A system approach to the study of structural failures

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A System Approach to the Study of Structural Failures

Méthode pour l'étude systématique des sinistres des constructions

Ein systematischer Ansatz zur Untersuchung von Schadenfällen an Tragwerken

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SUMMARY
The British building control system is described and some weaknesses discussed on the basis of detailed analysis of building failures and observations made on construction sites. Building control systems of various countries are studied and common principles identified for the development of a System Model. A simple table is proposed to describe the System Model and the relations between failure data and systems are discussed for Britain, France and the Federal Republic of Germany.

RESUME
On présente le système utilisé en Angleterre pour le contrôle des constructions. Sur la base d'une étude détaillée de quelques sinistres ainsi que sur celle d'observations faites sur les chantiers, on montre les faiblesses du système. Les systèmes de contrôle de différents pays sont comparés. On a résumé les propriétés communes aux systèmes qui pourraient servir de base à un système modèle. Enfin, on propose un tableau simple, qui permet d'établir rapidement les relations entre les dommages et le système de contrôle. La discussion du tableau a été faite pour l'Angleterre, la France et la République Fédérale d'Allemagne.

ZUSAMMENFASSUNG
Das britische System der Baukontrolle wird beschrieben. Aufgrund einer eingehenden Untersuchung von Schadenfällen im Bauwesen und Beobachtungen auf Baustellen werden einige Schwachstellen dieses Systems aufgezeigt. Kontrollsysteme verschiedener Länder werden verglichen und gemeinsame Merkmale für die Entwicklung eines Modells zusammengestellt. Schliesslich wird eine einfache Tabelle vorgeschlagen und die Beziehungen zwischen Schaden-Kenndaten und Kontrollsystem für England, Frankreich und die Bundesrepublik Deutschland werden diskutiert.

In preparing this paper the authors were well aware that the seminar would be attended by engineers from nearly 20 countries experienced in structural safety. Advantage is therefore taken of this opportunity to discuss two topics : Comparison of existing methods of quality assurance (QA) in various countries and evaluation of QA, as illustrated by the British model.

Evaluation of the British system of building control

There are no acceptable methods for the evaluation of QA systems but identifying what went wrong is a valuable starting point. Study on building failures (collapse and unserviceability) has indicated what went wrong that led to failure but could not uncover faults that did not matter at the time because of over-design or another fault. Hence it is important to study in parallel the processes of design and construction to identify what went wrong and in particular how much was not put right in the completed building. Since the construction phase is more critical in the sense that design faults can be revealed and there is considerable pressure to meet deadline, a study on site observation is presented here.

Figures 1 and 2 show the weaknesses in the system and team (organization of human activities) respectively and Figure 4 shows the various stages and processes in the building process together with the British system of control. The remedial measures are suggested in Figure 3. These diagrams are based on the results of a recent detailed study by BRE on 120 building failures in the UK.

A separate study was recently undertaken by BRE to observe problems arising during construction which were considered to affect the standard of quality. The study covered 27 sites involving contracts ranging in value from £100,000 to £12M and about 500 incidents were recorded where the relevant personnel had to pause in their work to consider the rightness of what was being built.

Figure 5 shows the causes of these incidents (also called quality-related events) and the extent to which the related problems were solved successfully. Figures 6 and 7 compare the extent of consultation among personnel between two sites (site with lowest and highest standards of construction).

Some conclusions are similar in nature to those of the failure study. Thus, the standard of construction depended very much on the quality of project information from the designer and workmanship problems were caused predominantly by lack of care on the part of tradesmen rather than by lack of skill or

knowledge. One observation made here but could not be made in the failure study is that a number of serious quality problems were identified but not solved, mainly because of the lack of authority of the client's quality controller (clerk of works). Furthermore, quality standards were found not to rely significantly on formal checking and acceptance or rejection of completed work.

Comparison of Quality Assurance Systems

The formal application of quality assurance to engineering construction is relatively new and work in this field on an international level was undertaken only in recent years. The primary objective of the work (by JCSS and CEB) was to promote structural safety but it is increasingly clear that the work has played two further roles. Firstly it has stimulated a closer examination of a wide range of activities in the overall building process. Secondly its output is expected to provide a basic framework of reference for harmonization of international construction. So far harmonization has concentrated on products and standards which have the least interrelation with other elements in the building process. Having now reached a saturated point, harmonization could not go much further until quality assurance procedures are at least better understood.

In the course of its work on quality assurance, CEB (Commission I) has identified a priority area : a comparison of the status quo of QA methods actually used in various countries. It has been suggested that a simplified table be prepared and tentative entries made for iterative corrections by the relevant experts. Figures 4 and 8 are the result of this suggestion and it is hoped that improvements will be discussed in this seminar.

FIGURE 1 : **WEAKNESS IN SYSTEM**

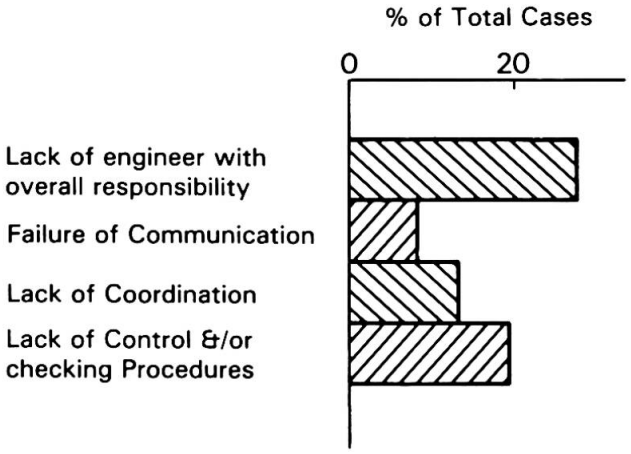

FIGURE 2 : **WEAKNESS IN TEAM**

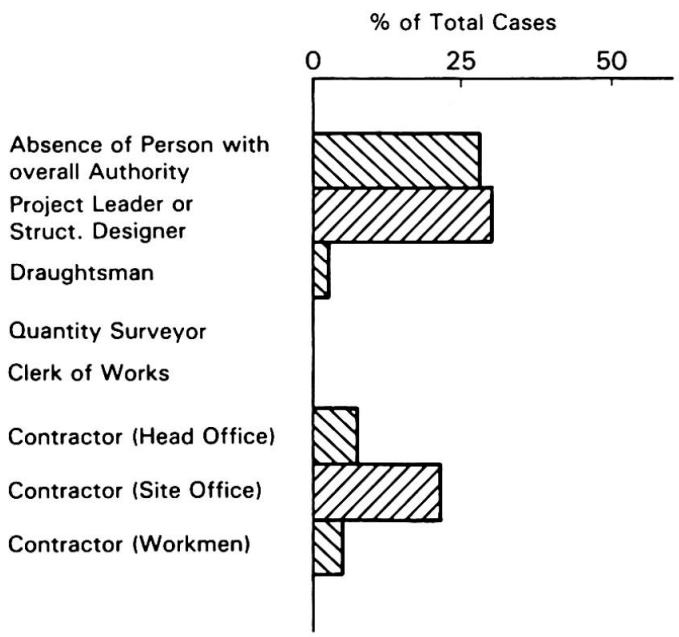

FIGURE 3 : **MEASURES TO MINIMIZE RECURRENCE**

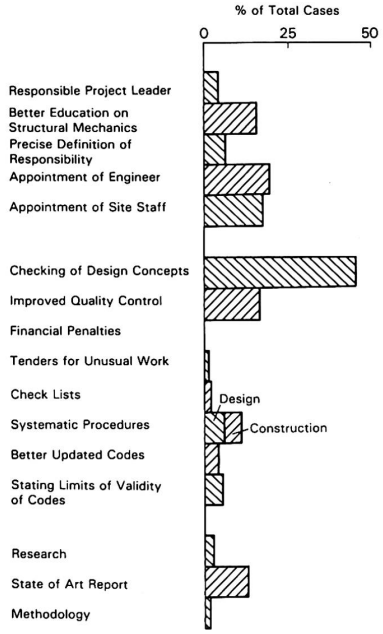

FIGURE 4

COMPARISON OF BUILDING CONTROL SYSTEM

Stages & Processes	Control Methods	Controlling Authority		
		England & Wales	Germany	France
Briefing				
Design				
Idealization				
Calculation	Building Regulations & Acts	Central Government & Parliament	Land Ministry & Parliament	Central Government (Decrees & Orders), Laws (Parliament)
	Codes & Standards	Standards Organization (BSI)	Standards Organization (DNA) & Engineering Association (VDI)	Mixed Committees
	Checking	Local Authority	Building Authority	Insurance Companies
Project Information				
Selection Materials Components Techniques	Standards Product Approval	BSI	DNA, VDI Building Institute	Mixed Committees CSTB
New Products	Agrément or General Approval	Agrément Board	Building Institute	CSTB
Construction	Codes & Standards Quality Control	BSI Industry	DNA, VDI Industry & Official Testing Stations	Mixed Committees Insurance Companies
	Inspection	Local Authority	Building Authority	Insurance Companies
Completion	Final Inspection	Local Authority	Building Authority	Insurance Companies
Use & Maintenance				

Stages & Processes	Control Methods	Controlling Authority	
		Scandinavia	Netherlands
Briefing			
Design			
Idealization Calculation	Building Regulations & Acts	Central Government Parliament	Local Authorities (Bylaws) & Parliament
	Codes & Standards	Engineering Associations	Association of Engineers
	Checking	Local Government	Local Authority
Project Information			
Selection Materials Components Techniques	Standards Product Approval	Engineering Associations Standards Organizations	Standards Organization (NNI) Official Approval Authority (KOMO)
New Products	Agrément or General Approval	Central Government	KOMO
Construction	Codes & Standards	Engineering Associations	Association of Engineers
	Quality Control	Industry	KOMO
	Inspection	Local Government	Local Authority
Completion	Final Inspection	Local Government	Local Authority
Use & Maintenance			

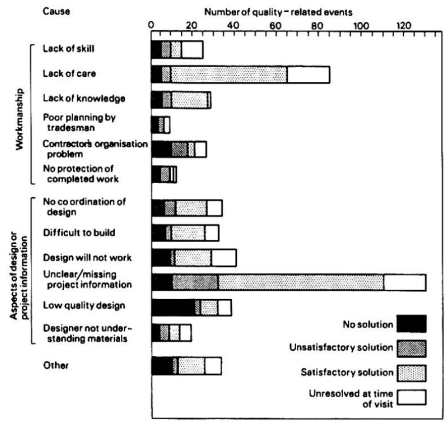

FIGURE 5 : Causes of all 501 quality-related events, and success with which they were resolved

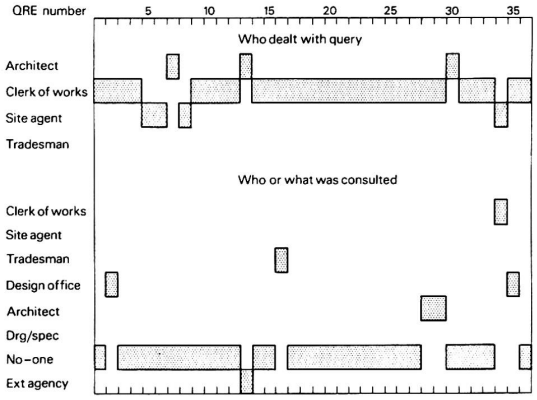

FIGURE 6 : Personnel involved with the quality related events (QREs) observed on a 'non-consultative' site. Quality standards were generally poor on this site

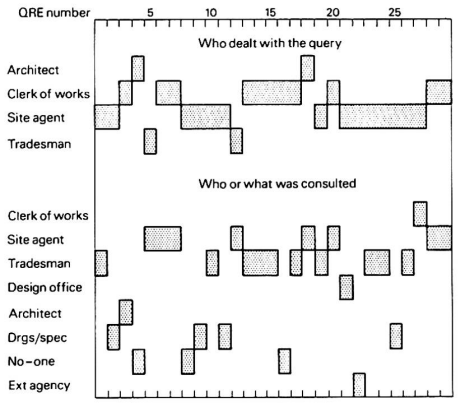

FIGURE 7 : Personnel involved with the quality related events (QREs) observed on a 'consultative' site. Quality standards were very satisfactory on this site

FIGURE 8

CODES OF PRACTICE – Simplified Table of Differences among some EEC Countries

	UK	Germany	Denmark	France	Netherlands	Italy
(A) Who issue Regulations & Codes	Secretary of State Dept of Finance (Northern Ireland) BSI	DIN Ministers of Federal Laender. Additional rules by Ministry of Transport	Ministry of Housing DIF (Danish Society of Engineers)	Public Contracts – Ministry of Equipment French Standards Assn (AFNOR) Private Contracts – Standards Technical Documents Grp or above	NNI (Netherlands Standards Institute)	Ministry of Public Works CNR, UNI (Italian Standards Institute)
(B) Are they Mandatory?	(1), (2) and (3) Mandatory (1) Building Regulations (2) Loading Codes (3) Standards & Technical Memoranda for Highway bridges (4) British Standards – deemed to satisfy	Yes (de facto) Approval may be given for departure in special cases	Laws and Circulars – Yes Codes – deemed to satisfy	Public Contracts – Yes Private contracts – Builders subject to 10-yr guarantee by law. Hence Insurance companies become approval bodies	Yes if client and contractor agree	Laws, Decrees, Circulars – Yes
(C) Do they define roles of parties to building works?	Building Regulations do not specify roles	Yes	Yes	Not generally	No	Yes, two "Directors":– Resident Engineer (design/construction) Site Agent (Workmanship)
(D) Is there a Master Code (Principles for various Material Codes)?	No	Yes, since 1977 Revised version near completion (not mandatory)	Yes, 1978 (NKB document)	Yes, since 1971	Yes, since 1972	Yes (1979)
(E) Future Codes based on Limit States?	BSI Committees agreed	Yes	Yes, since 1965	Yes, gradually	Yes, gradually	Yes, gradually
(F) Enthusiasms in Reliability Theory (0 = very low)	0	2	3	1	1	2