Zeitschrift: IABSE reports = Rapports AIPC = IVBH Berichte
Band: 47 (1983)

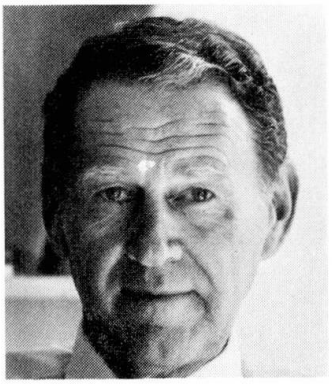
Artikel: Data control, supervision and checking
Autor: Essunger, Gunnar / Östlund, Lars
DOI: https://doi.org/10.5169/seals-36627

Data Control, Supervision and Checking

Contrôle et supervision

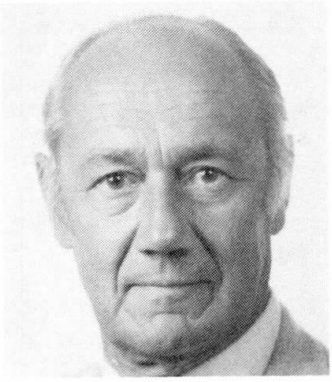
Kontrolle und Überwachung

Gunnar ESSUNGER
Senior Councelor
Nat. Board, Physical Planning / Building
Stockholm, Sweden



Gunnar Essunger, born 1916, got his civil engineering degree at Chalmers University of Technology, Gothenburg. He has acted as a structural engineer and as a senior official been responsible for building regulations and codes. Now he acts as senior councellor at the National Swedish Board of Physical Planning and Building.

Lars ÖSTLUND
Professor
Lund Institute of Technology
Lund, Sweden



Lars Östlund, born 1921, got his civil engineering degree and his doctor degree at the Royal Institute of Technology, Sweden.
For about ten years he worked with structural design. Since 1965 he is professor in structural engineering with special interest in problems concerning reliability and actions.

SUMMARY

Means and methods of control are different at the various stages of the building process. Several parties are involved in the quality control, e.g. designers, producers of components, contractors, clients and owners as well as users of buildings and authorities. The control should as far as possible be related to the production process. An interaction between self-control by the producer and supervision by an independent body is normally suitable in order to establish adequate control procedures. An important part of the control is to minimize the risks of gross errors.

RESUME

Les moyens et méthodes de contrôle varient au cours des différentes phases de la construction. Plusieurs partis sont impliqués dans le contrôle de la qualité, tels que les projeteurs, les producteurs d'éléments de construction, les entrepreneurs, les clients, les propriétaires et utilisateurs des bâtiments, et les autorités. Le contrôle devrait autant que possible être en rapport avec le procédé de production. Une action réciproque entre le contrôle par le fabricant lui-même et la surveillance par un organisme indépendant convient normalement pour atteindre un niveau de contrôle suffisant. Un des objectifs du contrôle est de réduire les risques d'erreurs graves.

ZUSAMMENFASSUNG

Mittel und Methoden der Kontrolle wechseln in den verschiedenen Phasen des Bauprozesses. Mehrere Parteien sind an der Qualitätskontrolle beteiligt, z.B. Konstrukteure, Hersteller von Bauteilen, Bauunternehmer, Bauherr, Besitzer und Benützer von Gebäuden sowie auch Behörden. Die Kontrolle soll so gut als möglich mit dem Bauprozess verbunden sein. Die Wechselwirkung zwischen Eigenkontrolle des Herstellers und Überwachung durch eine unabhängige Organisation führt normalerweise zu zweckmässigen Kontrollprozessen. Eine wichtige Aufgabe der Kontrolle ist die Reduktion des Risikos von schweren Fehlern.

1. PHASES AND OBJECTS

1.1 Introduction

For the user of a building it is evident that the quality of the finished building is of vital importance. Several properties of a building can in some way be determined when the building is finished, for example the air quality and the sound level. Also the safety of a structure can, of course, be tested when the building is finished - this mode of procedure is in fact often applied as a final check of bridges, before they are opened for traffic. But all important aspects on the quality can not be determined in such a simple way at the final stage, for example the durability of a concrete structure.

In most countries the authorities endeavour nowadays to give quantitative requirements in the building regulations. As far as it is practical the requirements are related to the completed product and connected to verification methods. Also the client or builder as well as the future owner of the building are usually more interested in the ultimate functions of the building than in the details of the structure or the methods of producing the building.

There are, however, several reasons to check the quality step by step during the entire building process including the design of components and the structural framework etc. and the manufacturing of materials and components as well as the management and maintenance of the building in use. It is very important to define adequate control steps and to use economical control methods.

1.2 Stages in the building process

The building process starts with the planning and design of the building, based on the requirements of the client (owner) and the authorities. This phase of the process will result in drawings and descriptions which constitute the quality of the building as well as the costs.

Before the construction of the building can start, the client must normally apply for and be granted a building permit by a building authority. Building products aimed for general use are to-day often produced industrially in long runs. In several countries such products can be type approved in relation to requirements in the building regulations by a central body vested with the necessary authority. One condition in the type approval certificate is normally that the approved product shall be tested and inspected according to a programme for quality assurance or a control programme. Prefabricated products whose properties are specified in regulations or standards, e.g. cement, reinforcing steel and structural timber, can directly be subject to production control.

The design documents, including possible type approval certificates, form the base for the construction stage in the building process. Depending on several circumstances, e.g. the type and the complexity of the building, sub-stages may be defined in order to find out strategical opportunities for testing and inspection. The control steps ("check-points") should be chosen with regard to inter alia the possibility of verifying requirements in the regulations or in the contract. Consideration may also be taken to the prerequisites for correcting possible mistakes. Such control steps should also be laid down at points where responsibility is transferred from one party to another.

When the construction work is finished and the building accepted, the entity of the building is a fact. According to instructions the use of the building and later on the maintenance can start. But there still remain some check-points in relation to the responsibility of the producer and the guarantee given by him.

1.3 Conclusions

Summing up, the quality of a building can be considered and determined with respect to various objects in the course of the following different phases:

a) Design process

- Specifications, calculations, drawings and descriptions for 1) materials and prefabricated components and 2) the structure to be erected at the building site.

b) Production of materials and components.

c) Erection at the building site.

d) Use.

Means and methods applied in order to control the quality at these four phases of the creation and entity of a building are quite different with respect to the objects of the control. For this reason the problems regarding the control means and methods must be delt with in various ways.

2. MEANS AND METHODS

2.1 Requirements and control

There is generally an interaction between requirements and control. Fundamentally the requirements, concerning for example properties of materials, are based on what is necessary in order that the structure shall serve its purpose. The aim of the control is to verify that the requirements are fulfilled. In certain cases, however, it is not possible to verify, in an operative way, that the requirements are fulfilled. That is, for example, the case if a requirement concerns durability and if it is formulated in a general way which implies that a structure shall be durable for a specified time. In these cases the requirements have to be changed to some substitutes which can be verified by means of control. For the example above the requirement on durability has to be changed to a requirement concerning the composition of the material or something similar. Thus, it is not always easy to find out if requirement or control is primary in reality. They are, however, almost always closely connected and at least formally the requirement is primary.

2.2 Design

The control of the design can be divided into the following phases:

- checking the assumptions for the design
- checking the design calculations
- checking that drawings and other documents are in accordance with the calculations
- checking that the structure, as shown in the drawings, is in accordance with regulations and good practice.

The control concerning the calculations (the three first items above) can be made in different ways. One way is just to follow the designers´calculations and check that they are correct. Another way is to make a new calculation (simplified) and to compare the results. These two ways can be regarded as extremes, many procedures between them are possible. A disadvantage with the first way is the fact that the person who makes the checking will be more or less guided by the designer and the risk of overlooking an error is not so small. A disadvantage with the other way is the fact that the method is laborious and that it is difficult to find the reason, if there is a disagreement.

Special problems occur in those cases when the design calculations are made with the aid of a computer, as it is not easy to follow computer calculations. In the near future, however, they will be the dominating methods for calculations. For this reason the computer program should include the control aspects in order that it shall be possible to control the calculations. The program ought to be made so that they account for part results with relatively small intervals which makes it easier to follow and to check the calculations. The program should also have special control moments included, for example comparison with results from calculations made in a different way.

For prefabricated products for general use in different buildings it is often justified to execute the calculations very carefully and to prepare the drawings with the utmost exactitude. As a consequence the checking of the calculations and the drawings can be done rather rationally.

2.3 Production of materials and components

In this section that case is treated when materials and components are produced in a factory separated from the building site. Particularly for type approved products, manufactured industrially in long runs, it is convenient to control the products according to a programme for quality assurance. The control system may in that case be very flexible depending on inter alia the complexity of the product and the production process.

One of the main questions is what should be controlled: the production process or the completed products. It is, of course, important that the internal control (self-control) includes the production process in order to steer the process. As regards those who shall use the products for a structure it is in principle most important to control directly the properties of the completed products. According to section 2.1, however, it is not always possible to control a required property of the products. Then it could be necessary, as a substitute, to control the basic material for the production, the production process or something else.

Another question is if the control of the completed products should be made in the factory at the end of the production process or if it should be made when the products have been delivered at the building site. In most cases it is advantageous to execute the control at the factory as an internal control (compare section 4.3). Then one will obtain a continuous control of relatively uniform products which gives the best information about the quality. If the control is mainly executed at the building site, it has often a disturbing influence on the erection process and therefore it is sometimes regarded as something that is negative. The most ideal would be that the control of material and components at the building site only consist of checking that the right products have been delivered and that they have been controlled and approved at the factory.

A system for production control of prefabricated products based on self-control by the producer is normally connected with inspection and spot checks by an external body. It is of interest to study the relation between the self-control and the supervision in order to establish an adequate quality control system.

2.4 Erection at the building site

If the properties of materials and components are controlled at the factory according to the discussion in section 2.3, the control at the building site can be concentrated on the erection problems, i.e.

- that the materials and components are placed in the right place
- that the connections are properly made
- that the measures of the structure are correct within given tolerance limits

- that the components have not been damaged during the erection.

This control implies that the structure must be checked continuously during the erection. It is not possible to execute the control for the completed structure only.

The control mainly consists of visual inspections, measurements and perhaps testing of non-destructive material (to verify that the material properties have not changed during transport and erection). The results of the control shall be recorded.

The erection at the building site is probably that stage of the building process, when there is the greatest risk for the occurrence of gross errors. Therefore the control at this stage is extremely important.

2.5 Use

The control during use may concern

- the way the structure is used, for example the loads it is subjected to
- the condition of the structure with regard to its load bearing function.

The possibilities of control during the use of a structure differ very much from one structure to another depending on, among other things, if the structure is easily accessible for inspection or not. There is also a difference from one country to another with regard to legal rules.

There are many questions concerning control during the use, for example the following:

- should there be legal requirements for the owner to make periodical inspections of the structure (or to engage an expert to make them) and to report the results to some authority?
- should there be a legal right for some authority to make periodical inspections of a structure?
- are there any possibilities of using automatic systems in order to indicate the need of maintenance, repair or substitution?

3. PARTIES - OBLIGATIONS AND WAYS OF ACTING

3.1 Parties involved

There are many parties involved in the building process and the management of a building. Responsibilities and duties of the different parties in relation to contracts and legislation are delt with in session 3. In this section some questions and problems regarding the tasks and obligations of the parties involved in quality control systems should be discussed.

Normally, the control is carried out as a consequence of an agreement (a contract), based on civil law and in accordance with public law and mandatory regulations. It is of interest to discuss in which way the different parties involved may co-operate and co-ordinate their efforts in order to rationalize the control procedures and to reduce the control costs.

Based on the contract and the relevant regulations, adequate measures and routines can be compiled in a programme for quality assurance in order to secure the proper quality of a building. In such a programme the different parties involved in the quality control procedure should be settled and their obligations should be defined. In this connexion several problems can be discussed. How far in detail should such a programme be precised? The relation between persons engaged in the prefabrication of materials and components on one side and persons at the building site? The role of the designer? Separate from the quality assurance programme - or perhaps included in it - there is also a need to define the obligation and the right of "third party persons", e.g.consultants and

building inspectors.

3.2 Ways of acting

The parties involved in a private agreement (according to civil law) are on one hand the person, who orders the erection of a building (the client) - usually also the future owner - and on the other hand consultants, contractors, suppliers of components, credit grantors and insurance companies as well as tenants or other "users" of the building.

When an agreement is at hand concerning the conditions of delivery of a certain achievement or product, such as design or erection of a building, the receiver of the "supply" normally arranges some kind of control by a person or body engaged and paid by the client (external control). According to the agreement the "supplier" can often be imposed to check or to test the "delivery" by means of internal control (self control).

Several building components - composed of several materials or parts - are produced at factories, which are subject to some kind of production control. In which way and how far should the producer of such components arrange for control of delivered products?

Public laws usually affect, in the first place, the relation between the client (the future owner) and the proper authorities. Also designers, contractors and producers of components can sometimes be subject to some kind of public supervision. Is it reasonable to require that e.g. designers are authorized? And by whom? Is it more appropriate to judge the result of a designer - by means of self control, spot checks (or other measures) - instead of forming an opinion of a person´s skill?

The control, executed by the authorities, always implies to be impartial and according to public law. The extent of this control varies in view of several factors. It is often presupposed that self control, specified in advance, shall take place and be documented (see section 4). The supervision by the authorities can under such circumstances be rather restricted - how far? Which measures and steps may be taken in order to establish a fruitful interaction between self control, involved as far as possible in the production process, and supervision by impartial control bodies?

The parties involved in the use, management and maintenance of a building are in the first place the owner and the user. Also the authorities have normally to some extent a legal right to inspect the building, but the responsibility to keep the building safe rests exclusively with the owner (see 2.5). A question to discuss is: which obligations should the designer have to prepare instructions for periodical inspections and maintenance of the structure?

3.3 Parties involved in international co-operation

From the point of view of international trade it is of great value if the quality control procedures, applied by national approval and control bodies in the country of manufacture, can in some way be accepted by the corresponding bodies in the country of destination. Even if the requirements in the regulations are not yet harmonized, barriers to trade will be reduced, if national control bodies co-operate in order to avoid duplication of testing and inspection.

Several international governmental and non-governmental organizations are more or less involved in negotiations and studies aimed at international harmonization of approval and control systems and mutual recognition of test results. Basic rules of general nature are given in the GATT Agreement on Technical Barriers to Trade, in force since 1 January 1980. Furthermore, the Working Party on Building within the United Nations Economic Commission for Europe (ECE) has stressed the need of co-operation between national approval and control

bodies. ILAC (International Laboratory Accreditation Conference) has paid considerable attention to problems regarding international recognition of test results. Other organizations, such as RILEM, CIB, CEB, ECCS and ISO, are involved in the preparation of unified test methods.

However, an operative action programme is still lacking for an international system for approval and quality control of building products. It may therefore be discussed which steps should be taken in order to facilitate the introduction of products from one country into another.

Lack of harmonization of approval and control rules is not the only barrier to trade. The difficulty in obtaining immediate and clear information about the specific rules and systems in a foreign country often causes considerable problems for a producer, who tries to market his product in a country with a different pattern of approval and control. Which bodies and organizations are suitable and ready to provide for such information?

4. EXTENT, EFFECTIVENESS AND COSTS

4.1 Does control always lead to better results?

The presence of control has an influence on the work which is subject to the control. This may occur in different ways. The following two possibilities are to be regarded as extreme cases.

One of these possibilities means that the person doing the work may think in the following way, if there is no control: "No one but me will look at this and therefore I had better watch the result of the work to make sure that it is well done". If there is a control, he may think: "Someone else will look at this work and will find out if anything is wrong so therefore I can leave it as it is". If this corresponds to reality, it is better to have no control at all than to have a badly functioning control.

The other possibility means that the person, doing his job, thinks in the following way, if there is a control: "I know that someone will look at this and therefore, if I shall not be blamed, I had better to do a good work". If there is no control, the thinking may be: "I know that nobody will look at this and therefore my work is not so important and a great care is unnecessary".

The question is: Does control have a favourable effect on the quality of a work whether the control is efficient or not or is an unefficient control even worse than no control?

4.2 Do several control steps always give better results?

It is a common opinion that a control consisting of several independant control steps, for example internal control, control by an independant consultant and control by authorities, is favourable with regard to the quality of the project. This is probably true, if the different control steps are really independent of each other in a statistical sense. However, in principle the same points of view that were given in section 4.1 could be applied here, if control is regarded as a work included in the total process. This means that each one of the persons, executing control, is aware of the fact that there are other persons entrusted with control tasks. Perhaps each one of them trusts the efficiency of the others to such an extent that he considers his own part of the control as unimportant, uninteresting and unnecessary. Thus, in the worst case the total effect of several control steps could be less than the effect of a control, concentrated to one step and one person.

4.3 Internal control, external control or a combination?

If one intends to concentrate the control mainly to one of the organizations which take part in the building process, the question arises which is the most efficient control, internal control or external control. The internal control is executed by persons from the same organization which has the responsibility for the performance of the work, which can be design, production of material or components or erection at the building site. The external control can be executed by persons from the client's organization, by an independant consultant or by the authority.

The external control has the advantage of being less dependent on such factors as the conditions of the work, the actual working situation, the economic result of the work etc. The external control is generally considered as more neutral than the internal control.

The internal control has the advantage of being executed by persons who often have a great knowledge of the character of the work, which is subject to the control, and who are aware of what kind of problems that can be expected.

A possible way to obtain the advantages of both the internal and external control could be to combine them. This could be done in such a way that the work is directly subject to an internal control which benefits by the knowledge of the persons executing the control. The external control is mainly directed to an evaluation and a judgement of the efficiency of the internal control. Thus, the tasks of the persons executing the external control are different from the tasks of those who execute the internal control, i.e. they do not control the same things which may be an advatnage (compare section 4.2).

4.4 Should the control be directed to reach an acceptable quality level or to discover gross errors?

In most cases collapses and other severe failures of load bearing structures seem to be caused by some kind of gross error. That does not mean that the general quality level is of minor importance. If the quality level becomes too low - however, not so low that this is to be regarded as a consequence of a gross error - the consequences are often unsatisfactory behaviour during normal use, unsufficient durability and abnormal costs for maintenance. It is therefore important to direct the control to reach an acceptable quality level as well as to discover gross errors.

However, these two aims can generally not be reached by the same control methods. It is often convenient, and in most cases sufficient, to use random checking for the control of the general quality level. The gross errors, however, are relatively rare and therefore it is generally not possible to discover them by a random checking. The checking ought to be almost total. On the other hand, in this case, it is not necessary that the results of the checking are very accurate, in most cases it is sufficient with just an estimation.

What is said above does not mean that control shall always have two different aims. Gross errors occur with a relatively small probability. In those cases when a failure causes mainly economic losses, it is often more economic to accept a probability of failure, which is of a similar order as the probability of the occurrence of a severe gross error, than to arrange an extensive control. Thus, a control directed to discover gross errors is necessary in those cases mainly when a failure has very severe consequences including loss of human lives.

4.5 Should the objects which shall be controlled be chosen randomly or according to a control program

In many cases it is not possible or justifiable from an economic point of view to let the control include all parts and all details of a structure, especially if the control contains measuring and testing. Thus, a choice has to be made in some way. This choice can be made by the person who executes the control and according to his judgement or according to some random method. The objects which shall be controlled may also be chosen according to a control program drawn up beforehand and based, for example, on points of view given by the designer.

There are many advantages of a control program. A program makes it possible to balance the control efforts for the different objects against each other in a reasonable way. It also makes it possible to direct the control activities to the most important and sensitive parts of the structure, for which an error could lead to severe consequences (compare section 4.4). Thus, for given control resources, a control program may contribute to improve the result of the control.

A control program has also some disadvantages. If the objects which shall be controlled are specified in a program, the consequence will be that also the objects which shall not be controlled can to some extent be regarded as specified. According to the discussion in section 4.1 this may in some cases lead to an undesirable differentiation of the quality level between the structural parts.

4.6 Economic aspects

What is written in sections 4.1 to 4.5 is more or less valid for the whole process consisting of design, production of material or components, erection at the building site and use. The control activities should be regarded as part of this process and the costs of control as part of the costs for the building. As for the other parts of the costs, the costs of control should give some gain which may ideally be expressed in economic terms. This gain could, for example, consist of increased quality, less maintenance, smaller consumption of materials etc.

To some extent control and other measures, taken for the purpose of increasing the quality, are interchangeable. The relation between the amount of control and the amount of other measures should ideally be determined by an economic optimization. However, this is possible only if there is a sufficient knowledge about the effect (expressed by means of some numbers) of different control activities. To-day the existing knowledge about these matters is unsufficient and therefore it is only possible to make formal optimizations using, for example, formal relations between the number of tests and the degree of utilization of the strength of a material.

Leere Seite
Blank page
Page vide