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Problems of Safety and Quality Assurance in the Third World

Problèmes de sécurité et d'assurance de la qualité dans le tiers monde

Sicherheits- und Qualitätssicherungs-Probleme in der dritten Welt

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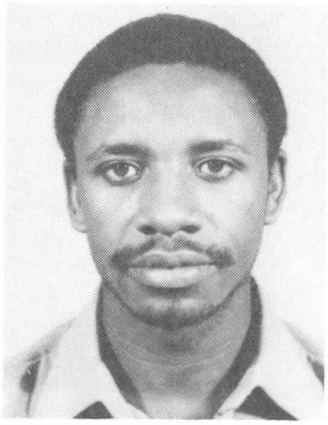

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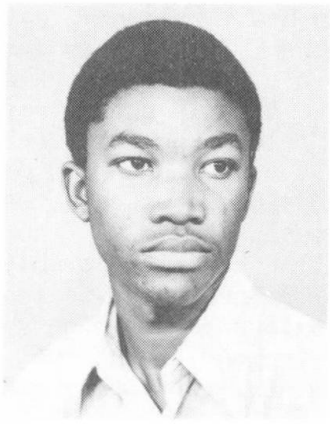

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SUMMARY

Decisions and actions affecting the safety and quality of civil engineering structures depend highly on the skill, experience and attitudes of the individuals involved during design, construction and operation of the structures. This paper intends to look at how the level of development and organisation of the civil engineering profession in Third World countries influence these human and other organisational aspects which cause safety and quality assurance problems in these countries. Recommendations on how the situation could be improved are also put forward.

RÉSUMÉ

Les décisions et les actions qui ont une influence sur la sécurité des personnes et la qualité des ouvrages, dépendent pour une large mesure des capacités, de l'expérience et de l'attitude des personnes concernées lors du projet, de la construction et de l'exploitation des structures. La contribution présente le niveau de développement et l'organisation de la profession d'ingénieur civil dans les pays du tiers monde et l'influence de celle-ci sur les aspects humains et d'organisation, lesquels ont une influence directe sur la sécurité et l'assurance de la qualité dans ces pays. Des recommandations sont présentées sur les possibilités d'améliorer cette situation.

ZUSAMMENFASSUNG

Entscheidungen und Handlungen, welche die Sicherheit von Menschen und die Qualität von Bauwerken beeinflussen, hängen in hohem Masse von den Fähigkeiten, der Erfahrung und der Einstellung der beim Entwurf, bei der Ausführung und der Nutzung von Bauwerken beteiligten Fachleute ab. Im folgenden Bericht wird gezeigt, wie der Stand der Entwicklung und die Organisation des Bauwesens in Drittweltländern menschliche und organisatorische Aspekte beeinflusst, die ihrerseits Sicherheits- und Qualitätssicherungs-Probleme verursachen. Zuletzt werden Empfehlungen zur Verbesserung dieser Situation gegeben.

INTRODUCTION

The design, construction and maintenance of any civil engineering structure is normally closely guided by standards, generally referred to as "codes of practice" which, if adhered to,are supposed to safeguard agreed safety and quality levels for these structures at "reasonable" costs. Assuming that the standards adopted are optimal, any attempt to increase the safety and/or quality level of a structure would cost more than the additional benefits, while any attempt to reduce the cost of the structure would result in a disproportionately big reduction in the safety and/or quality levels of the structure. This trade-off between cost and safety and quality of a structure is dependent on not only the level of knowledge and experience of the individuals involved but also the environment they train in, practice in and live in which shapes their attitudes and professional conduct. This trade-off is done consiously or unconsiously at different stages in the conception, design and construction of the structure and by various individuals at various levels of organisation.

Thus, decisions that do affect the safety and quality of civil engineering (CE)structures have quite a heavy reliance on the human qualities (attitudes) and organisational aspects of the CE profession which in turn depend on the level of development of the industry in a given society. A study of structural failures in various parts of the world [2] have clearly shown that these human and organisational aspects play a very significant role in the failures. It is therefore,the objective of this paper to look at how the special human and organisational aspects existing in the Third World countries cause problems in safety and quality assurance of structures in the CE industry in these countries. In the paper, we will look at how the following factors do have an influence on the problem:

- shortage of well trained and experienced personnel at all levels;
- non-existent or existance of infant and inexperienced professional bodies for guidance of the development of the industry and profession;
- financial constraints, for capital and maintenance investment and for training of personnel;
- low level of development of the supporting industry, e.g. building materials industry, transportation, etc.

In the following chapters, we will first present a discuasion on the general level of development of the CE profession in a typical Third World country, and later on discuss on how the factors listed above interact to contribute to the problems of safety and quality assurance of CE structures in these countries.A few examples will be presented to illustrate these problems. But, it must be appreciated that such examples are going to have quite scanty details, since availability and access to information on structural failures in Third World countries is quite difficult due to the fact that such information is hardly kept and if available is normally highly confidential. The discussion and examples in the paper will be heavily biased towards the Tanzanian experience, which we strongly believe to be characteristic of a typical Third World country.

The paper will be concluded by presentation and discussion of our recommendations for possible improvement or rectification of the situation.

2. LEVEL OF DEVELOPMENT OF THE CE PROFESSION

In most parts of the Third World, engineering education, especially at college level is quite young and a fairly recent development. For example, in Africa, South of the Sahara (excluding South Africa), the first engineering school was started in 1938 at the University of Kumasi in Ghana. Most other countries established their schools or colleges after attaining political independence. Tanzania's only engineering school was established in 1973 at the University of Dar es Salaam with capacity to produce about only 60 graduate civil engineers per year. Thus, the CE industry in quite a number of these countries is largely dominated by foreigners and a few foreign-trained nationals. The situation is improving at a fairly slow rate. Tanzania,for example

has an estimated 3000 engineers only, for all disciplines, for a country of more than 20 million people [6].

Besides this formal education, practical training, i.e. the period during which a graduate engineer works under close supervision of an experienced engineer ,is very important in the making of a competent engineer. But because of the scarcity of engineers, this aspect of training is skipped and it has been and still is to a lesser extent very common in Tanzania to find a fresh graduate being assigned to a top-most position in an organisation or a project straight after school. According to a survey conducted in Tanzania by the Institution of Engineers Tanzania [7] very few organisations or firms have training programs for fresh graduate engineers.This obviously causes problems, since you have a situation whereby inexperienced engineers are occupying critical decision making positions.

Yet another common feature in the CE profession in Third World countries is the adoption of foreign standards and codes of practice and lack of adequate building regulations. In Tanzania, for example, British standards are being used directly without proper modifications to account for the local prevailing conditions, like the differences in the levels of site supervision, workmanship as well as the level of quality control both on site and in industries producing the various building materials, let alone the different environment, culture and behaviour.

Worse still, professional bodies as well as building authorities which could act as watch-dogs and guide the development of the profession, both in performance and training, are either non-existent or are too young and still exist in a fairly ineffective form. In Tanzania, for example, the only professional engineering body,the Institution of Engineers Tanzania (IET), was established only in 1977, after the break of the East Africa Institution of Engineers.

Such is the level of development of the CE profession in a typical Third World country. Obviously, the attitudes and performance of all those involved in the CE profession in these countries are greatly influenced by these factors. Their effect on safety and quality assurance of CE structures will be discussed next.

3. DISCUSSION OF IMPORTANT ISSUES AND PROBLEMS

3.1 The role of Building Authorities

One of the key players in the enforcement of safety and quality standards for CE structures are the area building authorities who are normaly represented by city or town engineer(s). They are legally empowered to check and approve designs and construction of all CE structures. Third World cities are known to have very high grogrowth rates resulting in very high pressure on housing needs. This together with the fact that there is an ever increasing need for office accommodation and industrial facilities, puts very high pressure on the construction industry. The resulting construction activities by far outweigh the capacity of the poorly staffed and improperly organised building authorities. This leads to a situation where several civil engineering structures are being constructed without or with extremely poor follow up from the building authorities. Even building permits are issued without proper checking of all the aspects of the structure regarding land use, structural safety and health (sanitary) requirements fully analysed.

3.2 Quality Control

Another factor that greatly affects the quality and safety of civil engineering structures is quality control. In this respect reference is made to quality control of various building materials involved in these structures. One of the main problems in this area is the in-adequecy of testing facilities and qualified personnel to run them. In Tanzania, for example, there are only three known laboratories for testing various building materials. Moreover they are all located in Dar es Salaam! This makes testing for upcountry sites, some of them more than 1,000 km from Dar es

Salaam, and with poor transport facilities, very expensive and impractical as far as time is concerned. As such almost all upcountry constructions proceed without proper quality control.

It should be noted that this question of quality control is even more important in the Third World countries because even the quality of some inputs like cement, re-bars etc.,is quite unreliable. This means that to expect the desired quality and safety of a structure by simply adhering to what the code of practice says may be disastrous, unless the designer had taken the uncertainity factor in his/her design, say by deliberately overdesigning. In fact some consulting firms do overdesign in trying to compensate for the above problem.

Another problem as far as quality control is concerned is the fact that some decision makers at the sites do not fully appreciate the importance of quality control. In this aspect you find even the client or a representative of the client not very particular about it. As a result, you find even in major projects , some involving big international companies, the contractor may be free to choose whether or not to carry out specified quality control measures.This may set not very good examples to the growing local firms.

3.3 Non-adherence to Professional Ethics

Like in all other professions engineers and contractors are supposed to adhere to some code of conduct for the betterment of the profession. While the engineer is required to supervise the project during construction on behalf of and in best interest of the client, the contractor is supposed to adhere to the design specifications in order to uphold the safety and quality of the structure as per design. In some Third World cases these responsibilities are deliberately not adhered to either by the resident engineer,consultant or contractor or all may collude to cheat the client. For example in some public projects, the representative of the client, either for self-interest (economical or otherwise) or lack of commitment, may ignore recommendations put forward by the engineer and may tend to be working in the interest of the contractor e.g. keeping a blind eye when the contractor deviates from specifications without engineer's approval, at the expense of quality and/or safety of the structure.

Another problem in this aspect is contractor cheating by some unscrupulous contractors,who try to take advantage of the prevailing situation. They may, for example, violate specifications in order to save material. An example in this case is a situation where a contractor was discovered to have constructed a highly defective residential building by providing only 120 mm thick slab instead of 150 mm and 270 mm deep beams instead of 450 mm as specified in the design.

This behaviour together with the fact that there is no proper quality control leads to a serious problem. This is further complicated by the fact that there may exist no clear legal provisions specifically governing the conduct of engineers as is the case for Tanzania [4].

3.4 Incompetence

Shortage of well trained manpower, as well as lack of appropriate equipment and machinery are the main factors resulting in poor performance for both engineers and contractors. One interesting case in this regard is a recent event in Dar es Salaam in which a huge industrial building was saved from total collapse at the last minute. The building consisted of reinforced concrete portal frames to stand on pad footings three metres below floor level, and a boiler whose foundation was to be about twelve metres below floor level and within two metres of the outside walls. During construction, the contractor chose to start with the the erection of portal frames and when he later started excavating for the boiler foundation , he had reached a depth of about six metres below floor level when, as would be expected, the unprotected pit started to show signs of collapsing. If it were'nt for an experienced consultant who was called in urgently to recommend remedial

measures, the entire structure would have collapsed. It should be pointed out that this project was the biggest for both the contractor and consultant,and apparently both firms did not have well qualified engineers.

Another case in point, is a bridge project in Tanzania. Here, the Tanzania Government had to expel the main contractor from the site allegely for "non-performance". At the time of expulsion, the contractor was almost 9 months behind schedule and had failed to carry-out recommended remedial measures after heavy floods had caused the collapse of 14 bridge poles and badly damaged two others [1]. This is certainly another case of an incompetent contractor.

One could go on and on giving these examples. The point is, there are many other projects being handled by incompetent contractors and/or engineers that go unnoticed but whose safety and quality leave much to be desired.

3.5 Safety on Site during construction

In most Third World countries construction work is mainly labour intensive with a minimum of the essential machinery. Hence the safety of workers on site is quite important. But, according to a survey conducted in Dar es Salaam [9] in 1984,safety conciousness among contractors, supervisors and workers on site is very low,and not much efforts have been made to safeguard the workers on construction sites. It appears that even the ministry responsible for industrial safety has no standard guidelines for safety measures on these sites [9] . Even basic items like crash-helmets, gloves and boots for the workers are often never supplied . In a number of cases you find casual labourers going around on site barefooted, carrying on their naked heads broken "karais" full of concrete and balancing them with bare hands!!. Even hot bitumen may be sprayed by workers who are bare-handed and without proper gum-boots.

Major site accidents reported in Dar es Salaam in the period 1980-84 are summarised in Table 1. In the table, traffic accidents include people injured or killed on their way to or from site on dump-trucks (not permitted to carry passengers).People falling from temporary structures included those falling from scafolds,working platforms and defective ladders. Most of these type of accidents could have been avoided if checking of the temporary structures by qualified people were performed.

Falling from permanent structures were mainly from areas designed to have hand rails or gates but at the particular stage of construction were not yet in place and no temporary fancing were provided. In other cases falling resulted from using poor quality or wrong tools. Falling of materials was found to be primarily due to overloading of cranes and lack of proper maintenance of machinery.

Table 1: Analysis of 212 Major Site Accidents [9]

	Traffic Accidents	Fall of persons		Fall of Materials	Nature of Injuries			
		From temporary structures	From permanent structures		hand/ arm	Legs/ feet	Head	Others
No of accidents	28	24	23	67	83	59	15	55
%-ge of total	13%	11%	11%	32%	39%	28%	7%	26%

Thus, a look at the table suggests that absence of safety equipment like helmets , gloves and boots is one of the major causes of lack of site safety. We can generally conclude that the major cause of site accidents is the ignorance, careless - ness and the contractors' attempt to cut costs at the expence of the safety of his workers.

3.6 Inadequate Maintenance

Another major cause of problems of safety and quality assurance of CE structures in the Third World countries is poor or absence of maintenance. In Tanzania,for example, pot-holes are a common feature on highways. Even relatively cheap maintenance activities like ditch and culvert clearing are often never done. As a result an increasing number of highways are becoming very unsafe due to the sometimes half-hazard manner in which traffic has to move to dodge potholes and other defects on the roads. Why is all this happening despite the existance of special maintenance departments in various organisations ? The following factors may help highlight some of the causes of these problems.

3.6.1 Lack of maintenance awareness.

Quite a good number of decision makers, especially those responsible for allocation of funds, are not technically trained and/or do not seem to appreciate the importance and magnitude of the maintenance problem. They are more willing to issue funds for new projects rather than for maintenance of existing structures, i.e. they much more readily respond to the need for "increased quantity" as opposed to maintenance of "existing quality". Budgetary allocation of funds for developmental and recurrent projects clearly display this phenomenon [8].

3.6.2 Lack of well qualified maintenance personnel.

There seems to be a general attitude among young engineering graduates and even some top decision makers in the Third World countries that an engineer's job is to design and/or construct only. Maintenance is looked upon as a job for the less technically qualified people since, they claim, it is not "technically challenging". As a result, many well qualified people are not keen to join maintenance departments and the few who are already there are generally not enthusiastic with their jobs. This could be partly due to university curricular, which does not generally stress on the importance and techniques of good maintenance management, but mainly due to the general shortage of qualified personnel. The situation is made worse by lack of incentives which would reward for good maintenance work done and punish for poor maintenance work.

3.6.3 Influence of Foreign designs.

Quite often, foreign consultants have come up with designs for structures, which, after construction, have posed a lot of maintenance, and hence, operational problems due to heavy reliance on imported machinery, equipment, spare parts and sometimes even personnel!

Many examples do exist in this category. One of them, in Tanzania, is an infamous railway level crossing, between a 3-track rail-line and a major 4-lane highway in the capital city. The crossing was designed to operate with an automatic alarm system in combination with traffic lights, but just a year after openning the automatic alarm system went out of order and the crossing has since claimed a lot accidents, causing loss of lives and property. The authorities have failed to repair the system apparently for lack of spare parts which have to be imported. A look at other automatic alarm systems in the city had already indicated the unreliability of these systems in Dar es Salaam. A strong metal-gate operated manually (since the train frequency is fairly low) to block the way could have been a better solution at may be the same cost.

This clearly spells out the need for foreign designers to study in their projects maintenance feasibility of the designed structures.

4. RECOMMENDATIONS

4.1 Manpower Training

- While at college the engineer to be must be thoroughly educated on the importance of keeping to professional ethics as well as the importance of maintenance.
- Practical training for graduate engineers should be given more emphasis. Efforts to establish training procedures, as is currently been tried in Tanzania [7] , should be encouraged with machinery to enforce its implementation.

4.2 Monitoring of Performance.

- Professional bodies should be strengthened to provide a more effective media for sharing experiences and as a body to advise governments on how to improve the performance of the profession.
- The authorities concerned with the development of the construction industry should try their best to acquire more testing facilities and locate them in a geographically balanced manner.
- Supporting industries should try to have better quality control during the production of the inputs to the construction industry.
- Clients must be educated on the importance of making sure that contractors , do follow existing building regulations and quality control procedures.
- There should be incentives that reward for good performance while costly mistakes which are proved to be deliberate actions are heavily punished by say the withdrawal of registration.
- There should be a thorough check, by competent bodies, on both credentials and ability of engineers reported to be working for any engineering company just before its registration, and from time to time on the availability of those engineers to that particular company.
- Analysis of structural failures and site accidents should be well documented and made available to the profession to do away with possible repetitions of mistakes.

4.3 Maintenance.

- Efforts should be made to quantify the benefits aquired from the maintenance of civil engineering structures. This will place maintenance activities at a competitive footing with new projects when it comes to the allocation of funds.
- To improve efficiency governments could employ private contractors to avoid current inefficiencies known to exist in the in-house maintenance crews.
- To check on the suitability of projects designed by foreign firms, there should be a machinery for ensuring, among other things, the maintenability of the structure under prevailing Third World conditions.

4.4 Others

- The government ministry responsible for industrial safety should set safety regulations on site and establish procedures and machinery to enforce them.
- Before the use of any foreign code in a Third World country, a critical review should be made to ensure that it complies with the prevailing level of development of the CE industry.

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