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## Construction and Inspection

- Moderator: K. Sriskandan, Chief Highway Eng.  
Dep. of Transport; London, UK
- Panelists: Robert Fechtig, Prof.  
Swiss Fed. Inst. of Technology; Zürich, Switzerland  
Bernd Hillemeier, Dr.-Ing.  
Hochtief AG; Frankfurt, Fed. Rep. of Germany  
Marita Kersken-Bradley, Dr.-Ing.  
Consulting Engineer; München, Fed. Rep. of Germany  
David W. Quinion, Company Chief Eng.  
Tarmac Constr.; Wolverhampton, UK  
S. A. Reddi, Chief Eng.-Projects  
Gammon India Ltd.; Bombay, India  
Ken Umeda, Senior Managing Dir.  
Kajima Corp.; Tokyo, Japan
- Taking part in the discussion from the floor:  
G. Breitschaft, Berlin  
A. G. Meseguer, Spain  
S. Mino, Japan  
P. Mtenga, Tanzania  
J. O'Brien, Australia  
S. Ono, Japan  
J. Schneider, Switzerland  
A. G. Simpson, UK  
W. von Olnhausen, Sweden  
L. Vu Hong, France  
Y. Yokoyama, Japan  
J. H. Willenbrock, USA

**K. SRISKANDAN, UK, MODERATOR**

The way we propose to run this panel discussion, is to have discussions under 6 or 7 themes. What we propose to do is to introduce each topic by a panelist, a short statement of about 2 minutes.

The first one is "How important is the control of materials in execution" to be introduced by Dr. Hillemeier.

**B. HILLEMEIER, FR Germany**

In Germany and other countries specific procedures for approval and testing of construction materials exist. These approval procedures normally do not require additional testing on a construction site. Nevertheless, for certain sites it is advisable to execute further testing especially when there are extreme conditions regarding shipping of materials and atmospheric conditions. The extent of further testing would be testing at random with the aim for the identification of the material and to check the relevant properties. In our company we usually take samples for additional material testing in accordance with a test program proposed by the QA department. On big sites in foreign countries these tests are performed in a local laboratory whereas in Germany these tests are performed in our central laboratories. This is, for instance, valid for cement whose quality may be impaired by humidity or for additives the quality of which might be impaired by high temperatures. Reinforcement bars should be tested at random especially with regard to brittleness.

**MODERATOR**

The floor is now open.

**D. QUINION, UK**

In the U.K. the adoption of quality assurance means that there is a requirement that quality assurance procedures apply to the manufacturers. This is done in a variety of ways, but the popular way which is extending to cement, to ready mixed concrete and is already evoked in the case of reinforcing steel and structural steel, is that the producers of the raw materials operate quality management systems. Those systems are assessed by a third party certification scheme which is representative of the manufacturers of the materials, the users of the materials, such as contractors and consulting engineers, and the clients, the principal government bodies and private companies who are concerned that the quality is right.

The third party certification scheme is very akin to an audit team which initially assesses the quality management system and goes round periodically and assesses what is going on. These means ensure that materials such as cement, ready mixed concrete and reinforcing steel come to the site already produced to a given standard.

There is an alternative way with a new material for which there is no great background of knowledge, and we have to encourage the adoption of new materials if, as an industry, we want to move forward. These materials have to get what is termed an "Agrément Board Certificate". The Agrément Board assesses a new material for the purposes for which it is being promoted and issues a certificate, when it is satisfied for the stated uses and stated compositions, that the material is fit for use for a given life. It might be 10 years, it might be 50 years.



This enables new materials to be put forward and adopted by industry. So, in the U.K., we recognize the importance of materials control and we are expecting the supply industry to set up their own systems to supply sites with materials of stated and proven properties.

**MODERATOR**

Thank you David. Can we now put that question to the panel. Is there a similar quality assurance scheme for materials in other countries? Do suppliers get together and have quality assurance schemes in other countries?

**G. BREITSCHAFT, Berlin**

We have in our country a very similar system as mentioned before by Mr. Quinion. It is a system subdivided into a standardized area and in a non-standardized area. The standardized area will be covered by our DIN standards and there is a very similar certification procedure showing that the products are in accordance with the requirements of the standards. And for new materials and new systems, we also have a procedure on a legal basis, we call this - what is in the U.K. the Agreement - in our country "Zulassung". These performance qualifications will be standardized by the "Institut für Bautechnik, Berlin" after all the necessary tests have been carried out. Also questions of durability, lifetime etc. are included in this technical review. Maybe, in the near future, we will have in Western Europe, within the borders of the European Community, in the near future a common system for all the countries.

**M. KERSKEN-BRADLEY, FR Germany**

I want to ask Dr. Hillemeier if he was suggesting that the means, methods or objectives of testing are not sufficient as they are employed at the present time. Should testing put more emphasis on assessing suitability or identification, rather than on assessing compliance or non-compliance?

**B. HILLEMEIER, FR Germany**

In Germany the situation is like Mr. Breitschaft explained. Because building materials are procured on the basis of standards and approval certificates describing the properties of the materials, no additional tests have to be performed. As I already mentioned before, additional testing is advisable when special conditions are given. Identification and compliance testing helped us in several cases to avoid damage.

**MODERATOR**

Anybody else on that? Mr. Reddi, would you like to say finally what you think about the discussion so far, as far as cement and concrete is concerned and how it compares?

**S.A. REDDI, India**

As far as cement goes all the earlier remarks are very appropriate, where the cement is used in the country of production.

We had a number of projects being executed in third world countries, where the cement has to be imported. In that event, there is a possibility of deterioration of quality, maybe during transport. We have noticed in a few cases that the quality of products for the export into third world countries, to be very frank, is not exactly the same as the one for use in their own home countries. In such



cases, I think, it is imperative that for medium and large projects in-house testing must be resorted to. In fact we have a number of case histories, where our own company had the problem both with respect to quality of cement and reinforcement steel. In fact, with the reinforcement steel we had problems about the conformity to the dimensional requirements. So maybe, even though it costs a little more, it is worth having on site testing facilities, except for very small projects.

**MODERATOR**

Thank you. We move on to the next subject now which is: "Control of Components", i.e. precast products, prefabricated steel, anything that is produced off site. Can I ask Mr. Reddi again to make a short statement about that.

**S.A. REDDI, India**

We have already dealt with cement and reinforcement. Before I go on to precast members I would like to make a few observations on certain other components, which are totally bought items. For instance in the case of precast concrete, anchorages are bought from specialist agencies. How far are we right in merely using these materials based on the trade literature supplied by the manufacturers? Should we think in terms of some independent test, I would like the audience to react on this.

Similar is the case of bridge bearings. We have metal bearings, bearings with neoprene and the like. At the moment all the quality assurance aspects of certain bought bearings are entirely dependent on the data furnished by the manufacturers and we have to accept them as such.

For some of the export contracts in the less developed countries, we are obliged to get some of these products tested at some independent established laboratory and we found, rather surprisingly, unsatisfactory results in a few cases, even though the products were supplied by some of the very well known international suppliers.

The next point related to this is the role of specialist sub-contractors and who is responsible for quality in such cases, prestressing for instance. It is not always the general contractor that carries out prestressing work, maybe prestressing of a precast member. Sometimes, the precast members are purchased from factories and if they are prestressed members, we have problems apart from the dimensional accuracy. There are problems related to deflections. When the deflections are not uniform, there are problems about matching the components.

Then there are items which are temporarily sub-contracted out, waterproofing for instance or, coming down to buildings, architectural railings, expansion joints for buildings. We did come across a large amount of conflict on interpretations as to who will be responsible for these qualities. Generally, the specifications are drafted by the specialist contractors or specialist suppliers. I would like you to react on this.

**MODERATOR**

Thank you Mr. Reddi. - First of all, manufactured products like anchorages, bridge bearings and the like. What is the audience's view on testing of these and quality control of these products?



Obviously, you are all very happy with the way the discussion is going on.

**K. UMEDA, Japan**

Let me talk about my own experience. Because of the recent very strong Yen some of the Japanese contractors are seriously thinking of structural steel fabricated outside Japan. For instance, if we could import fabricated steel from Korea, economically speaking this is very helpful. However, the problem is the welding. According to the building regulations of Japan, prior to the shop fabrication, when welding is associated in it, we have to submit details of the welding for approval by the relevant authorities. Now, whether that welding can be done in strict accordance with this specification or not, is a problem. That is one point.

The second point is: In the international operation of our business we sometimes have to transport fabricated steel a very long distance by ocean freight. Now our experience told us, even though the fabrication of steel was done properly in our country and it was inspected by a professional quality inspector, still there is a problem, that is transportation. The damage which may occur, damage to the rust protection coating for instance which may occur during the process of transportation. Now, this creates lots of problems.

An extreme case: When we constructed a thermal power plant in Cuba, some important pieces of fabricated steel were lost. They disappeared into thin air. So not only to the quality control at the shop, but also to the logistics, transportation and insurance we had to pay very much attention.

**MODERATOR**

Thank you.

Could we turn to the next subject please: "Construction and erection on site", including accuracy of site work.

**D. QUINION, UK**

There are several points which one has to take into account when considering the quality of performance on site. The first one is: What are the tolerable deviations which may be allowed on the accuracy of members and their position and on the composition of various materials. Tolerable deviations should be carefully specified and they should have been taken into account by the designer. The materials at the time of delivery to site must conform to the specification. They have got to be transported to the site safely. We need to check them at the time they arrive, make sure they are unloaded in a manner which is acceptable to the supplier and that they are carefully stored and carefully issued, so the right thing goes in the right place. A very clear example is when somebody employs a black, mild steel bolt, when a high tensile bolt should have been used and I know a tower crane collapsed for that reason.

Construction work should be carried out to consistent standards. This is so that the men who do the work know the accuracy that is normally required of them and the standard of finish that they have to provide. This means that they work with knowledge of what they have to do. If we are consistent from site to site, then we will produce the standard of work required much more cheaply.



The next point is: Check as you go. You need to check what is going on as it goes on. The consequences, for instance, of removing a pour of concrete which has hardened when you have perhaps continued work on the next pour above it, are very costly and they are very time consuming.

Take the instance of piles and foundations which are to be covered up. I know of no alternative to having somebody directly inspect every single pile after it has been formed, before it is covered up or concreted. Not only do you need somebody to inspect and make quite clear that things are as they should be, but you need some form of further inspector or auditor to keep him on his toes, to make him aware of the fact that his activities are subject to inspection and if the inspector gets it wrong, then you fire him immediately.

**MODERATOR**

Those are some of the points which Mr. Quinion thinks should be looked at, tolerances, check as you go, inspection of piling. What are things the audience thinks should be checked?

**M. KERSKEN-BRADLEY, FR Germany**

Looking at standards in our country, and I think it is similar in other countries, there is quite a discrepancy between the density of regulations in relation to control of materials as compared to the density of regulations regarding construction on site. Is this considered appropriate in view of the fact that site construction, works on site, cannot be controlled or are more difficult to control in terms of acceptance and rejection and thus are considered to be more appropriately supervised or monitored? Does this explain the difference completely, or do you also share the opinion that there may be some inappropriate preponderance in the density of rules comparing material control and construction control?

**MODERATOR**

Any reaction on that one?

Well, in that case, we are going to the next topic: "Temporary Works and how they might affect Quality Assurance".

**B. HILLEMEIER, FR Germany**

On the site, in my experience, those construction details will be realized correctly which are described in the drawings. The drawings are important because they are actually present on the site, and that without alteration of information. Let us, therefore, put all relevant data into the drawings and not rely on doing the work like children at play: When the first child whispers a little story to his neighbour and then this child passes the story on to the next one and so on... Then we should not be astonished about the final results.

The details in the drawings must be the better the more the personnel lacks skill and experience. Quality Assurance can pick up here. This is an organizational step.

**J. SCHNEIDER, Switzerland**

What about site inspection, just looking whether the site is tidy or not? For me it is always a good indicator to look if things are left in the way of people, e.g. if someone could fall over some bar and



break a leg. Also if people wear their helmets, their ear shields, or wear their glasses if they are doing something on the machines gives useful information. I think, these are indicators of whether a site runs well and is run well. I think this is also a good indicator of the quality of the construction. I am not so concerned about concrete cube testing. This is just an alibi. We say, look here, we do a lot for quality. But we do the wrong things. So what about this: is a tidy site a good sign?

**J. WILLENBROCK, USA**

The title of the symposium is "Safety and quality assurance of civil engineering structures" and I have heard a lot so far about safety from the point of structural adequacy. I wonder whether under this topic of safe construction, it is not important also to think about the preplanning that is necessary for the safety of the workers on a construction site. It seems that nobody has really addressed that and I think that your point is probably the tip of the iceberg related to that whole area of construction safety.

I know, in the United States, over the last 10 or 15 years there has been a lot more emphasis in the area of construction safety. I think the preplanning for quality and the preplanning for safety often go hand in hand because those two elements run counter to cost and schedule, which are the primary areas we often tend to emphasize. I wonder if we would not want to expand that area of a clean site and look at the broader issue of what is required to guarantee that we have a safe site.

**MODERATOR**

I think that is terribly important. Anybody who wants to comment on that from the audience?

**G. BREITSCHAFT, Berlin**

I want to contribute a second time to the question raised by Mrs. Kersken. I think this question was not covered up to now. The question was: Is it necessary to have the same density of regulations for control or supervision on site as in the production field?

If we look at the statistics about failure rates which are presented in a lot of papers at this symposium, we see that a lot of causes have to be seen in connection with the work on site. Therefore, I personally have the feeling, that we should do more in this field.

The other question is: Is it possible to do this in the same way as it can be done in the production field? The production field is a continuous process. In this area it is possible to make common regulations describing the procedure of control. The work on site differs from this process and, therefore, I would propose not to try to write detailed codes or detailed standards how the work or the control work should be performed on site. I think it is better to follow a proposal made for instance by Jörg Schneider, to require for each project a special control plan. Such a control plan can be elaborated by the designer, knowing where the possible weak points in the structure are. This control plan can then specify or identify the necessary steps of control on site and the way how to perform it.

**MODERATOR**

In a way that touches on the question raised by Professor Willenbrock, which is preplanning for construction safety which is related to site organization.

**D. QUINION, UK**

If I could come back to the question of safety. Safety like quality is required in the U.K. to be a particular responsibility of the man who runs the company. So, the Managing Director, Vice President or whoever you may call him, is held responsible in the U.K. for the operation both of the quality management system and the safety management system within the company. On a large site we will have a safety officer and for smaller sites we have a series of travelling safety officers and it is their duty to draw the attention of the project management to any practice which they consider is unsafe or one which is going to be carried out which involves risk and hazard. If they are not satisfied that the proper standards are going to be achieved, then they can report the matter and it is put right by the highest level of management.

A recent investigation into falsework collapses 10 years ago and an observation of what was going on around the world showed that an unreasonable number of accidents were taking place, far too many people were being killed and lots of people were being injured. As a result, in the United Kingdom, we instituted a specific investigation. The report of that investigation was partly technical, it was partly concerned with the organization of work, it was partly concerned with the training of people in safety and it also addressed the question of "how can we make it better?". A code of practice was produced for falsework and in that document it was recommended that a coordinator be appointed for each and every site, who had to make sure that temporary works were carried out to designs and that somebody would be responsible for seeing that this was carried out and checked. It also indicated a checklist of items which should be given attention to in checking the design and in checking the work on site.

Now, when government safety inspectors tour sites - and they can go on any site at any time - they will examine whether these responsible actions have been taken, whether there is or is not a temporary works coordinator. If they are not satisfied they can issue a prohibition notice and from that moment work stops until they are satisfied that a safe method of working is to be used. The inspectors might be wrong, in which case the contractor can go to court to have the matter discussed and the prohibition removed, but normally they get it right and contractors have to conform.

**MODERATOR**

I think, Mr. Quinion was talking about temporary works and safety of temporary works and personnel, but there is one view that that does not contribute to quality assurance of the structure. Does anybody have a view on that?

**J. SCHNEIDER, Switzerland**

I am not so sure that the quality of the structure is the only thing we should look at. I think, we should really look at the safety of people at the site. This is, in Switzerland especially, but also in other countries, the most dangerous place you can find. We have to do something about this. What we have to do is not costly. It is in



fact cheap, much cheaper than doing nothing at all. A relatively simple site accident costs a lot of money. Assume, for example, somebody walks into a bar he does not see. He falls, possibly striking a nail with his hand and what do you think that costs? You can afford on a site half a man all day just to see that this bar and similar objects are not there. You can afford to pay that man by preventing this single accident. So why don't we do it? I am not saying that the quality of the structure is not important, but here we should remember the other aspects too.

**S. ONO, Japan**

The misuse of steel plate grade is nicely controlled in my company or generally in Japan. We have three types of steel plate grades and we use three identification paints for each steel plate.

**MODERATOR**

Does anybody else want to comment of safety on site as opposed to quality assurance of the structure?

**R. FECHTIG, Switzerland**

I will answer the question from Prof. Schneider. He asked about costs related to a small accident to a worker. We carried out a little research in our institute, looking at several sites and into several books of contractors. We have drawn from that research that a small accident costs a contractor between 500 and 2000 Swiss Francs per accident. So if you have 150 workers involved in 100 little accidents per year, you lose about 100'000 Swiss Francs per year. Your gain is that much lower. Think about it!

**Y. YOKOYAMA, Japan**

With regard to the labour safety problem, in Japan the government is very strict. To look after safety, we have in our company an independent department that is responsible for the safety control at sites. It has the authority independently to regulate the safety devices on the site. The reason why we have this organization in the company is confidence that safety pays anyway. That means, indirectly, safety improves the quality. For example, the government regulations request a very heavy scaffolding and protection net around the site. Our people follow those regulations. These improve not only safety records but also labour productivity. When we worked in the Middle East, our people used a similar system on the site. Our job sites have a very good safety record and the labourers from third world countries like to work with us. Many engineers from the U.K. or Switzerland study our sites and are very much impressed.

**K. UMEDA, Japan**

I have a few comments on safety. To be honest, I was not the advocate of company-wide quality control. I was against it. But now I accept the effect of it in terms of its result regarding the safety level. My company became a member of this nationwide quality control organization about 6 or 7 years ago. The largest effect resulting from the quality control concerned the safety level. The number of accidents in terms of safety decreased by 30% after we introduced company-wide quality control. In the companies who introduce this company-wide quality control, the definition of quality includes safety. The keyword "Q.C.D.S." reads as follows: Q means physical quality, C means cost, D means delivery time and lastly S means safety. I know many of our foreign friends are glad that we are including cost and safety and delivery time as very important



segments of quality.

**L. VU HONG, France**

As I understand, the Japanese way of quality management, what you call company-wide quality control, is just a kind of principle or philosophy and in all a kind of state of mind of everybody. Now, from the point of view of the organization, what is new that you have put in place, is what you call quality circle. Otherwise, you still have a Q.A. Department which performs some kind of monitoring of the system and secondly, you still have an independent quality control. And then what is new, in order to implement your policy of company-wide quality control, is just a quality circle.

**K. UMEDA, Japan**

We still have within the company quality control promotion sections, but this is mainly for guiding the company into the right direction in terms of quality control activities by making contact with other industries and other companies in the same line of business. And they never directly touch on the quality control at the production site and construction site.

On the other hand we have in our company a so called technology department and this is also responsible for guiding all the construction sites in the right direction of the quality control, but this department never does direct quality control at the site.

**M. KERSKEN-BRADLEY, FR Germany**

I am wondering whether the three contractors we are having here are truly representative, because the picture we receive from these companies is so perfect that I am not quite sure what we are talking about here. Do you consider yourselves really representative or are you first class contractors?

**MODERATOR**

We are not three contractors as I see it, we are five here. What does the audience think? Whether these are all perfect contractors and everything is fine?

**A.G. SIMPSON, UK**

Could I take up a comment of yours first, Mr. Chairman? When you said, "Does the quality of the temporary works affect the quality of the permanent design", I think the answer must be "yes, of course it does". Mr. Quinion, earlier this afternoon emphasized the need for care in the removal of temporary works. This is of vital importance, particularly where temporary works in a partially dismantled condition can impart unacceptable loads onto a very new permanent structure. Going on from that point, and the design of temporary works, our Chairman well knows that in his own Department in the U.K. it is a requirement that major temporary works should be checked and certified by an independent engineer.

But I would like to ask Dr. Hillemeier and Mr. Quinion how they assure the quality of the design of the temporary works in their own organizations. We have heard quite a lot this afternoon about materials and site activities, but very little about the assurance of quality in design.

**MODERATOR**

Thank you Mr. Simpson. - Before I answer this question, can I ask you please to give just one statement - do you check them or don't you?

**B. HILLEMEIER, FR Germany**

In general there are no problems with falsework because we have very efficient sub-contractors who are delivering good scaffolding and shuttering to our sites. With regard to scaffolding and shuttering only compliance with dimensional and structural requirements is of importance. In case of deviations these can be corrected with corresponding costs and no permanent damage in the sense of poor quality remains. So, in our company there is no need for the quality assurance department to check falsework except with extraordinary constructions.

**MODERATOR**

But the sub-contractor does check his work?

**B. HILLEMEIER, FR Germany**

I think he does.

**D. QUINION, UK**

As far as the U.K. is concerned and my company, it is a requirement that all temporary works are checked by an independent engineer on my staff.

**MODERATOR**

Thank you. - Can we now move on to "Competition in bidding". It was put there to be provocative. It was said that severe competition can lead to cut-price bidding with consequential effects on the quality of the structure. Does anybody have any comments on that?

**A.G. MESEGUER, Spain**

I have two points. In my country, formerly, the cost of quality control was included in the total cost and so the way in which the control organization was paid, was through the contractor. This produces many difficulties, because the contractor could put psychological pressure on the control organization. For several years now the costs for quality control appear separately and it is directly paid to the control organization without passing through the hands of the contractor. This system is operating very well. I wonder whether it is the same in other countries.

Now my second point is, that with our present system, if the contractor reduces the price by 20% in the tender, the cost of control is also reduced by 20% and this is very bad. Therefore, many times it has been proposed in my country, but up to now we have not changed yet, that the cost of quality control should be treated separately from the tender and not be submitted to rebates. And even there are some persons that ask for more money for control, when you are lower in price.

I would like to hear comments on this because for practical purposes we found that this is extremely important.

**J. SCHNEIDER, Switzerland**

I do not think that quality is achieved merely by control. So I am not so sure that your idea would work if any expenses for control



were paid separately and were not included in the bid. I have nothing against competition in bidding at all, but I think our system is wrong - at least in Switzerland - where almost every time, the lowest bid gets the job. I think this is wrong. We should, as a general rule maybe, give the job to the second lowest bidder, which would avoid this rather unsafe behaviour of contractors who need to be the cheapest within the competition. They should be motivated to not be the cheapest, but maybe the second cheapest and to deliver better quality instead.

**S. MINO, Japan**

I do not think that competition affects quality assurance. As long as the work is done according to the specifications, the owner will be satisfied. Most important is the selection of the contractors to participate in the bidding. The owner in Japan, usually selects the prospective bidders.

**J. O'BRIEN, Australia**

I would like to bring up the topic of the unscrupulous developer. We have quite a large number of problems in Australia arising from unscrupulous highrise development in resort areas. This is where somebody puts together a company, throws up a huge building, sells it when it is brand new. Ten years downstream the whole place is falling apart and the developer has vanished. I would like to ask particularly for a Japanese point of view: Do you have any unscrupulous developers? I have not heard of any. And with regard to the West, where I know there are unscrupulous developers, how do you stop it?

**K. UMEDA, Japan**

Well, this is a very touchy problem and many of the leading Japanese general contractors invest in real estate development business outside Japan, that is true. Some of them might have caused aggressive effect to the environment or by producing poor quality buildings. But in many cases Japanese contractors or investors in the development business outside Japan are led by the indigenous investors. So I do not think it is the Japanese investors only that must be blamed. However, when we undertake some major development business, not only in Japan but also outside Japan, good companies generally pay close attention to the quality of the product and its impact to the environment and I will keep it in mind that when my company undertakes any development outside Japan we will pay sincere attention to that.

**MODERATOR**

Thank you Mr. Umeda. - I think as far as Western countries are concerned, building regulations guard against that, because government building regulations require certification now. Anyway, can we now pass on to the last item please, which is "Inspection". - Could you say a few words please, Professor Fechtig?

**R. FECHTIG, Switzerland**

There is no doubt that inspection in quality assurance must be done. Who gives us the order for inspection. Is it the owner for periodical inspection, is it a handbook that has been worked out by a project team for a certain kind of construction, like bridges, tunnels, nuclear power plants. Or is it aimed at preventing damage that can affect a construction after a certain time of life? In the different countries over the world we really do not have the same standard



rules for inspection. What are the inspection systems of all those projects we have realised over the last 100 or 120 years? From my point of view there are some with quite a low standard. I am not thinking about nuclear plants, big bridge projects, skyscrapers, which have been erected during the last 20 years. But I refer to constructions between 1880 and 1910 when railway tunnels, or 1900 to 1930 when water power plants or smaller bridges were built. Has the owner of those objects a complete guideline to make a detailed inspection, so that he can be sure he knows when he has to start with bigger maintenance or perhaps with complete reconstruction?

I will remind you of the problem that we have on a lot of constructions which suffered from lack of maintenance because no periodical inspection by qualified teams had been made. How can all of us become more aware of this problem, so that we will include in our budget early enough the estimated costs for maintenance and for reconstruction. Inspections on an object like an old railway tunnel or highways, can force us to find new solutions to do reconstruction works under full traffic. I have been involved for several years with Swiss railway tunnel reconstruction work under full operation of the trains. That is really quite a problem of quality assurance and good planning.

#### MODERATOR

Professor Fechtig was talking about inspection after the structure is commissioned, in other words in service. There have been no papers on this subject, but I am sure it is a subject which deserves attention, because the quality assurance of a structure will depend on that.

#### P. MTENGA, Tanzania

I would like to refer my questions to the companies who are working in countries that have no well developed inspection and quality control procedures. How do these companies establish control procedures, control themselves and make sure that they keep to a certain standard (i.e. their prescribed level)? And, secondly, how do these companies help, say, by encouraging the indignant small contractor to keep to their standards, what measures do they take, what do they do to try to help the indignant small contractor to keep to their (1st world contractors') level of standard?

#### D. QUINION, UK

In England we have various organizations that have published documents which are used as operating documents and standards to control the way we operate: codes of practice and guides to good practice. These are available for anyone to buy and they are publicized in most cases fairly widely around the world.

#### S. MINO, Japan

Just a reaction to Professor Fechtig's comment. I do not know much about railway tunnels, but the Japan Highway Public Corporation has many highway tunnels and bridges. For the latter the inspection in service became very important. What is done now, is to facilitate the inspection during service by providing with easy accesses and inspection paths in the structures.

#### MODERATOR

Thank you. Is there any bridge owner or any owner of structures who has written down instructions of how regularly things should be



inspected and what shall be done about the inspection record?

**W. VON OLNHAUSEN, Sweden**

We are doing these things every day, we have in our Swedish Road Administration 12'000 bridges to inspect, to administrate and to rebuild and we have a lot of experience of the behaviour of the structures. And this experience should be the basis for design and construction and for our quality demands. I believe all of us aim in that direction.

We inspect at 3-years intervals - this can be discussed, but I will not do it here -. We have 3000 bridges which were built before 1940. And we know a lot about the older bridges too. But let me focus on just one point regarding their quality. I believe we have quite a good control in the construction phase. What we build is roughly OK. What we need is better durability. We have a safety factor on all the statical demands on the structure. We have no safety factors for the durability elements. And what can be done on this? We must study the durability factors more thoroughly, we must interpret them to measurable factors. Last but not least, all checking of quality should be done as close to the final product as possible, i.e. we should test drilled cores, not cubes, beside of the structure.

**MODERATOR**

Thank you. We have now reached the end of our time. Unfortunately the audience was warming up just as time was running out, so we have to close now. Thank you for at least trying to be patient with us here. Thank you all very much for coming and being with us.