate inappropriate situations and thus increase the risk of accident.

As with Generic Error Modelling (GEM) (Reason, 1990) and General Failure Types (GFTs) (Groeneweg, 1994) developed to model accident causation in the general industry and offshore or petrochemical industry, respectively, there is a need to identify the general failure types and their sources for construction accident causation. Understanding a mechanism for relating management actions, in an upstream part of the project organisation, to the processes and conditions of the construction site, may help in tracing back the stimulating factors of accidents and then determining who could potentially control them to eliminate, reduce or avoid their implications in precipitating unsafe incidents and accidents. This may echo the issue that Duff (1998) argued that in the behavioural perspectives, safety problems can only be fully resolved by a change in the behaviour of all the participants in the construction project.

A new theoretical approach for structuring management actions in construction accident causation has been developed by authors at UMIST (Suraji, Duff, and Peckitt, 2000, [Accepted for publication in ASCE Journal of Construction Engineering & Management]). This paper describes outlining construction management actions, within project development, which provide stimulants in construction accident causation. Firstly, a structure of construction accident causation is presented. This structure describes the pattern of accident causation representing a causal process of accident. Secondly, deficiencies in construction projects and their contribution to construction accidents are addressed. These deficiencies are identified by extensive literature research and working experience, then validated by past accident causation records provided by the UK Health & Safety Executive (HSE). Finally, construction management actions by builders are introduced.

A CAUSAL PROCESS OF CONSTRUCTION ACCIDENT

A model of construction accident causation has been developed. As shown in Figure 1 the model describes a pattern of causal relationship between accidents, deficient construction processes, and management actions. Latent failures or General Failure Types are represented by deficiencies in construction projects, including deficient planning, control, operation, site condition and operative action. A study of 30 construction accident cases by Whittington, et al (1992) found that these deficiencies contribute significantly to many incidents or accidents. Management actions are frequently factors leading to those deficiencies. These management actions can be represented as responses to project, business or environmental constraints confronting participants involved in the construction project. These participants’ constraints and responses are defined as the root causes of accidents. This model shows how project management actions by the client, client’s team, designers and construction management actions by builders may have a significant role in stimulating deficient construction processes and operative constraints. Builders in particular have a crucial position due to their duty to direct day to day processes. However, they may also face various constraints resulting from internal or external pressures (Fryer, 1997).

The proposed model is concerned particularly with upstream boundary of the accident event area. It deals with latent failures rather than active failures. Groeneweg (1994) suggested that accident prevention would be effective if one can eliminate, reduce or avoid the root causes of substandard acts, rather than the substandard acts themselves.

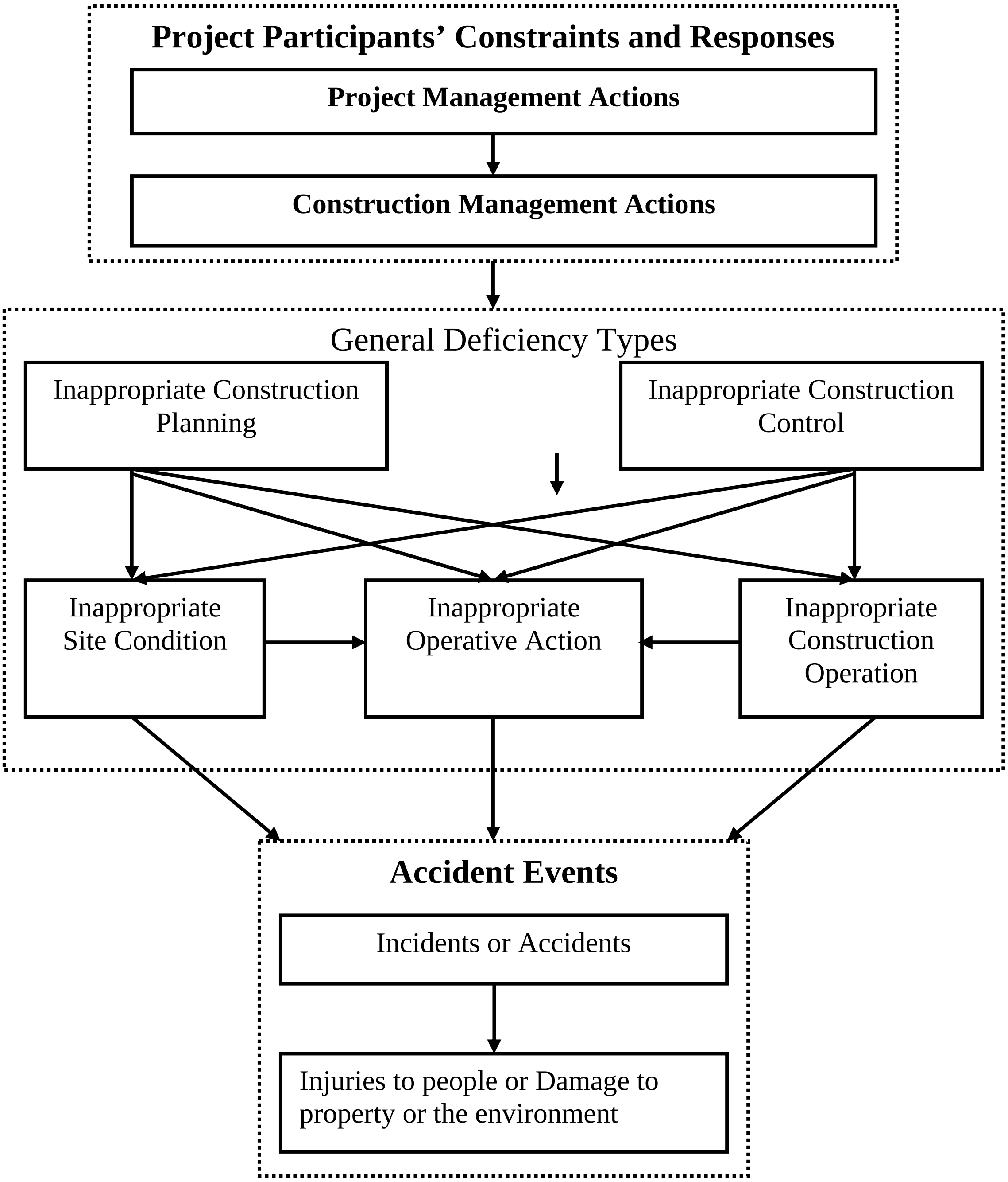

Figure 1: General Model of Construction Accident Causation

Groeneweg (1994) identified the root cause as general failure types (GFTs) which consist of design, hardware, procedure, error enforcing conditions, housekeeping, training, incompatible goals, communication, organisation, maintenance, management and defences. Although this is helpful, it is not enough to deal only with general failure types, more effort is needed to understand the causes of the general failures. Based upon the concept of this model that project participants' actions may precipitate deficient construction processes, project management actions or construction management actions, are concluded as the root cause of General Deficiency Types (GDTs) in the construction process. These management actions might be made by site managers, or top managers, as well as designers, client's team and the client. These project participants may precipitate deficient design, hardware, management systems or organisation, construction planning, control and operation.

DEFICIENCIES OF CONSTRUCTION PROCESS

Whittington, et al (1992) asserted that the deficient construction process is accident precursors arising from headquarter level or site management level. The model, as described in Figure 1, classifies general deficiency types as inappropriate construction planning, inappropriate construction operation, and inappropriate construction control, inappropriate site condition, and inappropriate operative action. These terms can be defined as follows:

Inappropriate Construction Planning
This is inadequate analysis or formulation of the construction plan, method statement or schedule, in relation to the risk of undesired events which may lead to injury or damage to construction personnel, the general public, the property of either or the environment. This represents such failures as:

Inadequate method statement;

Inadequate structural design for temporary support structures;

Inadequate site layout plan;

Inadequate site investigation.

Inappropriate Construction Control
This is inadequate, either in quantity or quality, effort to direct or supervise the factors of construction such as to cause deviation of the construction operations from plan, and increase the undesired events. This represents, for example:

Inadequate control of plant or equipment operation;

Inadequate supervision of operative work;

Inadequate control of weather effects;

Inadequate control of the reliability of temporary structures.

Inappropriate Construction Operation
This is unsuitable process of production of permanent or temporary work or improper construction states of being operative risk of which leads to increased undesired events. This represents, for instance:

Improper construction procedure;

Improper plant or equipment operation;

Inadequate illumination or poor lighting.

Inappropriate Site Condition
This is unsuitable physical environment, in which a construction operation takes place, which may impinge on the performance of the operation and directly increase the risk of undesired events. For example:

Unsuitable existing topography;

Unsuitable weather or climatic conditions;

Inappropriate ground condition

Unacceptable noise and crowded surrounding site;

Inappropriate Operative Action
This is improper action or inaction, either intentionally or unintentionally, by an operative which may result in increasing the risk of undesired events. Such as:

Carelessness;

Failure to adopt standard procedures;

Improper or inadequate use of PPE;

Failure to follow instructions;

These deficiencies or proximal factors of accident have been validated using approximately 500 past construction accident records provided by HSE-UK. The accident records are retrieved from HSE's FOCUS Database. A free format of accident description in each accident record is analysed. Only those causal factors specifically written, by the HSE Inspector, in the accident description were recorded. Analysis of the 500 accident records shows that accidents in construction projects involve: inappropriate construction planning (33.40%), inappropriate construction control (14.29%), and inappropriate construction operation (72.48%), inappropriate site condition (7.98%), and inappropriate operative action (34.66%). Analysing of each type of these deficiencies has identified the major contributor of construction accident causation as shown in Table 1.

Table 1: Deficiencies having the major contributor to accidents

Types	Deficiencies of construction process	% Involved in accidents
Inappropriate Construction Planning	Inadequate method statement	10.71%
	Inadequate preparatory training	9.87%
	Inadequate identification and assessment of risk	9.24%
Inappropriate Construction Control	Inadequate control of plant or equipment operation	3.36%
	Inadequate control of operative work	1.89%
	Inadequate control of system of work	1.89%
Inappropriate Site Condition	Inappropriate ground condition	3.57%
	Unsuitable weather or climatic conditions	3.36%
	Unsuitable existing topography	1.26%
Inappropriate Operative Action	Carelessness	8.40%
	Failure to follow instructions	6.51%
	Improper or inadequate use of PPE	6.09%
Inappropriate Construction Operation	Breach of regulation or standard of code of practice	24.58%
	Improper construction procedure	17.86%
	Inadequate temporary structure	8.40%

The total percentage of the above deficiencies distribution is more than 100%. It is due to around 65 % of those accident records have multiple deficiencies. It is worthy of note that either inappropriate construction planning or inappropriate construction control or both may cause a deficient construction operation and unsuitable site condition. In term of accident prevention, this evidence suggests that the accurate construction planning should be followed by the strong construction control in order to minimise deficient construction operation. However, the deficiency, individually or independently, can provoke a situation or condition in which elements of the construction work such as plant, temporary structure, and operative are vulnerable to have an incident or accident.

CONSTRUCTION MANAGEMENT ACTIONS

As described in the model, the fundamental question is why do those deficiencies happen in a construction project?. Following the fundamental concept of the model, the answer is because of human actions pertinent to management and organisational factors. Embrey (1992) described that policy deficiencies cause error-inducing factors, which stimulate latent failures and active failures. These deficiencies are classified as project management, safety policy, safety culture, risk management, design of instructions, training policy, and communication system. In the policy level, those factors can be influenced by global factors such as the general economic situation, and the prevailing political philosophy. Whittington, Livingston and Lucas (1992) described that policy failures are the root cause of subsequent failures in the project management, site management, and individual. These policy failures could happen at a company level, for example; inadequate training policy or poor methods of procurement. Then, they stimulate problems at project management level, such as lack of planning, poor scheduling of work or choice of inappropriate construction methods. This will have direct effects at site management level, for instance; poor communications, lack of supervision of failure to adequately segregate work, as well as those failure may provoke failures at individual level, for example; use of wrong equipment or failure to comply with an agreed method of work.

The construction management actions by builders are classified as construction management constraint, construction management response, subcontractor constraint, and subcontractor response. The following detail of these categories is deducted from logical approach and our experiences. The extensive literature research, covering project management in many different fields, has been used to elaborate the constraints and responses faced by all different participants in the construction project. Those categories can be explained as follows:

Construction Management Constraint
This is difficulties arising from client, project management and designer responses, or the project environment, which confront contractors during the project development stage. Table 2 shows the construction management constraints.

Construction Management Response
This is action or inaction by construction managers, usually of main contractor, to confront construction management constraints or problems created by the project environment. These responses deal with managerial, organisational, technical, and operational aspects of the production process during the project construction stage. Table 3 shows the construction management responses.

Subcontractor Constraint
This is difficulties arising from client, project management and designer responses, main contractor or the project environment, which confront subcontractors during the project development stage. The subcontractor constraint, for some respects, is same as main contractor constraints. The list of subcontractor constraints is given in Table 4 below.

Table 2: Construction Management Constraints

CODE	CONSTRUCTION MANAGEMENT CONSTRAINT
CMC-01	Design delay
CMC-02	Design variations
CMC-03	Complexity of project procurement systems
CMC-04	Complexity of construction specification
CMC-05	Economic and commercial or business effect
CMC-06	Environmental conditions
CMC-07	Excessively inclement weather
CMC-08	Incompetence of Sub-contractors
CMC-09	Incompetent project manager, site manager, and site engineer
CMC-10	Lack of appropriate technology
CMC-11	Lack of cash flow
CMC-12	Lack of suitable equipment
CMC-13	Lack of materials required
CMC-14	Labour skill shortage
CMC-15	Lack of utilities
CMC-16	Low project performance
CMC-17	Profit expectation
CMC-18	Project penalty
CMC-19	Social and political pressure
CMC-20	Time pressure
CMC-21	Unpredictable site condition
CMC-22	Other

Table 3: Construction Management Responses

CODE	CONSTRUCTION MANAGEMENT RESPONSE
CMR-01	Add or reduce human resource allocation
CMR-02	Adjust level of supervision
CMR-03	Break the contract
CMR-04	Change communication and co-ordination systems
CMR-05	Change construction method
CMR-06	Change equipment and tools
CMR-07	Change schedule of works
CMR-08	Change worker incentive schemes
CMR-09	Change working hours
CMR-10	Cost or budget reduction
CMR-11	Extend the project duration
CMR-12	Tight control of sub-contractors
CMR-13	Introduce new technology
CMR-14	Modify sequence of work
CMR-15	Modify site organisation
CMR-16	No response
CMR-17	Postpone or cancel work operation
CMR-18	Propose claims or complaint
CMR-19	Replace sub-contractor
CMR-20	Revise or accelerate construction programme
CMR-21	Wait for final decision from clients
CMR-22	Other

Subcontractor Response

This is action or inaction by subcontractor to confront subcontractor constraints or problems created by the project environment. These responses deal with managerial, organisational, technical, and operational aspects of the production process during the project construction. The subcontractor response can be also same as main contractor response. Table 5 below contains various subcontractor responses.

Table 4: Sub-Contractor Constraints

CODE	SUB-CONTRACTOR CONSTRAINT
SCC-01	Cash flow problems
SCC-02	Excessive work
SCC-03	Lack of relevant experience
SCC-04	Loss of profit
SCC-05	New additional requirements
SCC-06	New working operations
SCC-07	Payment delay
SCC-08	Pressure from other contracts for resources
SCC-09	Problems due to suppliers
SCC-10	Project acceleration
SCC-11	Project penalties
SCC-12	Shortage of equipment
SCC-13	Shortage of materials
SCC-14	Shortage of operatives
SCC-15	Social, political and economical pressures
SCC-16	Tight schedule
SCC-17	Variation order
SCC-18	Other

Table 5: Sub-Contractor Responses

CODE	SUB-CONTRACTOR RESPONSE
SCR-01	Adjust level of supervision
SCR-02	Change allocation of workforces
SCR-03	Change working hours or overtime
SCR-04	Modify construction procedure
SCR-05	Modify construction programme
SCR-06	Reallocate resources to another site
SCR-07	Recruit untrained operatives
SCR-08	Replace equipment or plant
SCR-09	Slow down work
SCR-10	Other

CONCLUDING REMARKS

The construction management action is introduced to be a stimulant to lead to deficient construction processes. General Deficiency Types (GDTs) in the construction process are latent failures increasing the risk of construction accident. These deficiencies are classified as inappropriate construction planning, inappropriate construction control, inappropriate site condition, and inappropriate operative action. From the analysis of 500 samples of HSE accident data, the most frequent category of deficiency is inappropriate construction operation, occurring in 72 % of all construction accidents. Based on the model of construction accident causation developed by authors, the root causes of those deficiencies are attributable to organisational and management factors, called project management actions and construction management actions. These actions represent constraints and responses by project participants involved in the construction project. The construction management actions are classified as construction management constraint, construction management response, subcontractor constraint, and subcontractor response. These are, for example, labour skill shortage, design variations, excessively inclement weather, adjust level of supervision, revise or accelerate construction programme, change construction method, cash flow problems, pressure from other contracts for resources, lack of relevant experience, slow down work, reallocate resources to another site, recruit untrained operatives.

FUTURE WORKS

Participants in the construction project can precipitate constraints and responses, which provoke deficiencies or latent failures in construction processes and to lead to accidents. An extensive research work is needed to examine the management actions by all participants of the construction project, beginning from project management actions by the client's, client's team, and designers to construction management actions by builders. This work will lead to determination of the potential management action leading to accident, structure of the relationship between those management actions, and study on how to mitigate the action toward general deficiency types leading to construction accidents.

ACKNOWLEDGMENT

This research is supported by the UK Health and Safety Executive. Thanks we due to Blair Hilton at HSE in Bootle for assistance in the use of the Focus database.

REFERENCES

Atkinson, A. (1998) Human Error in the Management of Building Project. *Journal of Construction Management and Economics*, **16**: 339-349

Bellamy, L.J. and Geyer, T.A.W. (1992) Organisational, Management and Human Factors in Quantified Risk Assessment. *HSE Contract Research Report* No. 33, HSE, London.

Duff, A.R., (1998) Management and Operative Safety Improvement: a Goal for the Whole Organisation. *In Proceedings of the International Conference on Environment, Quality and Safety in Construction*, CIB Working Commission W99-Safety and Health on Construction Sites, Lisbon, Portugal, June.

Embrey, D. (1992) Incorporating Management and Organisational Factors into Probabilistic Safety Assessment. *Reliability Engineering and System Safety*, **38**: 199-208

Fryer, Barry G. (1997) *The practice of construction management*. 3rd ed. Blackwell Science Oxford, England

Groeneweg, J., (1994) *Controlling the Controllable: The Management of Safety*. 2nd Revised Ed. DSWO Press, Leiden University, Netherlands.

Heinrich, H.W. (1969) *Industrial Accident Prevention*. 4th Ed., Mc Graw Hill, New York.

Rasmussen, J. (1990) Human error and the problem of causality in analysis of accidents. In Broedbent.D.E, Baddeley.A, Reason.J.T, (1990), *Human Factors in Hazardous Situations, Proceeding of a Royal Society Discussion Meeting,* Oxford Science Publications, Oxford.

Reason, J. (1990) The Contribution of latent human failures to the breakdown of complex systems. In Broedbent.D.E, Baddeley.A, Reason.J.T, (1990), *Human Factors in Hazardous Situations, Proceeding of a Royal Society Discussion Meeting,* Oxford Science Publications, Oxford.

Rowlinson, S. (1997) *HongKong Construction Site Safety Management.* Sweet and Maxwell Asia, HongKong.

Suraji, A., Duff, A.R., Peckitt, S.J.(2000) Development of a Causal Model of Construction Accident Causation. *Submitted to ASCE Journal of Construction Engineering and Management.*

Walker, A. (1996) *Project Management in Construction*. Blackwell Science, UK.

Whittington, C., Livingston, A., Lucas, DA (1992) Research Into Management, Organisational and Human Factors in the Construction Industry. *HSE Contract Research Report* No. 45/ HMSO