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envisaged, protective measures should be pre-planned to some extent.

All supervision measures found necessary to overcome risks could be stated in a supervision plan. This plan contains the supervision measures together with all details.

The basis for the elaboration of a supervision plan is a careful analysis of the situation to be supervised with respect to hazard indicators. Hazard indicators in this respect are all changes in a situation which can easily be observed or monitored and which may indicate the presence of increased risk.

A continuous supervision of special risks should be ensured by making a person responsible for it and naming his representative.

The persons charged with supervision activities should be carefully instructed by the project management with respect to the hazards envisaged and the hazard indicators. They should also be required to report on events and phenomenon which, though not specified in the supervision plan, may, according to their experience, have a relationship to the risk supervised.

The supervision activities should periodically be checked with respect to proper functioning. The same holds for automatic warning systems.

6. METHODS OF CONTROL

6.1 Introduction

Regarding the type of activity that is controlled one can distinguish between

- design control
- control of materials and components
- control of fabrication and/or construction at the construction site
- control during the use of the structure.

According to the simplified flow chart shown in FIG 1 these types of activity are differentiated in time. However in many cases the first three types of activity go on simultaneously.

The principles of control (according to section 5) are to a great extent the same but the methods of control differ for the different types of activity.

6.2 Design control

6.2.1 General

The design work consists mainly of design calculations and of preparing drawings, material specifications and similar documents.

The calculations are based on the specified requirements and conditions. The drawings, material specifications, etc. are based on the design calculations but also directly on the specified requirements and conditions.

The drawings are the main link between the design work and the construction work and are therefore in principle the primary object of design control. However, as the drawings are based on calculations, it is in many cases convenient or necessary to control the design calculations in order to verify that the whole design process is in accordance with the requirements of section 1.1.

6.2.2 Control of the calculations

Control of the calculations can be executed with different techniques and to different extent. However in any case the following checks should always be made

- checking that the calculations are based on the relevant fundamental requirements and operational, environmental and boundary conditions
- checking that calculations are made for all structural parts for which the design problem is of such a character that calculations are necessary
- checking that the relevant calculation models are used
- checking that there are no discrepancies between different parts of the calculation
- checking that all forces acting on the structure are correctly transmitted through the structure to the foundations.

Three different techniques for the checking of the calculations can be used

- total direct checking which means that the calculations are followed step by step.

  The advantage of this method is that discrepancies are immediately discovered. The disadvantage is that the person who makes the checking can be directed too much by the calculations. Therefore, in this case it is necessary too make special checks, for example, to discover any omissions.

- total parallel checking which means that special checking calculations are made completely separately from the design calculations. The results of the two different calculations are compared at certain points, determined beforehand.

  An advantage of this method is that the person who does the checking is not influenced significantly by the original design calculation. Another advantage is that the checks can be made with simplified methods in many cases. The disadvantage is that if discrepancies occur it is sometimes difficult to find their source.

- partial checking which means that certain representative parts of the calculation are chosen and checked with direct checking or parallel checking. For the rest of the calculation the results are checked by means of comparison.

  This method has the advantage of being the most rapid method. However it requires an experienced person to do the work.

Often a combination of the methods can be used. This is especially the case if the calculations are made by computer. Then direct checking is not convenient and in many cases not possible.

6.2.3 Control of the drawings

Control of the drawings should generally consist of checking

- that the results obtained from the calculations are correctly transferred to the drawings
- that the drawings are in accordance with given requirements

- that the drawings are mutually consistent
- that the drawings are in accordance with given environmental and boundary conditions
- that the drawings are made in such a way that they are unambiguous and that the risk of misunderstanding them is small.

6.3 Control of materials and components and of construction at the construction site

6.3.1 The control procedure

General

Concerning the control procedure one can distinguish between

- production control, which is a control of a production process. The purpose of this control could be the steering of a production process and the guarantee of an acceptable result.
- compliance control, which is a control of the output from a production process. The purpose of this control is to ensure that the product complies with given specifications.

In these two control procedures the properties of materials, components or structures that are the object of the control are not necessarily the same.

Production control

Production control is mainly directed to the production process.

The control may, for example, concern material, components, production equipment and the time used for different parts of the production process.

Production control also includes

- identification of materials and components
- preliminary tests (made before production starts)
- considering (before production starts) the fitness of materials or components to be used in the production
- tests (during the production) for steering the production.

Compliance control

Compliance control should be concerned with the control of the products resulting from a production process and their compliance with the given specifications.

> However, it may often be convenient to include some prescriptions about the production process in the specifications. In this case the specifications concerning the process and the specifications concerning its results shall be compatible.

The controller should also try to recognize if anything abnormal, not envisaged in the specifications, has occurred. It is necessary to specify the properties that should be controlled. These properties are always more or less conventional and generally relate to the design calculations. They may be

- qualitative, and may be checked by a visual control, comparison to drawings or specimens etc.
- quantitative, i.e. they can be measured.

> A visual examination could be made in order to find faults or to compare with agreed samples.

6.3.2 Control criteria and acceptance rules

General

Regarding the control criteria and the acceptance rules one distinguish between

- total control
- statistical control.

Total control

If the control is total every produced unit should be controlled. The acceptance rules imply that a unit is judged as good (accepted) or bad (not accepted). Normally the criteria, if they are quantitative, refer to given tolerances.

> If a certain number of the produced units can be considered a priori as identical one could be admitted not to control every unit.

In certain cases the units may be classified as belonging to different quality classes instead of being accepted or not accepted.

Statistical control

A statistical control procedure generally consists of the following parts

- batching the products
- sampling within each batch
- testing the samples
- statistical judgement of the results.

A batch must be such that it can be regarded as homogeneous with regard to the properties which are the subject of the control. This means that all units within a batch are produced under essentially the same conditions. If the properties of the products vary with time after production this has to be considered in the batching procedure. The batching should in principle be made by the person responsible for the control.

Within each batch a number of units are taken as a sample which is then submitted to testing. The methods of sampling should be given in the codes.

The assessment of a batch is made by comparing the test results with the given criteria. These are normally of the following types.

a) The criteria refer to the results obtained for the sample as a whole.

If a property of the product is quantitative the results may be given as some parameters (mean, standard deviation, fractile etc) of the statistical distribution for some value describing the property.

If a property is qualitative the result may be given as the proportion of the specimens of the sample that fulfil given requirements.

b) The criteria refer to the extreme results.

If a property of the product is quantitative an extreme result may for example be the most unfavourable value or the range between a minimum and a maximum value.

The assessment of the results should be made with regard to a given level of confidence or a given interval of confidence. The level of confidence is the probability that a criteria will be satisfied if the corresponding hypothesis is true (for example the hypothesis that the true value of a certain fractile of the population lies within a chosen interval). The level of confidence is not the probability that the hypothesis is true if the criteria is satisfied.

In principle the criteria should be obtained by a general statistical approach, which may include the use of statistical parameters which characterize the population, OC-curves, etc. However, the conditions on which this approach is based are in most cases not explicitly expressed in the final criteria. The conditions should generally be considered only as a rough description of the required goal. In practical cases, the goal is to avoid - as well as possible - the acceptance of products with a quality that is definitely unsatisfactory, even if it is assumed in the calculations that a small proportion of such products exists.

It should be noted that the justification for a decision based on statistical control may be considered to be unfounded for one or more of the following reasons

- unsatisfactory batching
- unsatisfactory sampling
- wrong assumptions for the statistical deductions
- the level of confidence is different from 1.

The total probability for an incorrect decision (in any sense) is often considerably greater than the value of the probability assumed at the design stage. Therefore it may be necessary

- to add to the main criteria certain absolute requirements for the test results and to require a certain global control (for example testing of a completed structure).
- to increase the number of test specimens if the criteria implies that the results obtained are on the bound of what is allowable. In such a case it may be unavoidable that the supplementary tests have to be made in another way.

GLOSSARY Appendix 1

Operational conditions

Conditions relating to the use of a building, for example, loads on floors, indoor temperature, etc.

Environmental conditions

Conditions determined by the environment of the building and external natural phenomena for example wind load, outdoor temperature, properties of soil.

Boundary conditions

Conditions determined by legal restrictions, by activities going on in the neighbourhood of the building etc. for example restriction regarding the height of a building, the necessary clearance under a bridge.

Safety, Serviceability and Durability, see 2.1

Utilisation scenarios and Hazard scenarios, see 2.2

Building code

In this document the term "building code" is used to cover all structural codes not just those used for building structures.

Client

A person or an organization which has found that there is a need for a building of some specific kind and therefore initiates the building process.

Overall project management

A person or an organization to which the client has given the right to take the final decisions about the building project.

Management on the construction site

A person or an organization to which the overall project management (or in certain cases the law) has given the right to take the decisions about a specified group of questions on the construction site.

Owner

A person or an organization which owns the building in a legal sense.

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