HETEK

Pre-Testing of Concrete, Constituent materials, Composition and Workmanship

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Abstract	This report forms a part of the Danish Road Directorate's research programme called High Performance Concrete - The Contractor's Technology (abbreviated to HETEK). HETEK is divided into eight parts where part no. 7 concerns pre-testing. The State of the Art report concluded that a differentiated graduation is needed to meet the contractor's demands concerning pre-testing of specific production methods such as e.g. vibration need. This report includes such a graduation of pre-testing. Estimated expenses have also been taken into account.
Front page photo	The front page photo shows the trial casting specimens which was cast as a part of the pretesting for The Gadholtvej Arch Bridge between Sæby and Frederikshavn, Jutland, Denmark built in high strength concrete and ordinary reinforcement.

Contents

0. Preface

This programme regarding trial castings is part of the Danish Road Directorate's research programme, High performance Concrete - The Contractor's Technology (in Danish: Højkvalitetsbeton - Entreprenørens Teknologi abbreviated to HETEK).

High Performance Concrete is concrete with a service life in excess of 100 years in an aggressive environment.

The research programme includes investigations regarding the contractor's design of high performance concrete and execution of the concrete work with reference to obtain the requested service life of 100 years.

The research programme is divided into eight parts, each on one of the following subjects:

- chloride penetration
- frost resistance
- autogenous shrinkage
- control of early-age cracking
- compaction
- curing (evaporation protection)
- trial casting
- repair of defects

The Danish Road Directorate invited tenders for the research programme which primarily is financed by the Danish Ministry for Business and Industry - The Commission of Development Contracts.

This programme regarding trial castings is performed by a consortium consisting of:

The Danish Concrete Institute represented by

- Find Meyer (Head of the programme)
- Carl de Fontenay
- Ulla Kjær
- Torben Wegmann

The Danish Technological Institute represented by the Concrete Centre

- Christian Munch-Petersen

Unicon Beton represented by

- Freddie Larsen
- Ib Jensen
- Lasse Toft

Jens Frandsen, 4K-Beton has participated as consultant.

The trial castings programme is divided into the following five phases:

Phase 1	State of the Art
Phase 2	Pre-testing of concrete, constituent materials, composition and workmanship, Graduation
Phase 3	Test Panels and Exposure Places
Phase 4	Incorporation of results from other HETEK research programmes
Phase 5	Final Report and Guide

The present report is the report of phase 2.

The work has been reviewed by Reidar Kompen, The Norwegian Road Directorate, who is a member of the technical committee associated with HETEK.

Nov. 1996

Steering Committee:
Find Meyer
Christian Munch-Petersen
Freddie Larsen
Jens Frandsen

1. Introduction

As described in the State of the Art report, pre-testing is usually carried out at one of the following levels:

Pre-testing, Level 1:	Pre-testing without trial casting.
Pre-testing, Level 2:	Pre-testing by trial casting of minor plain concrete test specimens of 0.1-1.0 m^3.
Pre-testing, Level 3:	Pre-testing by trial casting of larger reinforced concrete specimens. The shape and reinforcement reflect the construction in question and the casting is carried out using the actual planned production methods.

Based on the evaluation of the results from 12 Pre-testings carried out at level 2 and 3 and comparisons between these results and production results, it can be concluded that there is a need for further graduation of the pre-testing levels.

The purpose of a pre-testing is to increase the probability that production castings will result in the expected quality. Irrespective of the extent of pre-testing there will never be complete guarantee for the exclusion of defects. Very extensive pre-testing is however expensive. Consequently the extent of pre-testing should be assessed on the basis of:

- Probability for the occurrence of defects
- Expenses for the pre-testing

The influence of possible defects on the durability of the structure should also be taken into consideration. The occurrence of important and complicated construction details, which are difficult to cast, influence the decision as to whether it is necessary to perform test specimens which reflect the detail in question - or if a standardized basic specimen is sufficient. Estimated expenses according to extent of pre-testing are included in the report.

Most of the civil work structures, which are carried out in Denmark are based on specifications corresponding with the "Basic concrete Specification for Building Structures" (BBB) and "Tender and Construction precepts, Concrete Bridges, ordinary Work Specifications - abbreviated to AAB". These structures are typically minor or middle sized structures, and the main emphasis of this report is placed on them.

The report deals furthermore with the more specific definition of a basic pre-testing and also describes the cases where additional testing is recommended.

Decisions as to when not only pre-testing of concrete, constituent materials and composition but also pre-testing of workmanship may be based on documented previous knowledge are also treated.

During the preparation of the report it appeared that there are two different opinions of the definition of a Trial casting.

The one opinion is that a Trial Casting is a casting of a reinforced concrete specimen with a shape reflecting the construction in question. The casting is carried out using the planned execution methods.

The other opinion is that a Trial Casting is an investigation of the properties of a trial mix. The investigation does not necessarily need to be carried out by casting of a concrete specimen.

In consequence hereof the concept of Trial Casting has not been used in the remaining part of this and subsequent reports.

Instead the more capacious designation "Pre-testing" is used. Pre-testing is subdivided into:

- PRETESTING OF CONCRETE, CONSTITUENT MATERIALS AND COMPOSITION, which typically is performed by the concrete supplier, and

- PRETESTING OF WORKMANSHIP
  which is typically performed by the contractor.

It is, of course, disadvantageous that there are different opinions of the definition of a Trial Casting - especially when it was the original title of the research programme.

The title is now changed to Pre-testing of concrete, constituent materials, composition and workmanship.

2. Definitions

The report makes use of some specific concepts:

Pre-Testing:

> Pre-Testing is any kind of documentation of concrete, constituent materials, composition and/or workmanship, which is presented prior to production. The documentation can be based either on testing of the actual concrete or by documented knowledge from previous testing or casting.

Pre-Testing of concrete, constituent materials and composition:

> Pre-Testing of concrete, constituent materials and composition is Pre-Testing of production and design properties of the concrete including the constituent materials and composition. Usually this Pre-testing includes the changes in production properties caused by transportation of the concrete from the mixing plant to the casting place.

Pre-Testing of workmanship:

> Pre-Testing of workmanship is pre-testing of the suitability of the concrete assigned to casting of specific types of structures using specific production methods, or investigation of such additional production properties, which are not clarified during the pre-testing of concrete, constituent materials and composition but which are in fact relevant for the structure in question and/or the planned execution method.

Trial Mix:

> A trial mix is a mix with specific composition, which is used in the pre-testing of concrete, constituent materials and composition.

Design properties:

> The design properties of concrete are the properties, which are important for the use of the structure - for instance strength, elasticity and durability including the quality of the constituent materials, the W/C-ratio, etc.

Production properties:

> The production properties of concrete are the properties, which are to be paid attention to during production in order to ensure the specified design properties.

3. Elements of pre-testing

Differentiation between pre-testing of concrete, constituent materials and composition and pre-testing of the workmanship will be applied in the following.

PRE-TESTING OF CONCRETE, CONSTITUENT MATERIALS AND COMPOSITION
This pre-testing includes necessary investigations concerning:

- The basic production properties of the concrete.

- The basic design properties of the concrete including the constituents materials and composition.

The present report includes only investigations of the constituent materials and the concrete composition to a limited extent. More detailed description can be found in the Danish code of Practice DS 411 and related material standards.

Basic productions properties include the production properties, which are considered necessary to investigate for civil work structure, performed with concrete in aggressive environmental class. The basic production properties are described in section 4.

Pre-testing of concrete, constituent materials and composition is performed by the concrete supplier. If the concrete is supplied by the contractor, the pre-testing is performed by the contractors concrete department.

PRE-TESTING OF WORKMANSHIP
Pre-testing of workmanship includes necessary investigations of the suitability of the concrete assigned to casting of specific structures using specific execution methods. Such investigations (which are often designated "Full Scale Trial Castings") are performed by the contractor, using concrete which has been accepted by pre-testing of the concrete, constituent materials and composition.

Depending on the degree of complexity of the structure or on the production methods, further investigations of production properties, which are not included in the basic properties, may be required. Such investigations of additional production properties are included under pre-testing of workmanship.

Investigations of additional production properties are carried out by the contractor and, depending on their nature, may be performed by the contractor himself or by the concrete supplier.
The additional production properties are described in section 5.

4. Pre-Testing of concrete, constituent materials and composition

As mentioned in section 3, the investigations of concrete, constituent materials and composition are related to:

- The basic production properties of the concrete
- The basic design properties of the concrete

Further information concerning constituent materials and composition can be found in the Danish code of practise DS 411 and relatad material standards.

The basic production properties include:
- Workability and loss of workability due to transportation
- Air content and loss of air in the fresh concrete due to transportation
- Bleeding after transportation
- Setting time
- Heat development during hydration
- Compressive strength development

The basic design properties include:

- W/C-ratio
- Chloride content
- Compressive strength
- Frost resistance
- Separation (inhomogenety)

Based on the information selected in the first phase of the programme and in relation to the casting of civil work structures in aggressive environment, the steering committee has defined the necessary extent of a pre-testing of concrete, constituent materials and composition.

The pre-testing of concrete, constituent materials and composition is subdivided into.

- Basic pre-testing, which is necessary for all structures
- Extended pre-testing, which is required for some structures

4.1 Basic pre-testing of concrete, constituent materials and composition

The basic pre-testing shall include investigations with a trial mix. The volume of the trial mix shall be equal to or larger than the batch size used for the subsequent production.

The trial mix concrete shall

- be subjected to the same methods of transport as planned for the execution. The concrete shall remain in the transportation equipment for a determined period of time such that the subsequent transport, by means of pump, skip or rubberbelt conveyor, can be finished not earlier than 10 minutes before the planned maximum time from mixing to final placing.

- be investigated for basic production properties. The extent of testing is stated in Table 4.1.

- be investigated for basic design properties. The extent of testing is stated in Table 4.2.

Basic Production properties	**Comments**
Loss of workability and air content	Workability and air content shall be measured immediately after mixing and at least 3 times afterwards. The final measurement shall be made after the planned maximum time from mixing to final placing.
Bleeding	Bleeding shall be estimated after the concrete has been transported by pump, skip or conveyor.
Setting time	Setting time may be estimated based on τ_0 from the adiabatic or semiadiabatic calorimetry.
Heat development	Heat development shall be measured by means of adiabatic or semiadiabatic calorimetry. The measurement may be performed using a separate mix which is smaller than the above specified trial mix.
Compressive strength development	Compressive strength development shall be determined on 4 sets of test cylinders after 1, 3, 7 and 28 maturity days. One set consists of 2 test cylinders.

Table 4.1. *Basic pre-testing of concrete, constituent materials and composition. Requirements to basic production properties.*

Basic design properties	Comments
W/C-ratio	The W/C-ratio shall be determined on the basis of the quantities used for the trial mix.
Chloride content	Chloride content shall be determined by calculation using the mix design and the chloride content for each of the constituent materials.
Compressive strength	Compressive 28 days strength shall be evaluated based on the strength development, Table 4.1.
Frost resistance	The hardened concrete shall be tested for air content and air void distribution. The test shall be performed on a cylinder ø 100 x 200 mm drilled from a test specimen with a volume of at least 0.1 m^3. Alternatively the test may be performed on a cast cylinder ø 150 x 300 mm. The test specimen (or cylinder) shall be cast using concrete from the trial mix after it has been transported by pump, skip or conveyor.
Separation	Concrete shall be determined for uneven distribution of coarse aggregates by means of test method DS 423.35.

Table 4.2 *Basic pre-testing of concrete, constituent materials and composition. Requirements to basic design properties.*

4.2 Extended pre-testing

Depending on the static function, the complexity and/or the environmental exposure of the structure, it may be necessary to perform further investigations in addition to investigations into basic design properties, Table 4.2.

Additional investigations are typically related to resistance against deterioration caused by chloride penetration and frost/thaw attack.

The necessity of such extended pre-testing, test methods and acceptance criteria will be described in other HETEK programmes. When the results are available they will be incorporated into the Guide for pre-testing.

4.3 Previous knowledge

Pre-testing of concrete, constituent materials and composition may be omitted if it can be documented that investigations of the required production and design

properties have already been made, and that the concrete has previously been used for execution of a similar structure.

The constituent materials shall be of same origin and the type and size of mixer shall be unchanged.

4.4 Expences for pre-testing of concrete, constituent materials and composition

The estimated expences for pre-testing in accordance with usual requirement stated in BBB or AAB and for the present description of a basic pre-testing are:

BBB pre-testing	approx. DKK 20,000
AAB pre-testing	approx. DKK 60,000
Basic pre-testing	approx. DKK 20,000

The expenses do not include investigations of the constituent materials and composition apart from the investigations mentioned Tables 4.1 and 4.2.

5. Pre-Testing of workmanship

Pre-testing of workmanship includes investigations necessary to demonstrate that the concrete is suitable for execution of a specific structure with the planned execution methods. Such investigations (often named "full scale trial casting") are carried out by the contractor using concrete which has been accepted by pre-testing of concrete, constituent materials and composition (see section 4).

As mentioned in section 4, the pre-testing of concrete, constituent materials and composition includes only investigation of the basic production properties.

Investigation of additional production properties may be required depending on the degree of complexity of the structure and/or on the production methods. Such investigations of additional production properties are included under pre-testing of workmanship.

Pre-testing of workmanship is subdivided into:
- Basic pre-testing, which is required for all structures
- Extended pre-testing, which is required for some structures

5.1 Basic pre-testing of workmanship

The State of the Art report recommends a more detailed description of a pre-testing method for determination of the vibration need for poker vibration.

Usual work specifications in Denmark require investigations of the heat development in the structures.

The basic pre-testing of workmanship should therefore describe:

a. Poker vibration including the influence of reinforcement
b. Heat development in the structure

The investigations are performed using a relatively simple structure. The standard test specimen is shown on Fig. 5.1. The dimensions are 1.2 x 1.2 x 0.6 m. The reinforcement is shown on Fig. 5.2 and corresponds to normal reinforced structures with a reinforcement of approximately 100 kg/m³. The four reinforcement bars ø 10, shown on detail 1 and 2, are placed only if the test specimen is to be used for long term durability testing - ref. report for phase 3. The formwork may be carried out as shown on Fig. 5.3 and thermo couplers are placed as shown on the same Fig. 5.3.

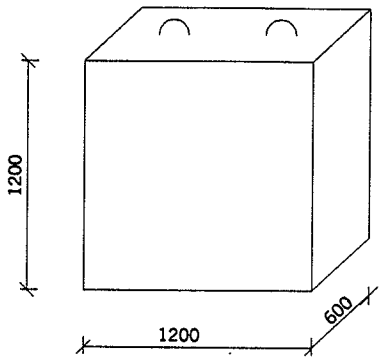

Fig. 5.1 *Basic pre-testing of workmanship. Standard test specimen.*

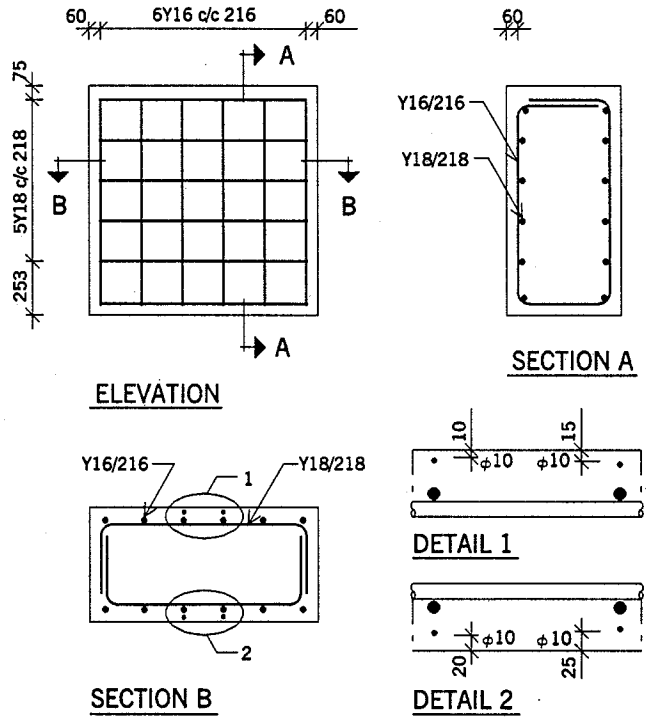

Fig. 5.2 *Basic pre-testing of workmanship. Reinforcement.*

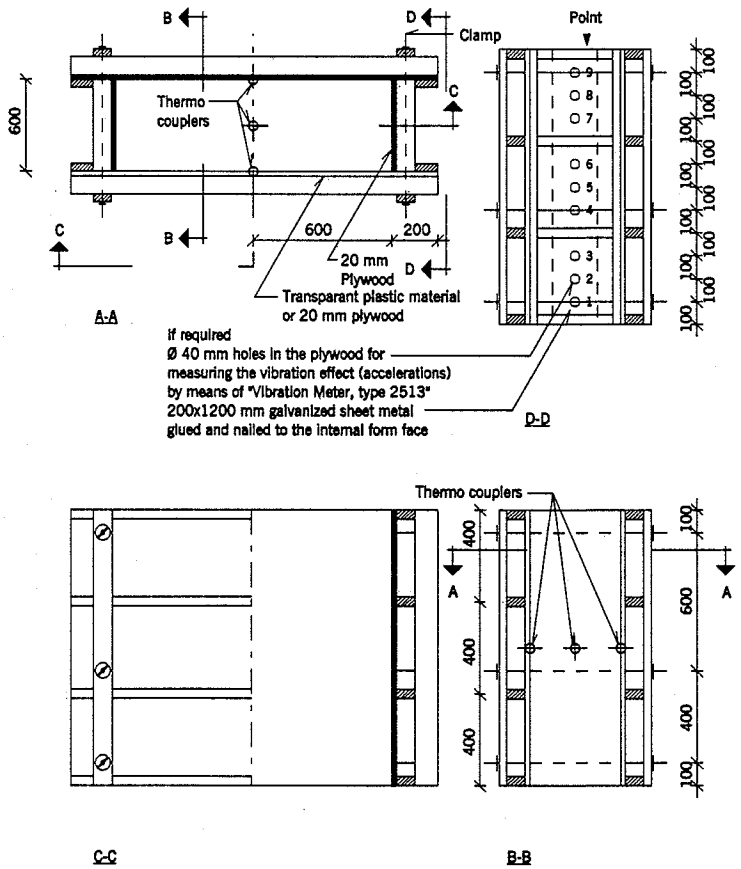

Fig. 5.3 *Basic pre-testing of workmanship. Formwork and placing of thermo couplers.*

a. Poker vibration/reinforcement
The effect of the poker vibrators shall be investigated during casting of the standard test specimen. The following parameters shall be established:

- thickness of casting layers
- vibration time
- insertion distance

Criteria for selection of these parameters are discussed in "Guide for Poker Vibrating" [The Danish Concrete Institute].

For the selected size of poker vibrator and concrete slump the parameters may be estimated by using Fig. 5.4 and Table 5.5. For the reinforcement used in the test specimen shown in Fig. 5.2, the insertion distance may be assumed to 8 · d (d is the diameter of the poker vibrator). The thickness of the concrete layers must not exceed 80% of the length of the selected poker vibrator.

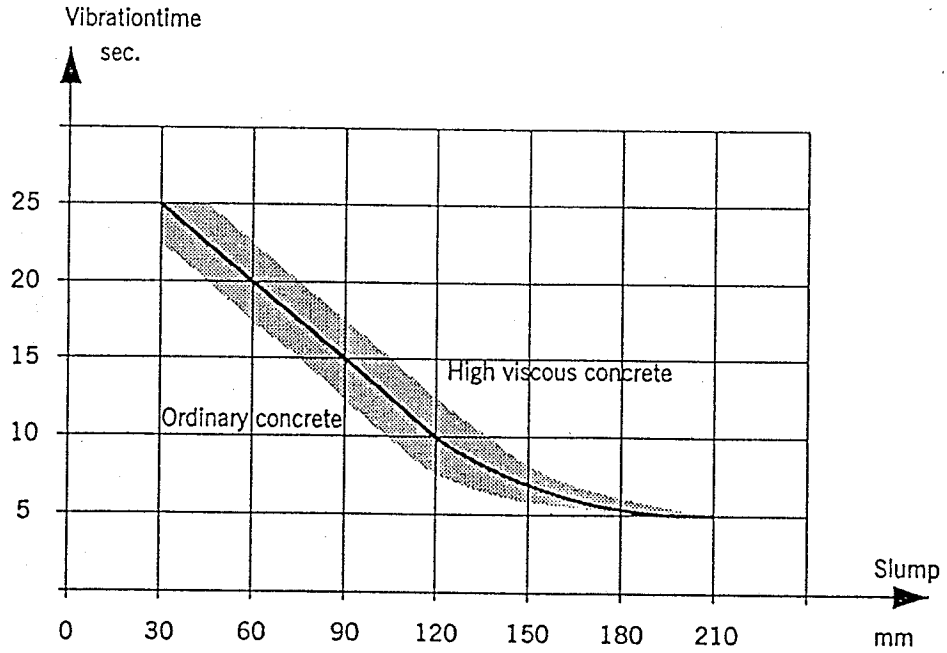

Fig. 5.4 *Relation between vibration time and slump.*

Degree of complexity	Example	Insertion distance a = n·d
1 Simple	Plain concrete and low steel percentage	10 d
2 Normal	Usual steel percentage	8 d
3 Difficult	High steel percentage and some congested areas	6 d
4 Very difficult	As 3 but many congested areas	4 d
5 Extremely difficult	Should not be used	2 d

Table 5.5 *Relation between the insertion distance and the degree of complexity.*

The effect of vibration may be investigated by acceleration tests as indicated Fig. 5.3.

One side of the formwork may be of a transparent plastic material. In this manner the movements of the coarse air bubbles may be observed during vibration, and thus assist the selection of the 3 parameters.

After stripping the concrete surfaces shall be inspected visually for defects and extent of blow holes. The in depth vibration effect on the concrete shall be investigated on drilled cores. The investigations should include air void distribution and possibly micro structure on thin sections.

The establishment of the 3 parameters:
- thickness of concrete layers
- vibration time
- insertion distance

to be used for production castings should be based on the obtained test results.

b. Heat development in the structure
Prior to casting of the standard test specimen, thermo couplers shall be placed in the middle and in the surfaces as indicated Fig. 5.3.
Prior to casting, the expected temperature development shall also be calculated for the above mentioned points.
The calculations shall be based on the adiabatic heat development (re. section 4.1) and the time for stripping of the formwork. The fresh concrete temperature and the outdoor temperature may be estimated based on the weather forecast.
During hardening, the temperature shall be registrated with such a frequency that

the actual heat development can be compared with the calculations. Of special interest is comparison of maximum temperature in the middle of the test specimen and maximum temperature difference between the middle and surface. This temperature difference must not exceed 20°C.

If there are significant deviations between the registrated and calculated temperatures, the reasons shall be found and necessary adjustments taken to ensure realistic assumptions for the production castings.

It should be emphasized that the pre-testing of the heat development as outlined above is only of a preparatory nature.

The specific conditions for production castings are usually much more complex than for the standard test specimen. This is, for instance, the case when a structural part shall be cast against a previous structure. A crack-free standard test specimen must therefore not be considered as an indication of crackfree production castings in general.

5.2 Extended pre-testing

Depending on the complexity of the structure, the execution method and/or the mix design it may be necessary to perform additional pre-testings. This section describes such additional pre-testings.

Additional pre-testing 1 (poker vibration/high reinforcement percentage)
The purpose of this additional pre-testing is to establish the 3 parameters for poker vibration for structures having significantly higher reinforcement percentages than the standard test specimen Fig. 5.2.

The investigations may be performed as described section 5.1.a by changing the reinforcement (ref. Fig. 5.2) to the percentage in question.

Additional pre-testing 2 (Additional production properties related to early age stress calculations)
The purpose of this additional pre-testing is to investigate the additional production properties required for calculation of the early stresses in the hardening concrete. Such calculations may be required e.g. in cases of strict requirements to the temperature difference between neighbouring, previously cast concrete and fresh casts.

The relevant additional production properties are:

- Early-age shrinkage and creep, test method TI-B102
- E-modulus development, test method NT BUILD 205
- Splitting tensile strength development, test method DS 423.34

The investigations shall be performed using concrete from the trial mix (ref. section 4) or from a smaller similar mix.

Additional pre-testing 3 (Testing of early-age stress calculations)
The purpose of this additional pre-testing is to test the early-age stress calculations by casting a test specimen using the precautions assumed in the stress calculations.

The distance between cracks which may occur due to restraint deformations is generally approx. 4 m. The test specimen shall consequently be at least 6-8 m long to reflect the real conditions.
The total volume for instance for pre-testing of a wall with a cross-section 3.5 x 0.6 m on a foundation slab with dimensions 1.0 x 3.0 m will be approx. 30 m^3.

The expenses are significant and such additional pre-testings are not usually carried out.

Additional pre-testing 4 (Complex structural details)
The purpose of this additional pre-testing is to investigate whether the concrete is suitable for casting specific complex structures or structural details.

The investigation is performed by casting a test specimen which reflects the complexity of the structure in question. The casting should be carried out using the planned execution method.

The structures or structural details which are recommended to be investigated are described in HETEK part 5: "Guide for structural design". The structures are:

4a	Structures with high reinforcement percentage, prestressing anchors and cast-in items including cooling pipes.
4b	Structures with a significant number and/or size of box-outs.
4c	Structures with cavity tubes.
4d	Structures with inclinated surfaces cast against formwork.
4e	Structures with inclinated surfaces cast without formwork.

The guide for structural design describes methods for the execution of the above mentioned structures.
Pre-testing is however recommended if the concrete gang has little or no previous experience from similar works carried out with high performance concrete.

Additional pre-testing 4a (High reinforcement percentage, prestressing anchors and cast-in items including cooling pipes)
The actual reinforcement, the prestressing anchors and the cast-in items can be placed in a test specimen of equal or larger dimensions as the specimen shown on Fig. 5.1.

Additional pre-testing 4b (Box-outs)
Pre-testing of large box-outs requires a test specimen which is larger than the standard test specimen (Fig. 5.1). There should be at least 1 m from the edge of the specimen to the box-out. If the box-out is for instance 1 m long the length of the test specimen should be at least 3 m.

Additional pre-testing 4c (Cavity tubes)
Investigations concerning casting methods for slabs or beams with cavity tubes require test specimens of significant horizontal extension. This is necessary in order to examine the buoyancy and possible deformations of the cavity tubes using the planned casting sequences.
This kind of pre-testing is expensive and is consequently not usually carried out.

Further information concerning execution methods can be found in HETEK part 5: "Guide for structural design".

Additional pre-testing 4d (inclinated surfaces cast against formwork)
The height of the test specimen for investigations of inclinated surfaces cast against formwork shall reflect the actual cross section. This is necessary in order to examine the effect of the planned vibration technique.
Especially the difficult vibration underneath the inclinated formwork (see Fig. 5.6) ought to be tested if the concrete gang has no previous experience from similar castings carried out with high performance concrete.

Further information concerning execution methods can be found in HETEK part 5: "Guide for structural design".

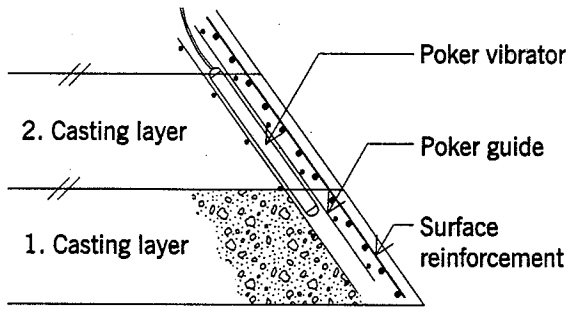

Fig. 5.6 *Vibration underneath inclinated formwork.*

Additional pre-testing 4e (inclinated surfaces cast without formwork)
The test specimen for investigation of inclinated surfaces cast without formwork may be a slab with thickness 0.3 m. The length and width can for instance be 3 x 3 m.

The planned production methods, including equipment and evaporation protection, shall be investigated during execution of the test specimem.

The production methods may be:

- poker vibration
- beam vibration
- screeding
- manual floating
- finishing machines (not recommended ref. Guide for use of high performance concrete, The Danish Concrete Institute, 95)

The evaporation protection may be performed using:

- covering with waterproof membrane
- covering with waterproof insulation mats
- application of curing compound

Additional pre-testing 5 (Underwater casting)
The purpose of this pre-testing is to test whether the concrete is suitable for underwater casting. Underwater castings are usually carried out without vibration of the concrete and it is therefore of significant importance to investigate the additional production properties concerning:

- flowing out, spread or viscosity
- internal cohesion

It should also be ensured that the execution method results in a homogene concrete without detrimental cavities.
The spread of the concrete may be tested by test method NT BUILD 194.
The viscosity and cohesion (yield stress) may be tested by means of a Rheometer. The method is described in "Guide for use of high performance concrete" [The Danish Concrete Institute 1995].

Investigation of the execution method may be performed by casting a test specimen in formwork placed under water. The formwork shall be reasonably long to reflect the real structure and to examine the flow of the underwater concrete.
The length can be for instance 4-5 m. The height and width may be reduced to 1.0 x 0.6 m. Some of the concrete may be coloured in order to clarify the concrete movements during casting.

The 6 tons test specimen should be brought on shore after hardening. Investigations of cavities may be performed by drilling out cores.
It should also be decided whether the character of the upper surface concerning irregularity is suitable for the actual purpose.

The pre-testing described above is expensive and is not usually carried out unless the structure is of significant importance for the process of construction and/or for the durability and strength.

Additional pre-testing 6 (slip form casting)
The purpose of this pre-testing is to investigate additional production properties which are of importance for slip form castings. A number of investigations have revealed a greater extent of microdefects for slip form castings compared to structures cast against fixed form. The influence of the micro defects, as far as durability is concerned is not known with certainty - but it should be taken into consideration during planning.

Concrete mixes with long setting time, significant stickiness and tendency to crust formation may lead to difficult execution of slip form castings. These additional production properties (stickiness and crust formation) are described in "Guide for use of High Performance Concrete" [The Danish Concrete Institute, 1995].

Test specimens for investigation of the slip form method should be of significant size, in order to form a realistic basis which can be used for production.
The front page photo on the State of the Art report shows the test specimens which were cast as a part of the pre-testing for the slip form casting of the Great Belt West Bridge caissons.
The volume of the test specimen was approx. 40 m^3.
The expenses are significant and such additional pre-testings are not usually carried out.

The influence of the concrete composition regarding the additional production properties, Stickiness and crust formation, should however be estimated.
The planning of thickness of casting layers and slip form speed may then be based hereon and on knowledge about the setting time which is investigated by pre-testing of concrete, constituent materials and composition (ref. section 4). Also the climatic conditions (temperature, wind and humidity) and their influence on the production properties should be taken into consideration.
Further information can be found in "Guide for use of High Performance Concrete" [The Danish Concrete Institute, 1995].

5.3 Previous Knowledge
The basic pre-testing of workmanship (section 5.1) may be omitted if it can be documented that the required investigations have already been made, or if the concrete has previously been used successfully for the execution of a similar structure.

5.4 Expenses

The estimated expenses for the described basic pre-testing and additional pre-testings are:

Basic pre-testing of workmanship	approx. DKK	25,000
Additional pre-testing 1 (high reinforcement percentage)	approx. DKK	30,000
Additional pre-testing 2 (production properties related to early-age stress calculations)	approx. DKK	95,000
Additional pre-testing 3 (Testing of early-age stress calculations)	approx. DKK	300,000
Additional pre-testing 4a (high reinforcement percentage etc.)	approx. DKK	35,000
Additional pre-testing 4b (Box-outs)	approx. DKK	25,000
Additional pre-testing 4c (Cavity tubes)	approx. DKK	150,000
Additional pre-testing 4d (Inclinated surfaces cast against formwork)	approx. DKK	50,000
Additional pre-testing 4e (Inclinated surfaces cast without formwork)	approx. DKK	25,000
Additional pre-testing 5 (Underwater casting)	approx. DKK	100,000
Addition pre-testing 6 (slipform casting)	approx. DKK	300,000

The expenses are based on an estimated volume of the test specimens and an unit price of 10-30,000 DKK per m^3 of concrete including reinforcement, formwork, labour, equipment, testing and reporting.

The expenses are exclusive removal of the test specimens.

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