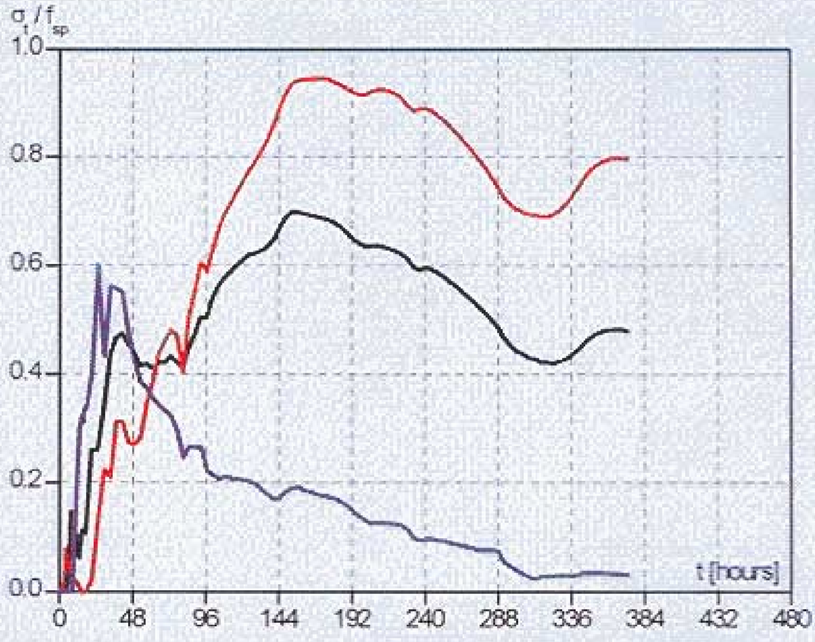
HETEK

Control of Early Age Cracking in Concrete
Phase 9: Stress Calculations and Crack Observations



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	Cracking	5211
	Development	9013
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	Numerical	6432
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	Stress Analysis	5573
	Thermal analysis	7152
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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). For durability reasons reinforced concrete structural members should be well protected against penetration of water, chloride, etc. This means that cracks should be avoided or at least the crack-width limited. Cracks can form already during the hardening process. An evaluation of the risk of crack formation involves a stress analysis. In stress analysis of hardening concrete structures, the load consists of the differences in thermal strains that arise from the heat of hydration. The mechanical properties (including autogenous shrinkage) of the concrete also change during the hardening process. If a stress analysis shows high stresses relative to the tensile strength there is a high risk of crack formation.

The purpose of the present report is to determine a permissible value for the ratio of tensile stress to splitting tensile strength, which do not results in crack formation. The splitting tensile strength is determined in accordance with DS 423.34.

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0. Preface

This project on control of early-age cracking 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).

In this programme high performance concrete is defined as concrete with a service life of at least 100 years in an aggressive environment.

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

The total HETEK research programme is divided into segments with the following topics:

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

The Danish Road Directorate invited tenders for this research programme which is mainly financed by the Danish Ministry for Commerce and Industry - The Commission of Research and Development Contracts.

The present report refers to the part of the HETEK project that deals with control of early-age cracking.

For durability reasons reinforced concrete structural members should be well protected against penetration of water, chloride, etc. This means that cracks should be avoided or at least the crack-width limited. Cracks can form already during the hardening process. An evaluation of the risk of crack formation involves a stress analysis. In stress analysis of hardening concrete structures, the load consists of the differences in thermal strains that arise from the heat of hydration. The mechanical properties (including autogenous shrinkage) of the concrete also change during the hardening process. If a stress analysis shows high stresses relative to the tensile strength there is a high risk of crack formation.

The purpose of the present report is to determine a permissible value for the ratio of tensile stress to splitting tensile strength, which do not results in crack formation. The splitting tensile strength is determined in accordance with [DS 423.34].

The project was carried out by a consortium consisting of:

The Danish Concrete Institute, represented by:

Højgaard & Schultz A/S
Monberg & Thorsen A/S
RAMBØLL
COWI

and

The Danish Technological Institute, represented by the Concrete Centre

and

The Technical University of Denmark, represented by the Department of Structural Engineering and Materials.

Two external consultants, Prof. Per Freiesleben Hansen and manager Jens Frandsen, are connected with the consortium.

1. Background

In major public works projects, it is often required that crack formation during the hardening process be avoided. A method of execution that ensures this can be based on stress calculations for the hardening structure, cf. [Pedersen, 1997]. Stress calculations are based on tests in which a number of concrete properties are determined:

- heat development
- coefficient of thermal expansion
- modulus of elasticity
- autogenous shrinkage
- creep
- an indicator of the tensile strength

In calculations connected with hardening, unlike those for bearing capacity, it is not possible to decide whether a given property should be allotted a high or a low characteristic value in order to be on the safe side. Only the mean values of the properties are therefore given, so that the calculated development will approximate to the actual development.

The tensile strength does not enter into the calculations, but is used solely for comparison with the calculated stress. As the properties are subject to variation, the calculated stresses will also vary. If all the properties, including the tensile strength, were uncorrelated, cracks would form in 50% of the cases in which the tensile strength was fully utilized. However, the properties are not uncorre-lated; for example, a high modulus of elasticity is correlated with a high com-pressive strength. The safety factor for crack formation is reflected in the permissible degree of utilization of the tensile strength. A high degree of utilization involves a significant frequency of damage, while an excessively low degree of utilization means that unnecessary measures will be taken during the hardening process.

The splitting tensile strength, determined in accordance with DS 423.34, is used as an indicator of tensile strength. The splitting tensile strength does not correspond precisely to the uniaxial tensile strength, which would be the natural basis of comparison with the calculated stresses. The relation of splitting tensile strength to uniaxial tensile strength during the hardening process is not well documented.

According to [Pedersen, 1997], crack formation during the hardening process is due to differences in temperature movements and shrinkage movements within the structure. When cracks form, these differences, and the internal forces they create, are greatly reduced. The width of the cracks depends on the relative rigidities of the cracked member and the member exerting the internal force. The more flexible the member that exerts the force, the wider will be the cracks. This is because the cracked member loses much of its rigidity on crack formation, whereas the member that exerts the force can "straighten itself out". The more flexible the structure, the more it is deformed prior to crack formation, and the more it will straighten itself out when the load is removed. The crack width is of course also influenced by the amount of distribution reinforcement.

These considerations show that

- variation of concrete properties
- the relation between uniaxial and splitting tensile strengths
- mechanisms of rupture

influence the choice of a permissible degree of tensile strength utilization. With our present knowledge it is not possible to determine a permissible tensile stress. The experience obtained during the execution of a number of projects has therefore been collected. This has made it possible to determine the degree of utilization of tensile strength at which cracks usually form.

2. Method

Temperature and crack observations on a number of structures were collected. Stress calculations were carried out in connection with the planning of these structures. For this purpose, material tests were made to the extent specified in [Spange, 1996]. The material properties are given as mean values, as mentioned in Section 1.

Stress calculations were carried out in which the observed temperature functioned as a "loading". The observed temperature histories deviated in some cases from the planned. This is due to deviations in the thermal boundary conditions (temperature of the concrete during casting, air temperature and wind speed) and/or deviations relative to the planned method of execution. The investigation included hardening processes that resulted in cracks and those that did not result in cracks. By comparing crack formation and calculated stresses, it was possible to determine the level of tensile strength utilization at which cracks form.

As described in [Pedersen, 1997], there is a risk of surface cracks when the concrete temperature is at a maximum, and a risk of through-going cracks in the cooling phase. The surface cracks normally close during the cooling phase, while the through-going cracks open. The through-going cracks can be observed in a subsequent inspection, while the surface cracks are difficult to detect. The present stress analyses are therefore concerned with the through-going cracks that form in the cooling phase.

3. Observations

Observations on crack formation (or its absence) were made on three projects - A, B and C below. The crack observations are shown i Table 3.1

Project A
The project in which the observations were made are not identified here, but the DTI Concrete Centre is aware of the origin.

Observations were made on 6 components geometrically identical but executed under different thermal boundary conditions and using different methods.

The cross-section is shown in Appendix IV. Due to symmetry only the half cross-section is shown. The length of a section is 15 m.

Formation of cracks were observed i 3 sections. The observed cracks are vertical and appear in the lower half of the walls.

In section A-2 and A-4 crack formation occurs respectively in 2 and 4 different locations along the tunnel. The distance between these locations is about 2.5 m.

Measured temperatures in the points according to Appendix I is shown in Appendix. II.

Project B
A test on a 10 m long wall on a base slab was carried out in Phase 7. A vertical crack was observed in the lower part of the wall. The test is described in detail in the report "Measured and Predicted Deformations in Hardening Concrete" [Pedersen and Spange, 1997].

Project C
A tunnel was investigated in Phase 8. The structure is described in detail in the report "Modelling of support conditions" [Andersen, 1997]. No cracks were observed.

Project	Inspection age [days]	Crack-width [mm]				Utilization [%]
		E-Inside	E-Outside	W-Inside	W-Outside	
A-1	90	0.18	0.1	0.2	0.1	94
A-2	44	0.06	0.1	0.1	0.16	106
		0.2	0.2	0.2	0.2	
		0.2	0.2	0.2	0.1	
		0.08	0.14	0.16	0.1	
A-3	13	÷	÷	÷	÷	>100
A-4	14	0.2	0.12	0.2	0.12	88
		÷	÷	0.04	0.12	
A-5	14	÷	÷	÷	÷	76
A-6	14	÷	÷	÷	÷	59
B	6	0.05	0.1			74
C	14	÷	÷	÷	÷	50

Table 3.1 Observed crack-width and calculated utilization of the splitting tensile strength.

4. Utilization of splitting tensile strength

Calculations of the hardening stresses undergone by the observed structures were made. These calculations were carried out with the aid of the programme CIMS-2D [DTI, 1995]. In the calculations, use was made of the data on casting temperature, air temperature and concrete temperature during hardening obtained during execution. The observed temperature history is the basis of the calculated stress history.

The stresses thus calculated are therefore a close approximation to the stresses developed in the structure.

Instead of using the measured temperatures in the foundation as a basis for temperature displacements in the analysis, the measured temperature is transformed into an eigen-strain, which is applied directly in the analysis. By doing this, troubles with making agreement between observed and calculated temperatures are avoided. This concerns only project A.

The length of the sections relative to the flexural rigidity of the cross-section is assumed to be so short that the stress pattern is not significantly affected by the dead load. All cross-sections are therefore assumed to bend freely [Pedersen et al., 1997].

4.1 Results of calculations

The results for projects B and C are given in [Pedersen and Spange, 1997] and [Andersen, 1997] respectively.

The results for project A is shown i Appendices II - IV.

Appendix II shows calculated temperatures at the points measured during the hardening process (see Appendix. I).

Appendix III shows changes in the maximum utilization of splitting tensile strength and the distribution of splitting tensile strength utilization at the time when temperature measurements are ended.

In Appendix IV the input-data, on which the calculations are based, is shown.

4.2 Evaluation

For given thermal boundary conditions, there is fairly good agreement between measured and calculated temperature histories (cf. Appendix II). This ensures that the theoretical model of the structure undergoes temperature changes similar to those that arise in the actual structure.

The high utilization of tensile strength seen in project A, at an early stage of cooling (see Appendix III), takes place around cooling pipes. If cracks are formed at this moment, these will close again when the temperature returns to the normal level. At the time when the surfaces were inspected, this type of cracks could hardly been seen.

This goes not for section A-1 because the cooling failed. The utilization is 94 % after 168 hours (see Appendix III). The critical stresses are not situated locally around cooling pipes due to the lack of cooling, but acts all over the lower part of the wall. A drastic crack formation could still be observed at the time when temperature measurements are ended (336 hours). At this time the utilization is only 72 % due to mutual temperature changes between foundation, walls and slab. However the cracks are probably formed at about 168 hours corresponding to 94 % utilization of the splitting tensile strength.

In the rest of the sections the tensile strength utilization at the time, when the temperature measurement is ended, is compared to the observed crack formations.

In section A-3 no cracks are observed even though the utilization is high. This is probably because the utilization is determined at the time when temperature measurements were ended. The measurements were ended before the temperature was returned to the ambient level. During the following cooling the cracks are probably closing again and they are not registred at the inspection later in the progress.

For the projects in which cracks were observed, it can be seen that the distribution of tensile strength utilization correctly indicates the position of the cracks (see Appendix III). In all the cases, except in project B, in which cracks appeared, the tensile strength utilization is seen to be over about 80 %. In the cases in which no cracks appeared, the max. tensile strength utilization is seen to be below about 80 % (see Table 3.1). In project B, the structure is supported statically determined in the laboratory. As a consequence, no redistribution of the supporting forces can take place, when a crack begins to form. In all the other considered structures, the sub-base damp down the possibility for propagation of cracks. The more brittle crack formation in project B could be the reason for the low value of the utilization.

5. Conclusion

Stress calculations were carried out on the basis of temperature measurements. When the calculated stresses are compared with the observed cracks, or their absence, it can be concluded that through-going cracks form when the splitting tensile strength utilization exceeds about 80 %.

6. Literature

Andersen, M.E. et al.: "HETEK - Control of Early Age Cracking - Phase 8: Modelling of Support Conditions", Danish Road Directorate, Report No.98, 1997.

DTI: "CIMS-2D, Version 1.1 - User Manual", October 1995.

Pedersen, E.S. and Spange, H.: "HETEK - Control of Early Age Cracking in Concrete - Phase 7: Measured and Predicted Deformations in Hardening Concrete", Danish Road Directorate, Report No. 106, 1997.

Pedersen, E.S. et al.: "HETEK - Control of Early Age Cracking in Concrete - Guidelines", Danish Road Directorate, Report No.120, 1997.

Spange, H. and Pedersen, E.S.: "HETEK - Control of Early Age Cracking in Concrete - Phase 1: Early Age Properties of Selected Concrete", Danish Road Directorate, Report No. 59, 1996.

DS 423.34 "Testing of concrete. Tensile strength deduced from splitting on cylindrical specimens", 1985.

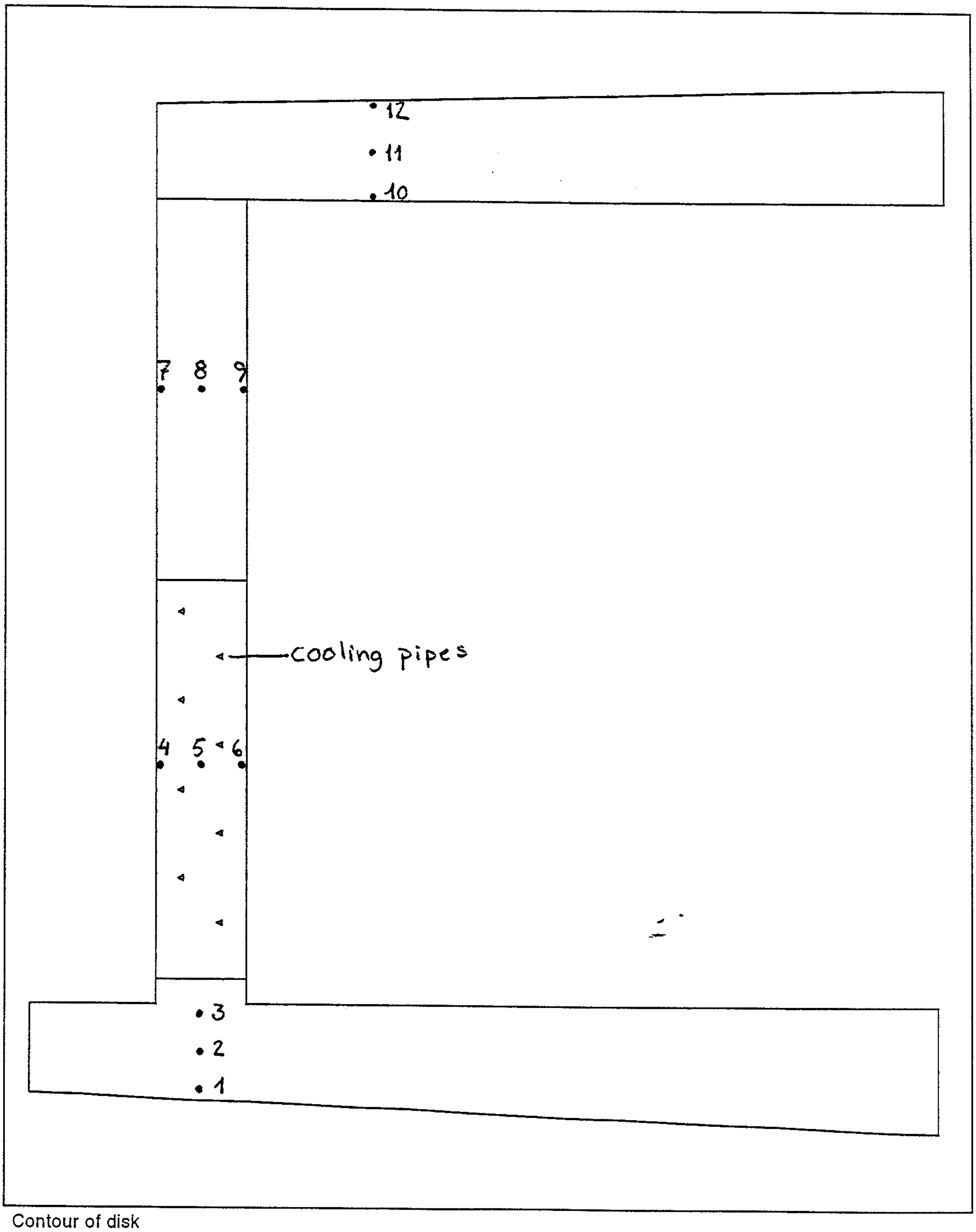
Appendix I

Placing of thermo-couples

DTI Building Technology Gregersensvej, DK 2630 Taastrup	CALCULATION RESULTS Documentation sheet

Client:	Ref. nr.:	Project: proj-a-2	Date: 22-04-97
Name:	Initials :	Id. nr. : VE-AA1490	Time: 12.53

THERMO - COUPLES



Contour of disk

Appendix II

Measured and calculated temperatures

DTI Building Technology Gregersensvej, 2630 Taastrup	Project A - section 1 Temperatures No. 4-5
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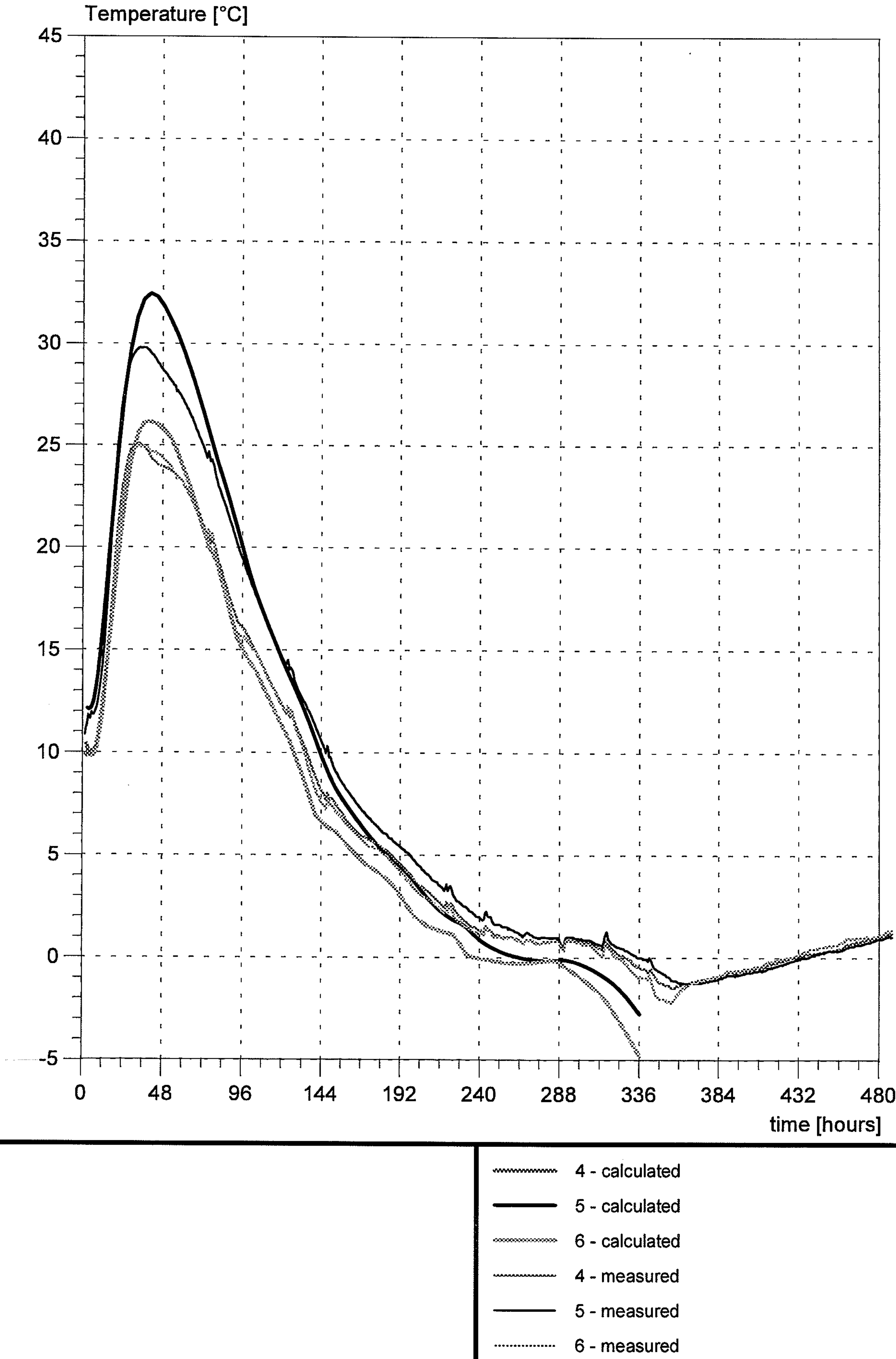

DTI Building Technology Gregersensvej, 2630 Taastrup	Project A - section 1 Temperatures No. 7-9
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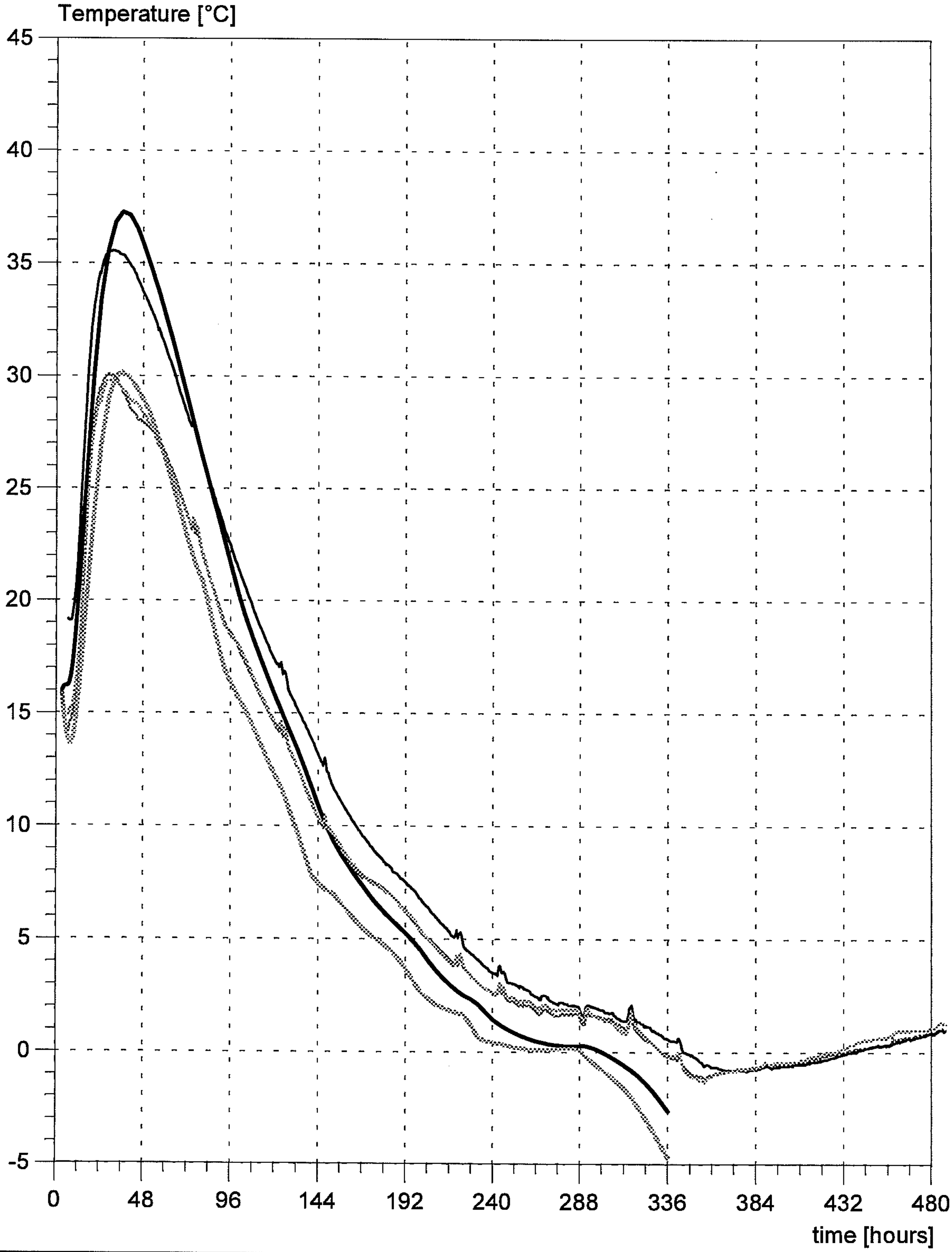

7 - calculated
8 - calculated
9 - calculated
7 - measured
8 - measured
9 - measured

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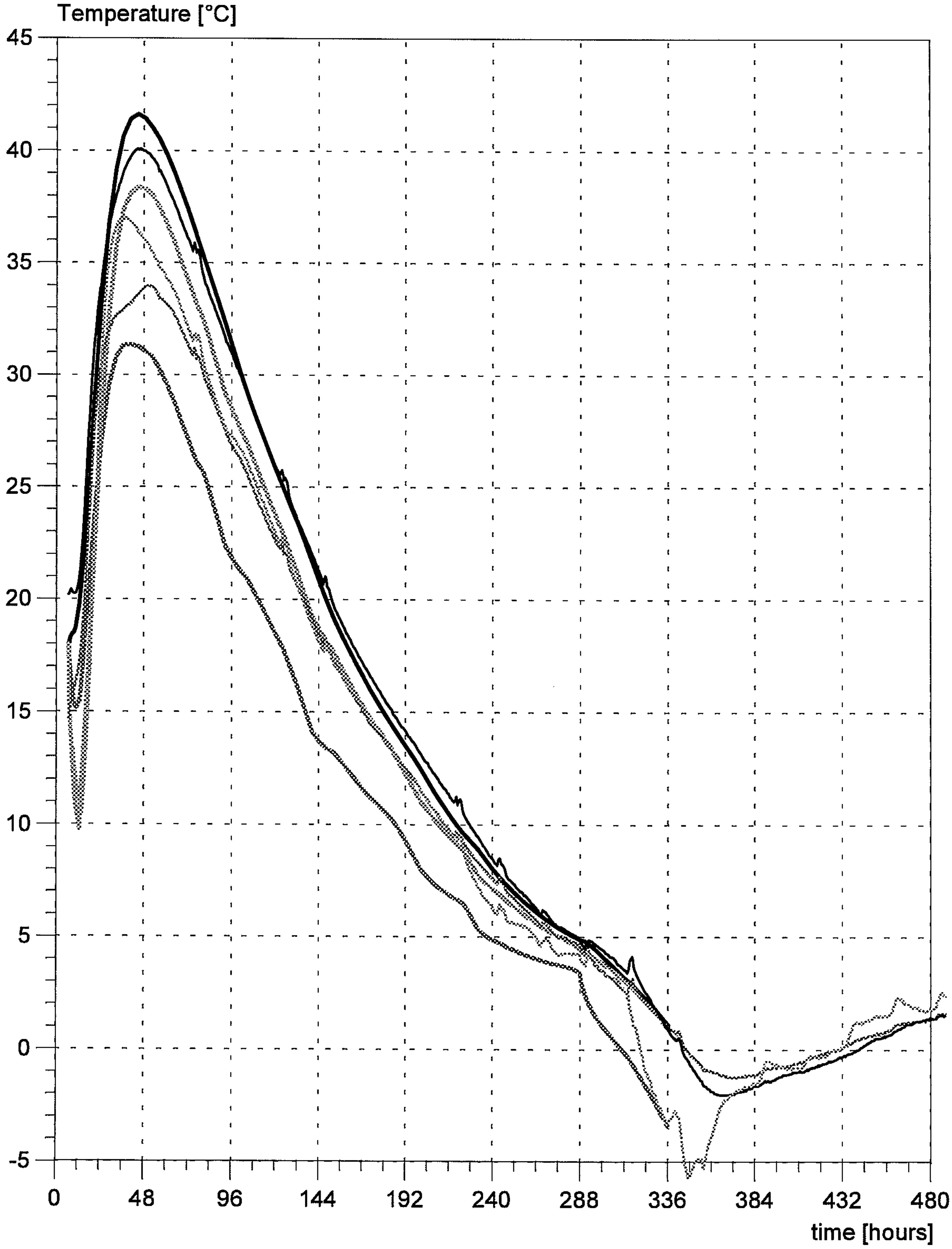
Client: HETEK 3 + 4 Name: Phase 9	Ref.: 53461 Init.: Date: 04/16/97



10 - calculated
11 - calculated
12 - calculated
10 - measured
11 - measured
12 - measured

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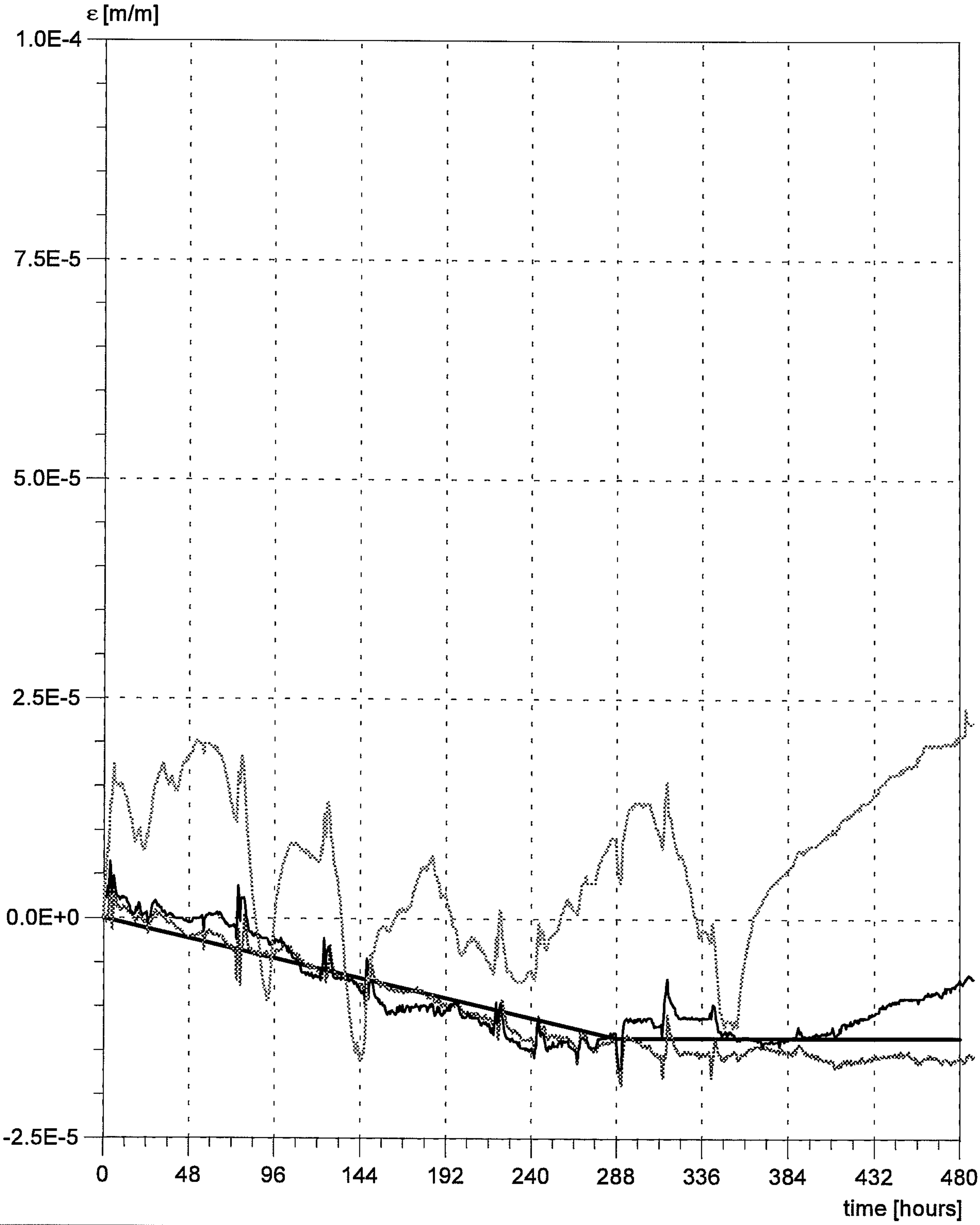
Client: HETEK 3 + 4 Name: Phase 9	Ref.: 53461 Init.: Date: 04/17/97



Thermal deformation based on measured temperature is calculated as

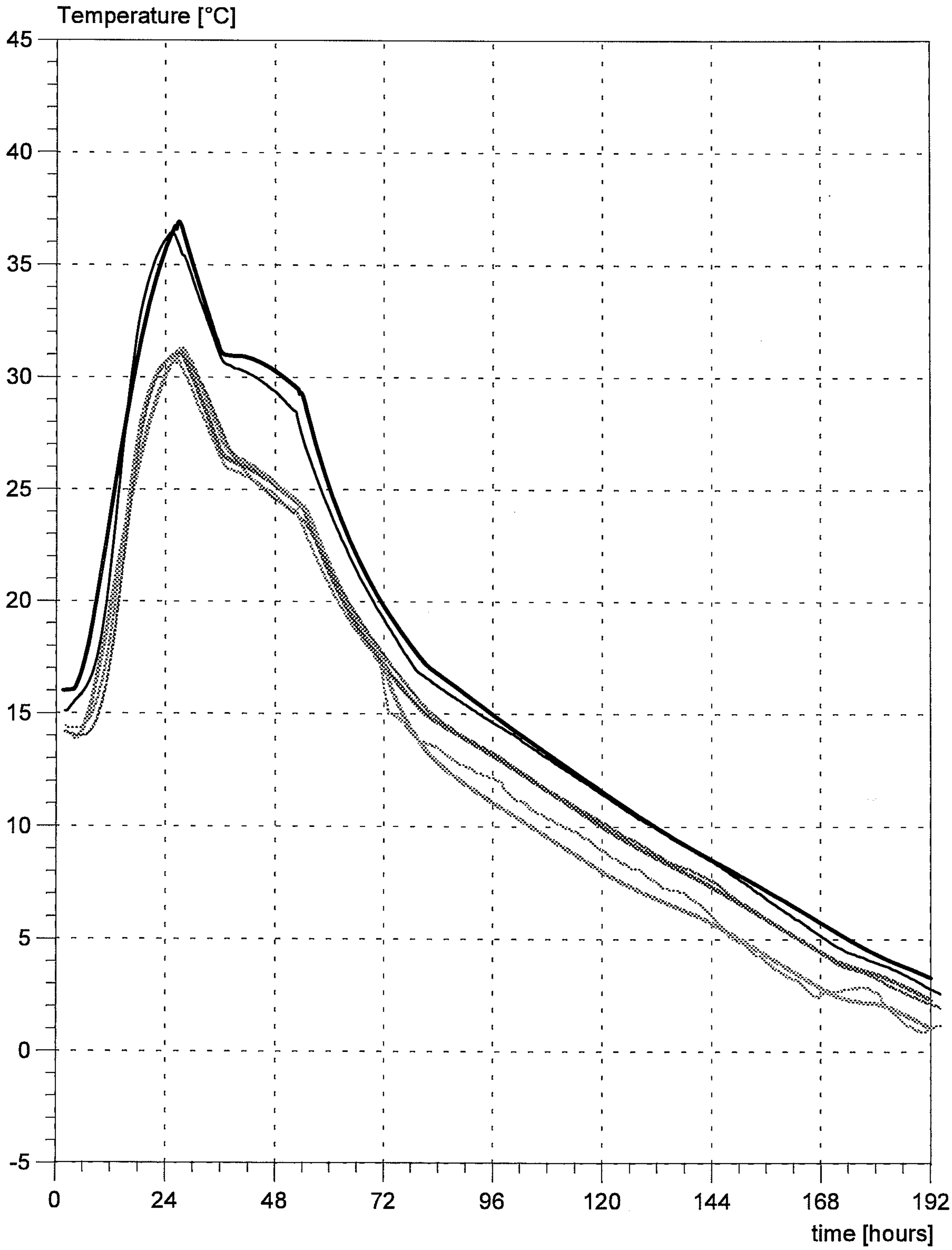
$\varepsilon = 0.9E\text{-}5 \cdot \Delta T_{measured}$

- corresponding to measured temp. No. 1
- corresponding to measured temp. No. 2
- corresponding to measured temp. No. 3
- strain used in calculation

DTI Building Technology Gregersensvej, 2630 Taastrup	Project A - section 2 Temperatures No. 4-6

Client: HETEK 3 + 4
Name: Phase 9

Ref.: 53461
Date: 04/17/97
Init.:

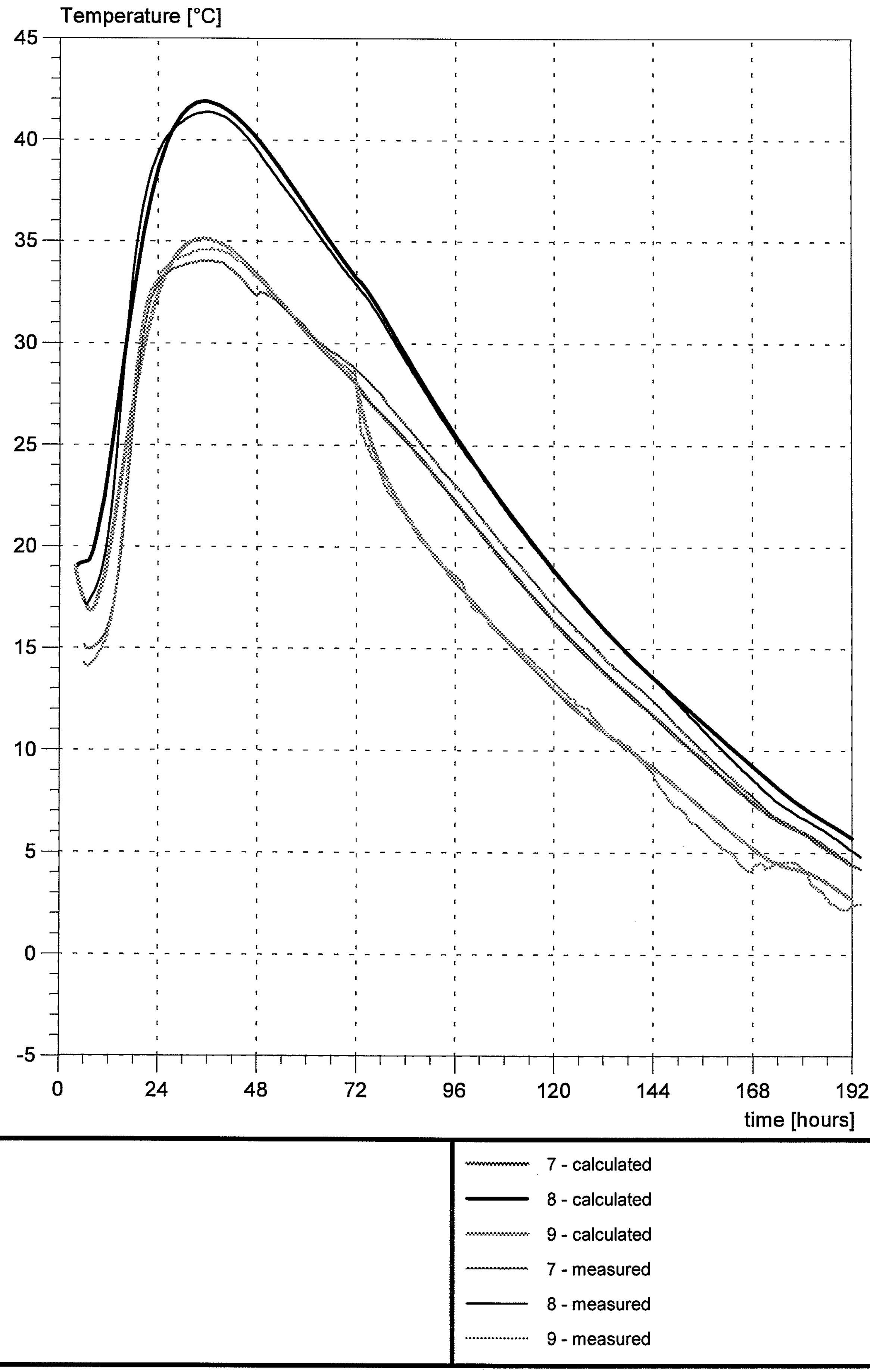


4 - calculated
5 - calculated
6 - calculated
4 - measured
5 - measured
6 - measured

DTI Building Technology Gregersensvej, 2630 Taastrup	Project A - section 2 Temperatures No. 7-9

Client: HETEK 3 + 4
Name: Phase 9

Ref.: 53461 Init.:
Date: 04/17/97



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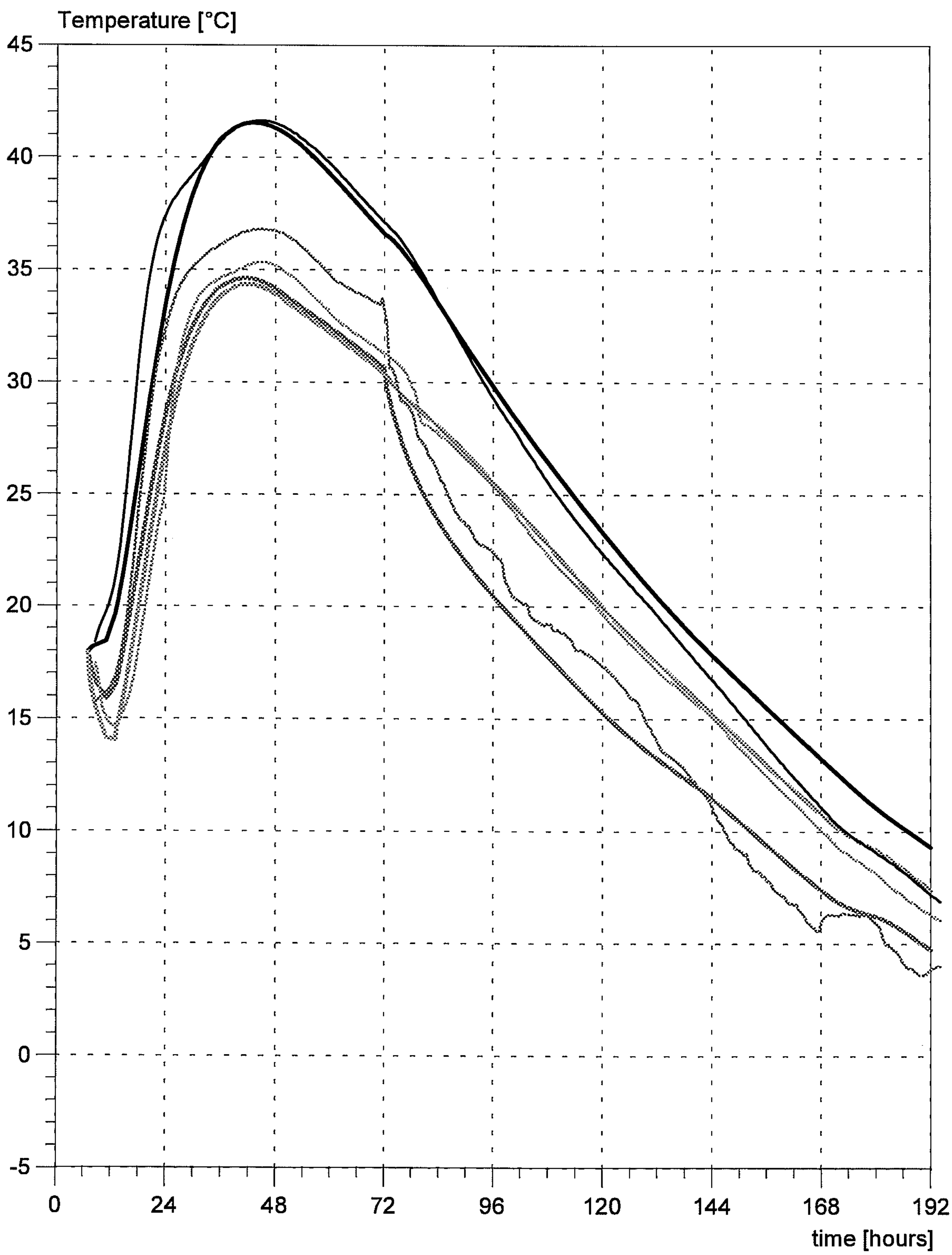

10 - calculated
11 - calculated
12 - calculated
10 - measured
11 - measured
12 - measured

DTI Building Technology Gregersensvej, 2630 Taastrup	Project A - section 2 Thermal deformations in foundation
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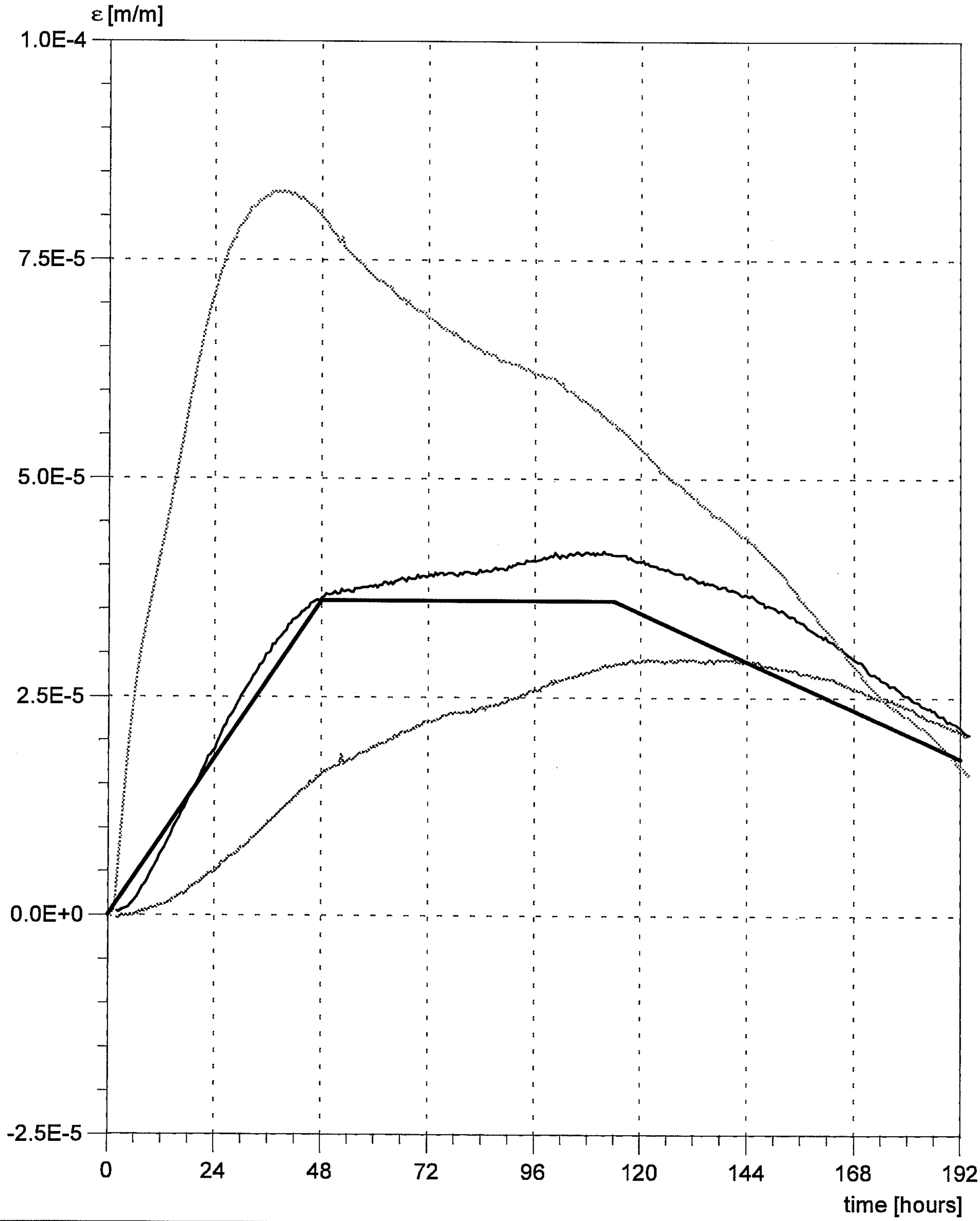


Thermal deformation based on measured temperature is calculated as

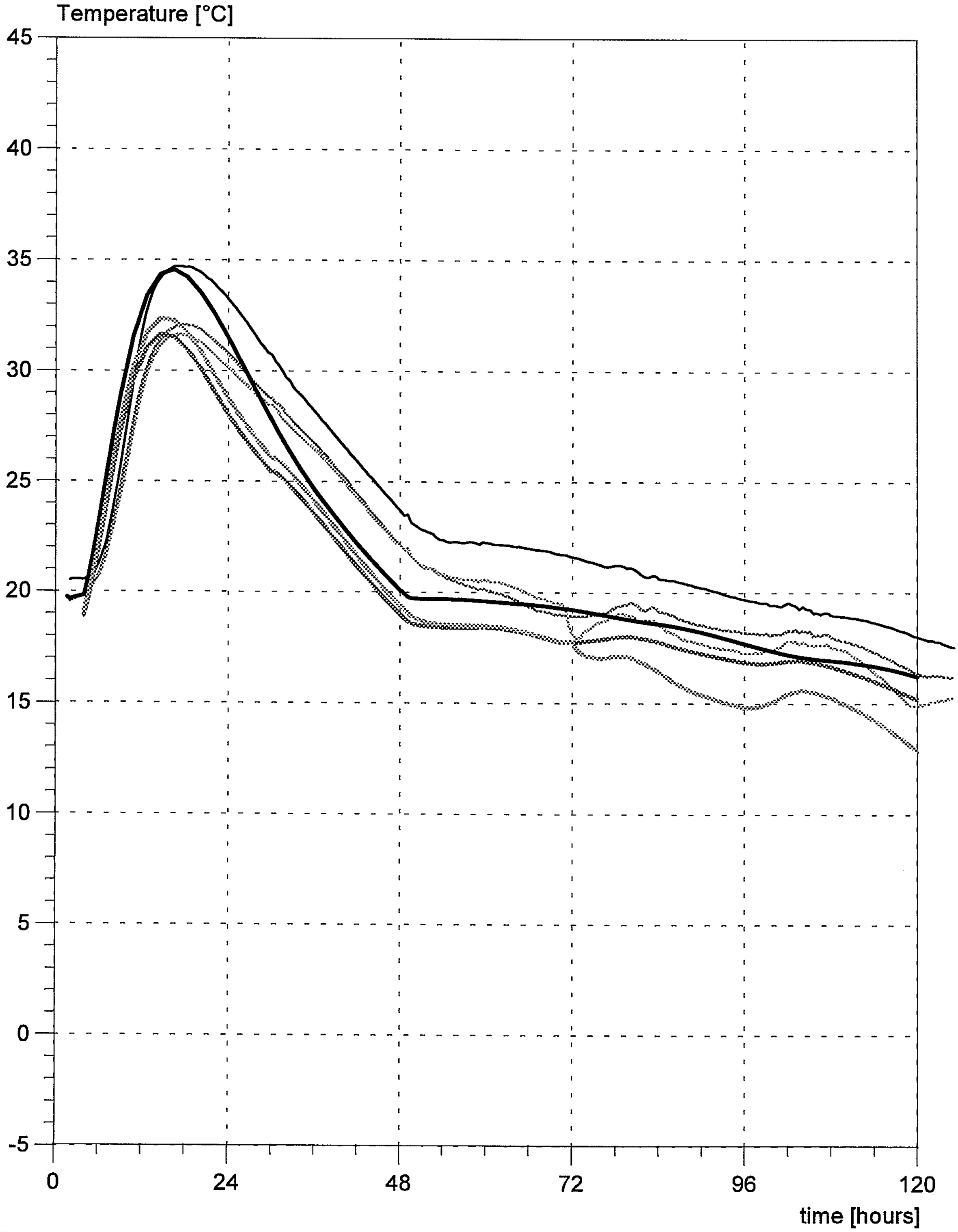
$\varepsilon = 0.9E\text{-}5 \cdot \Delta T_{measured}$

- corresponding to measured temp. No. 1
- corresponding to measured temp. No. 2
- corresponding to measured temp. No. 3
- strain used in calculation

DTI Building Technology Gregersensvej, 2630 Taastrup	Project A - section 3 Temperatures No. 4-6

Client: HETEK 3 + 4
Name: Phase 9

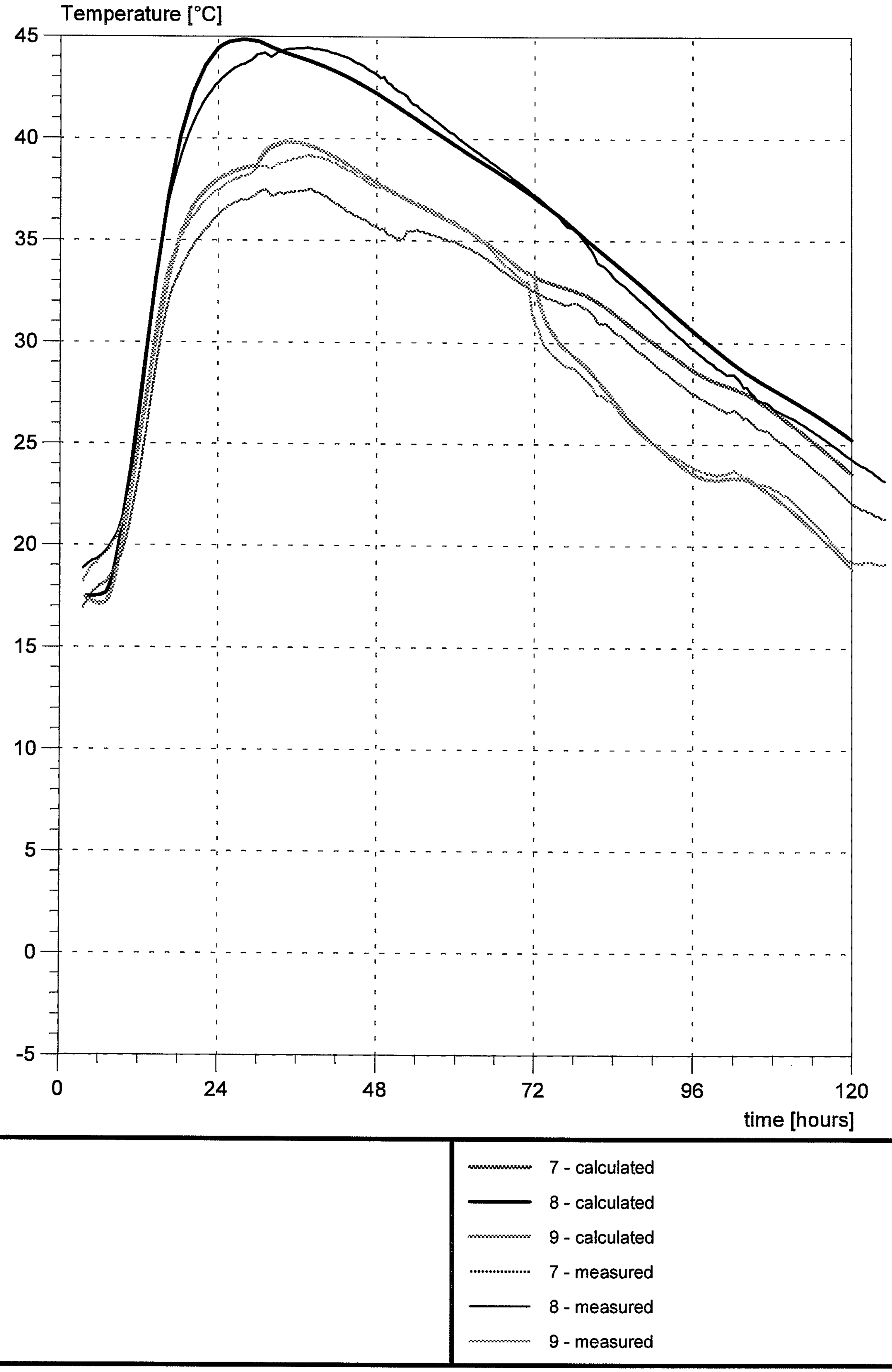
Ref.: 53461 Init.:
Date: 04/17/97



4 - calculated
5 - calculated
6 - calculated
4 - measured
5 - measured
6 - measured

DTI Building Technology Gregersensvej, 2630 Taastrup	Project A - section 3 Temperatures No. 7-9

Client: HETEK 3 + 4	Ref.: 53461	Init.:
Name: Phase 9	Date: 04/17/97	



DTI Building Technology Gregersensvej, 2630 Taastrup	Project A - section 3 Temperatures No. 10-12

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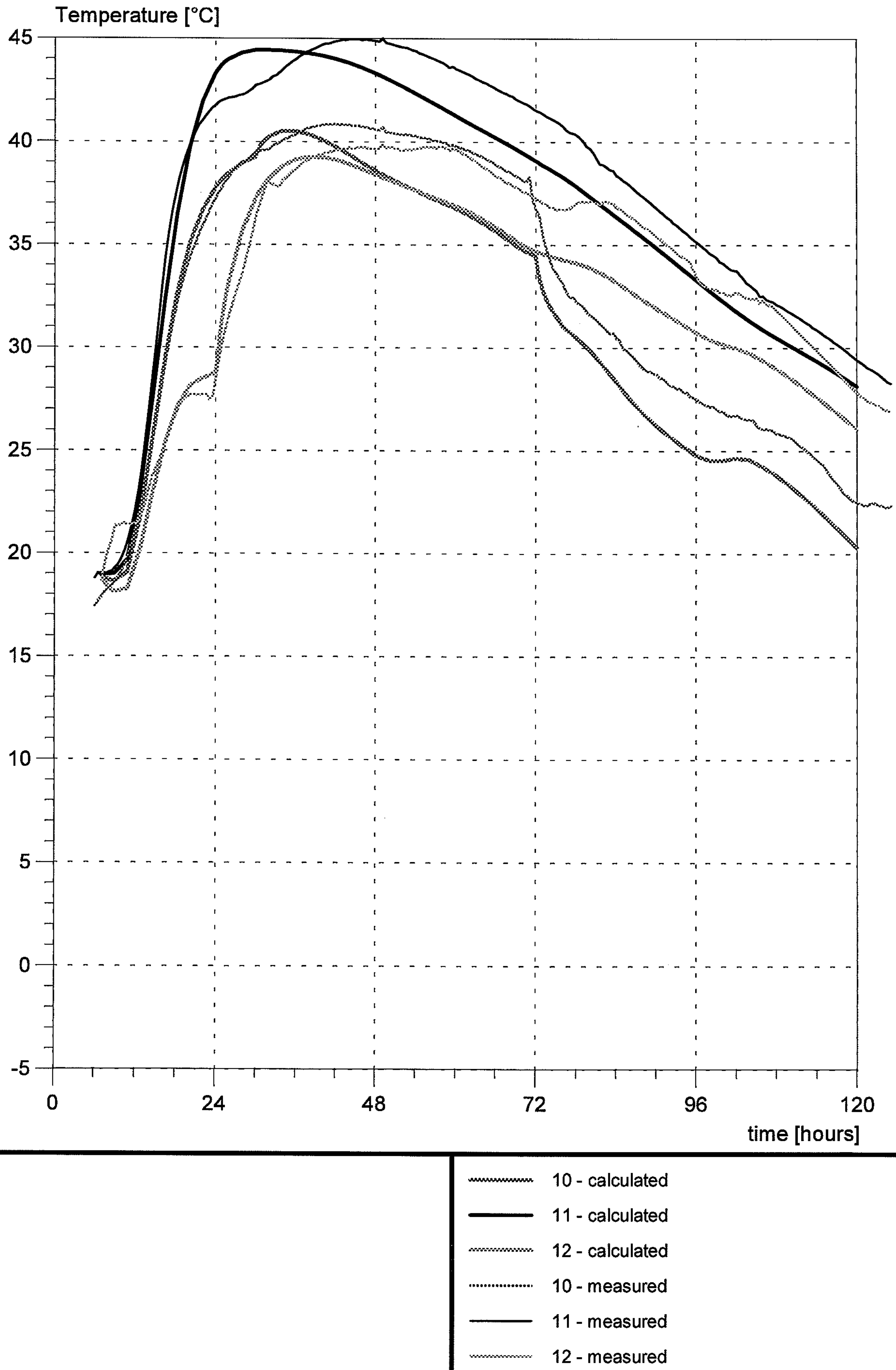
Name: Phase 9

Ref.: 53461
Date: 04/17/97
Init.:



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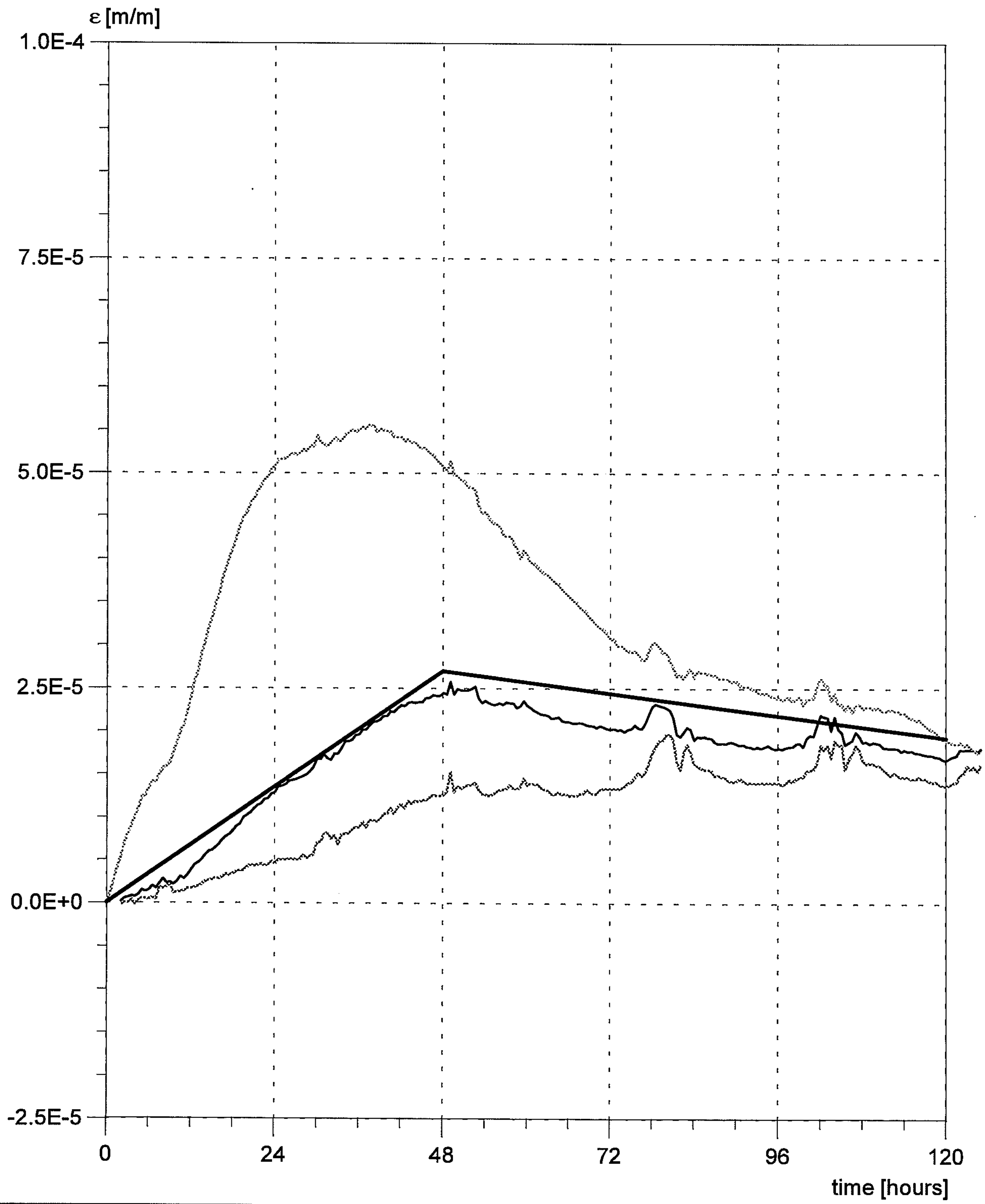

Thermal deformation based on measured temperature is calculated as

$\varepsilon = 0.9E\text{-}5 \cdot \Delta T_{measured}$

- corresponding to measured temp. No. 1
- corresponding to measured temp. No. 2
- corresponding to measured temp. No. 3
- strain used in calculation

DTI Building Technology Gregersensvej, 2630 Taastrup	Project A - section 4 Temperatures No. 4-6	
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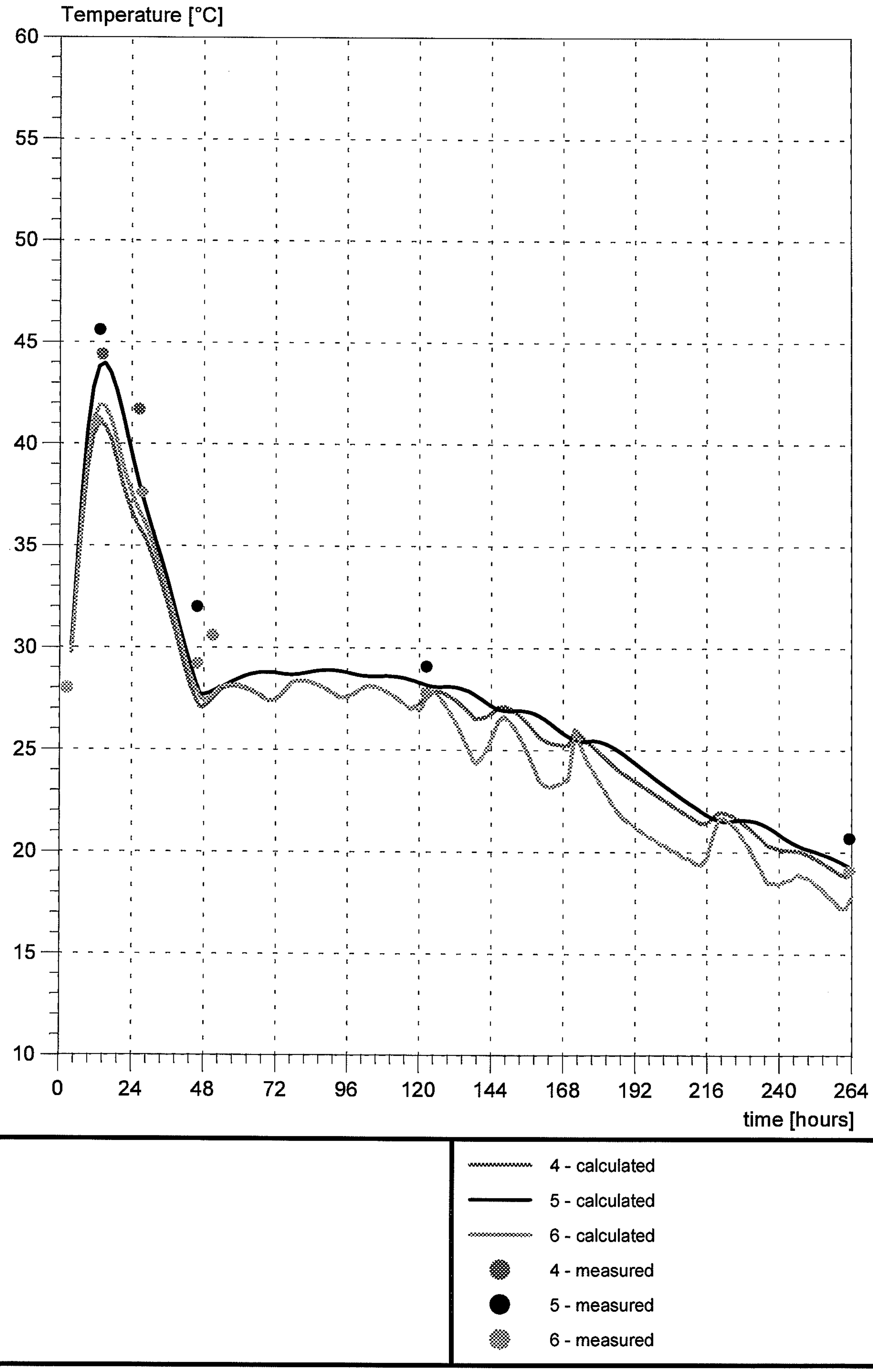

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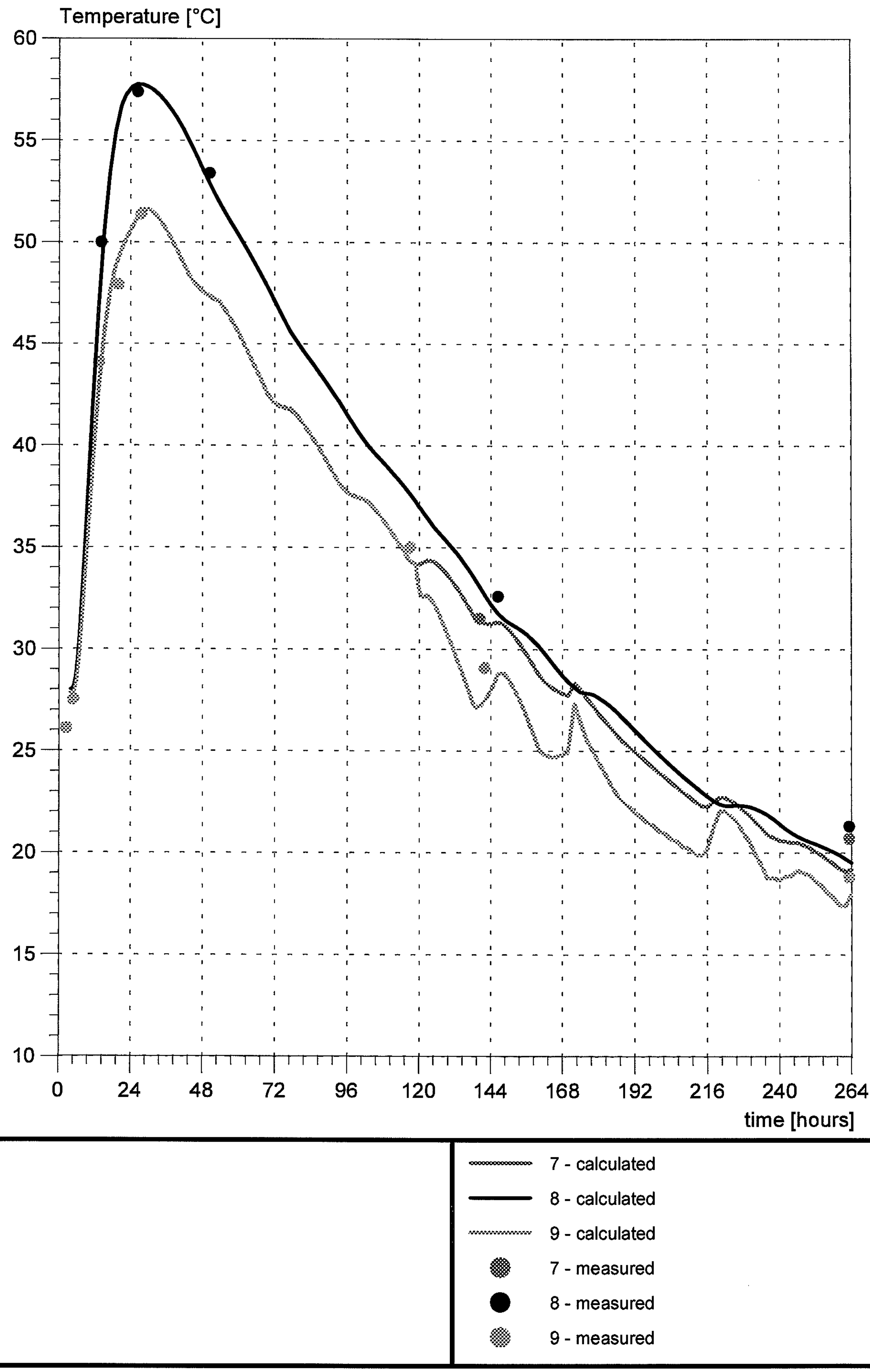

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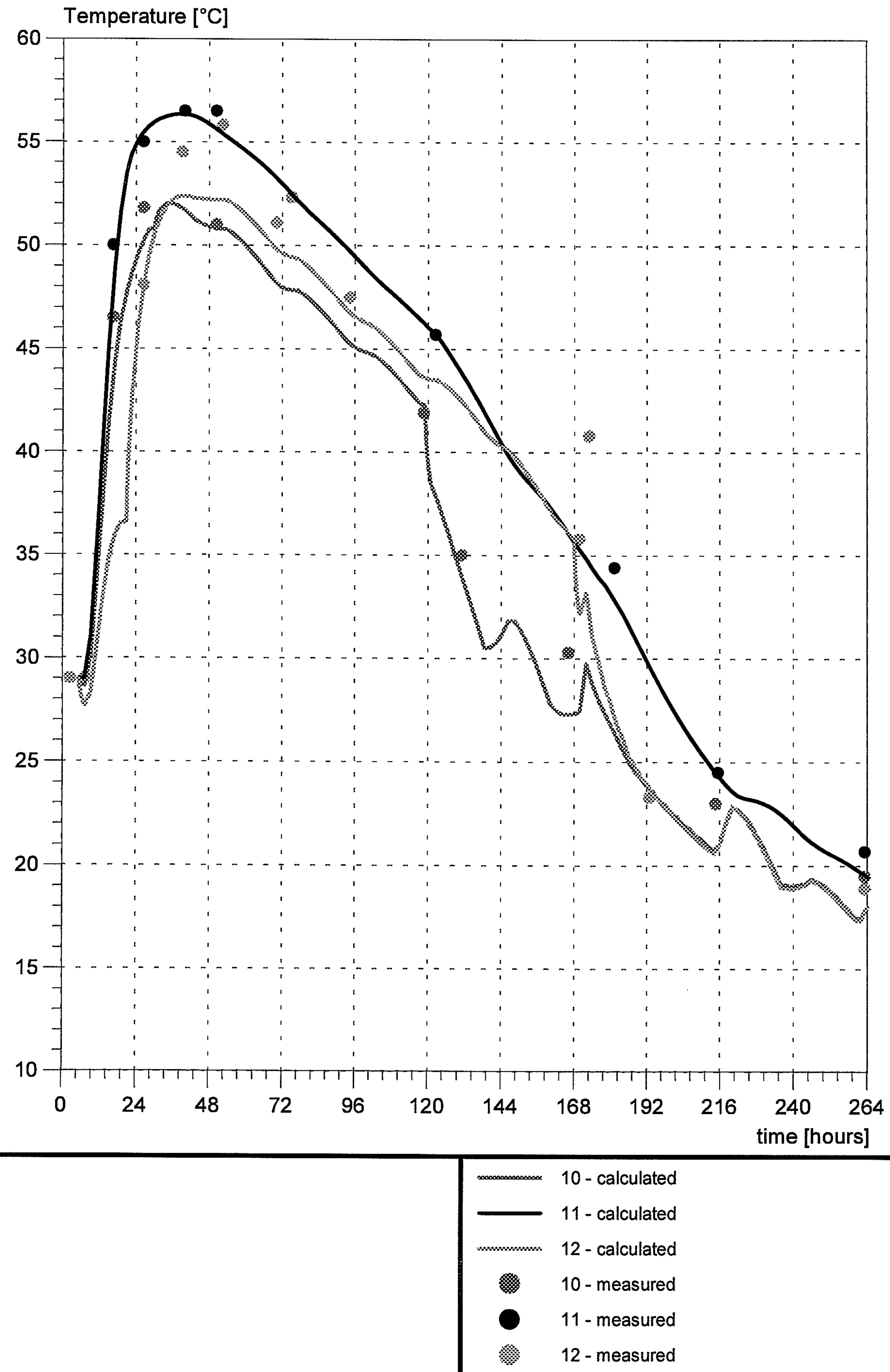

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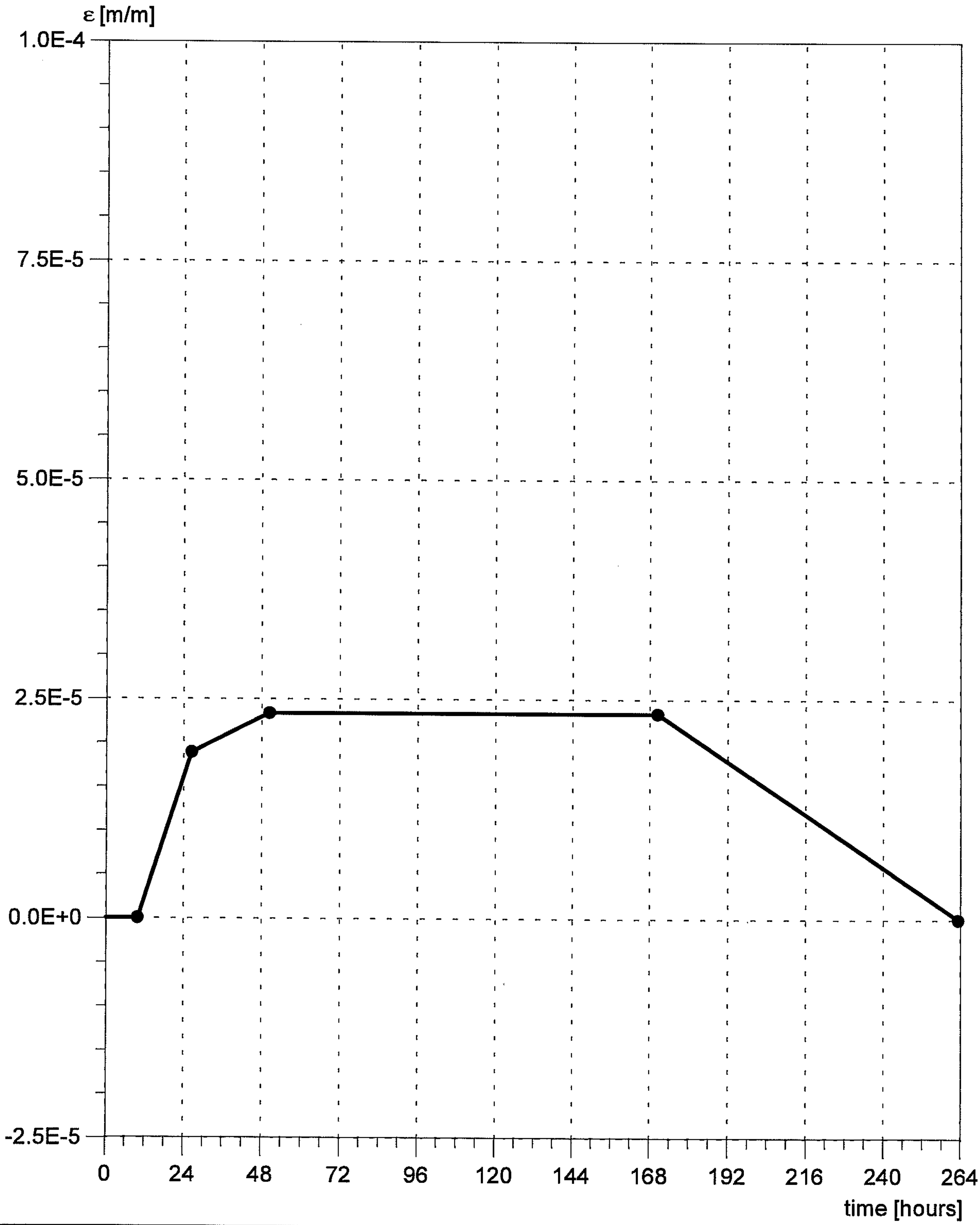


Thermal deformation based on measured temperature is calculated as

$\varepsilon = 0.9E\text{-}5 \cdot \Delta T_{measured}$

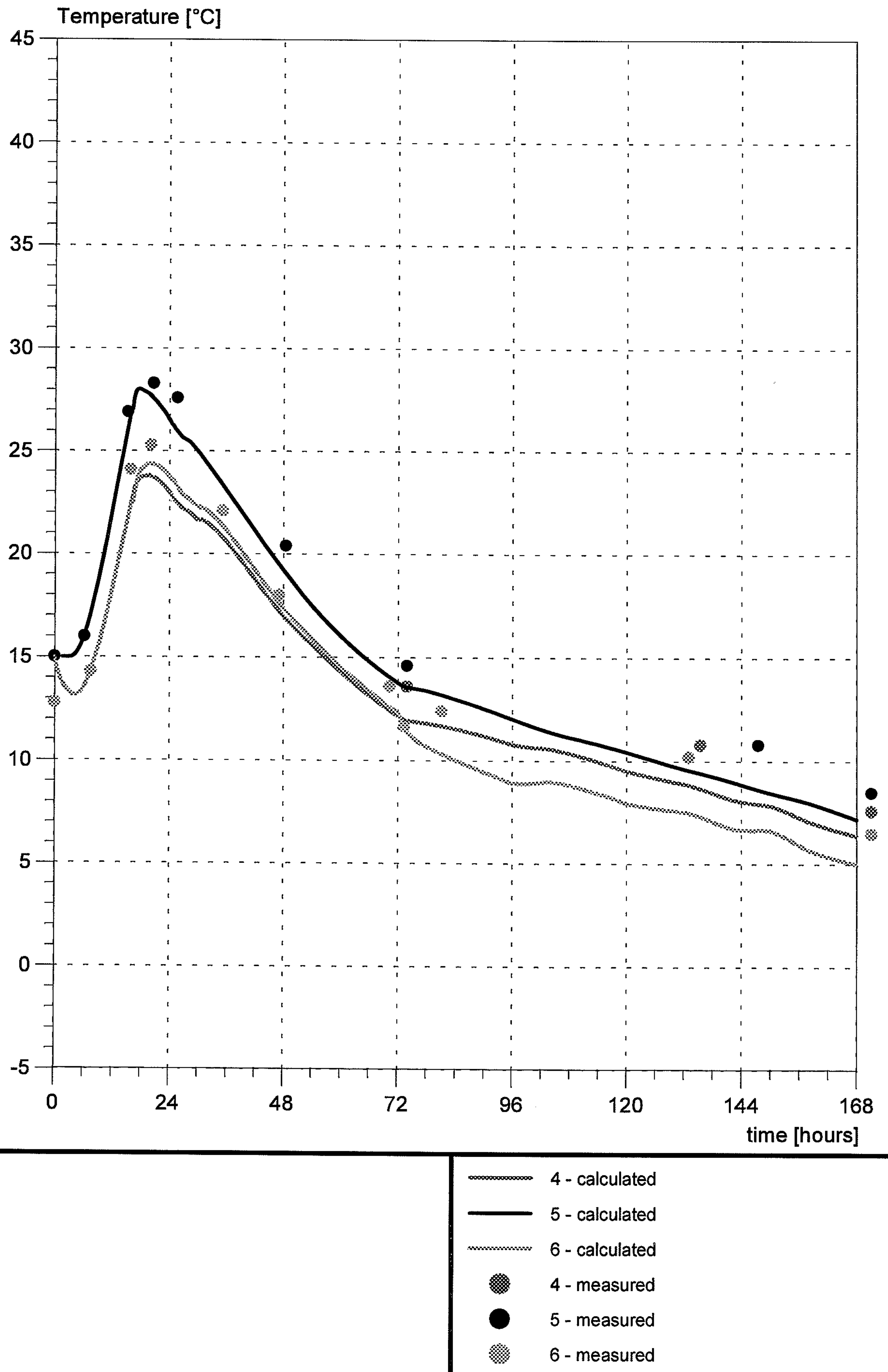
● corresponding to measured mean temp.

—— strain used in calculation

DTI Building Technology Gregersensvej, 2630 Taastrup	Project A - section 5 Temperatures No. 4-6

Client: HETEK 3 + 4
Name: Phase 9

Ref.: 53461 Init.:
Date: 04/21/97



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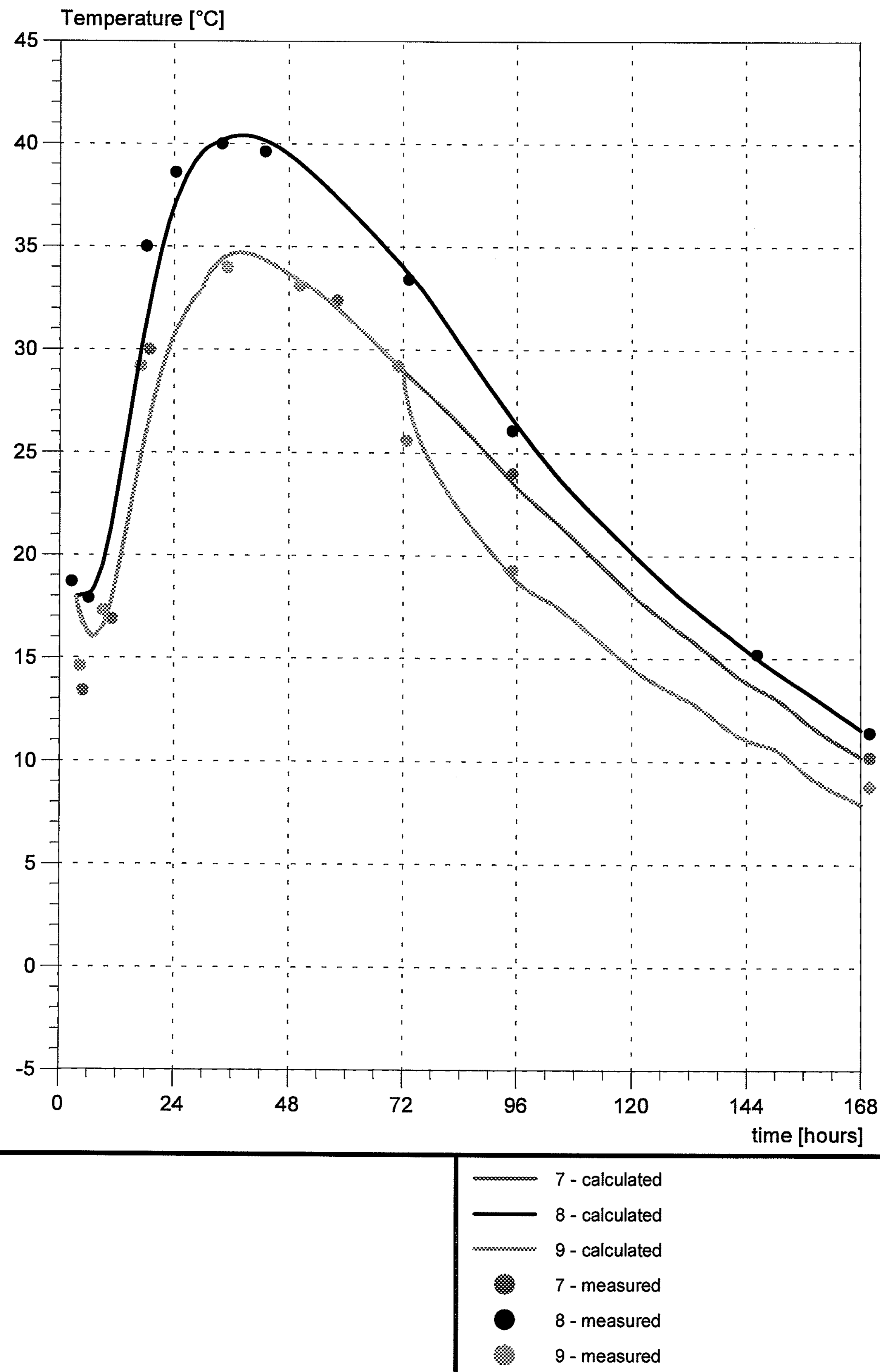

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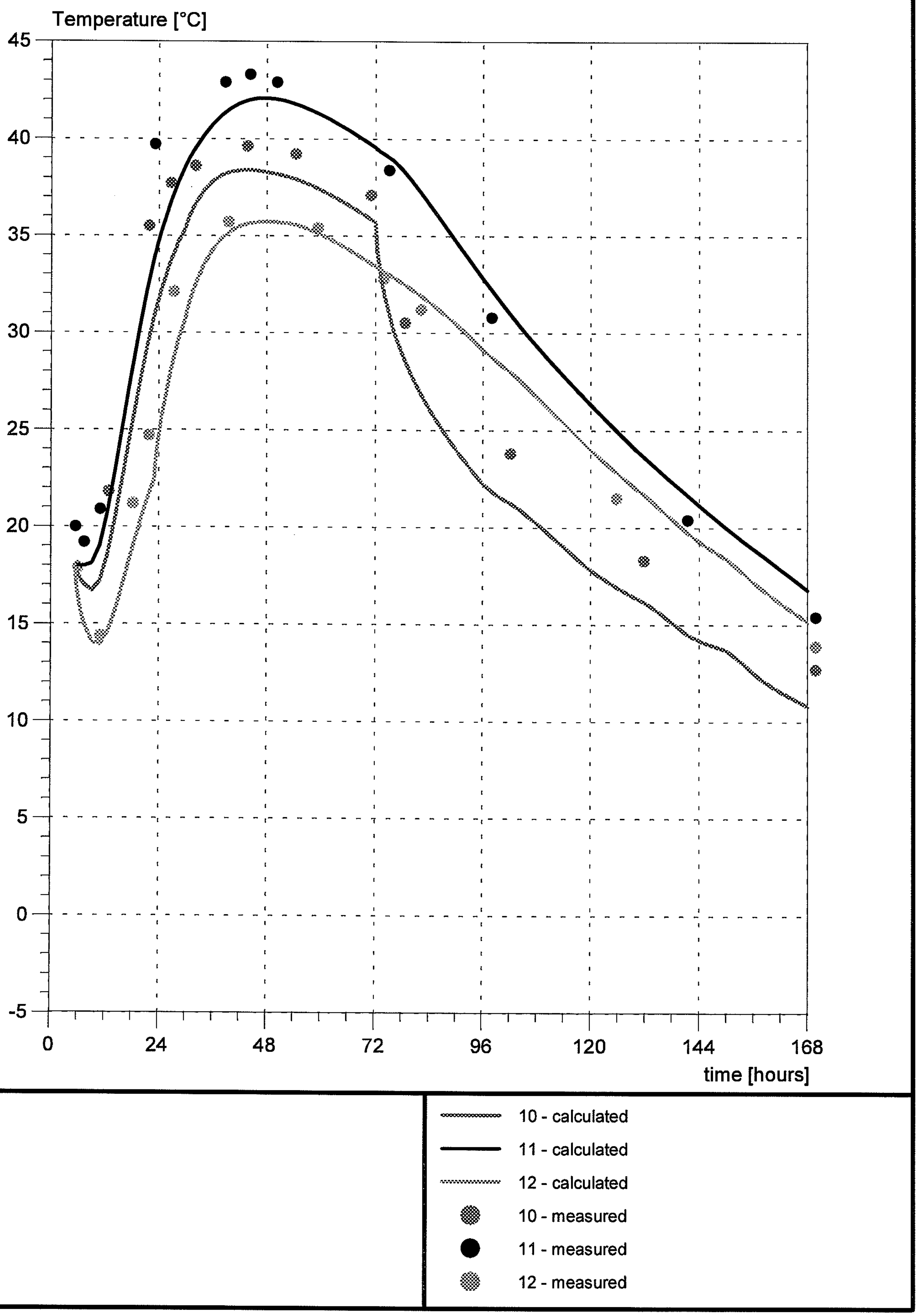

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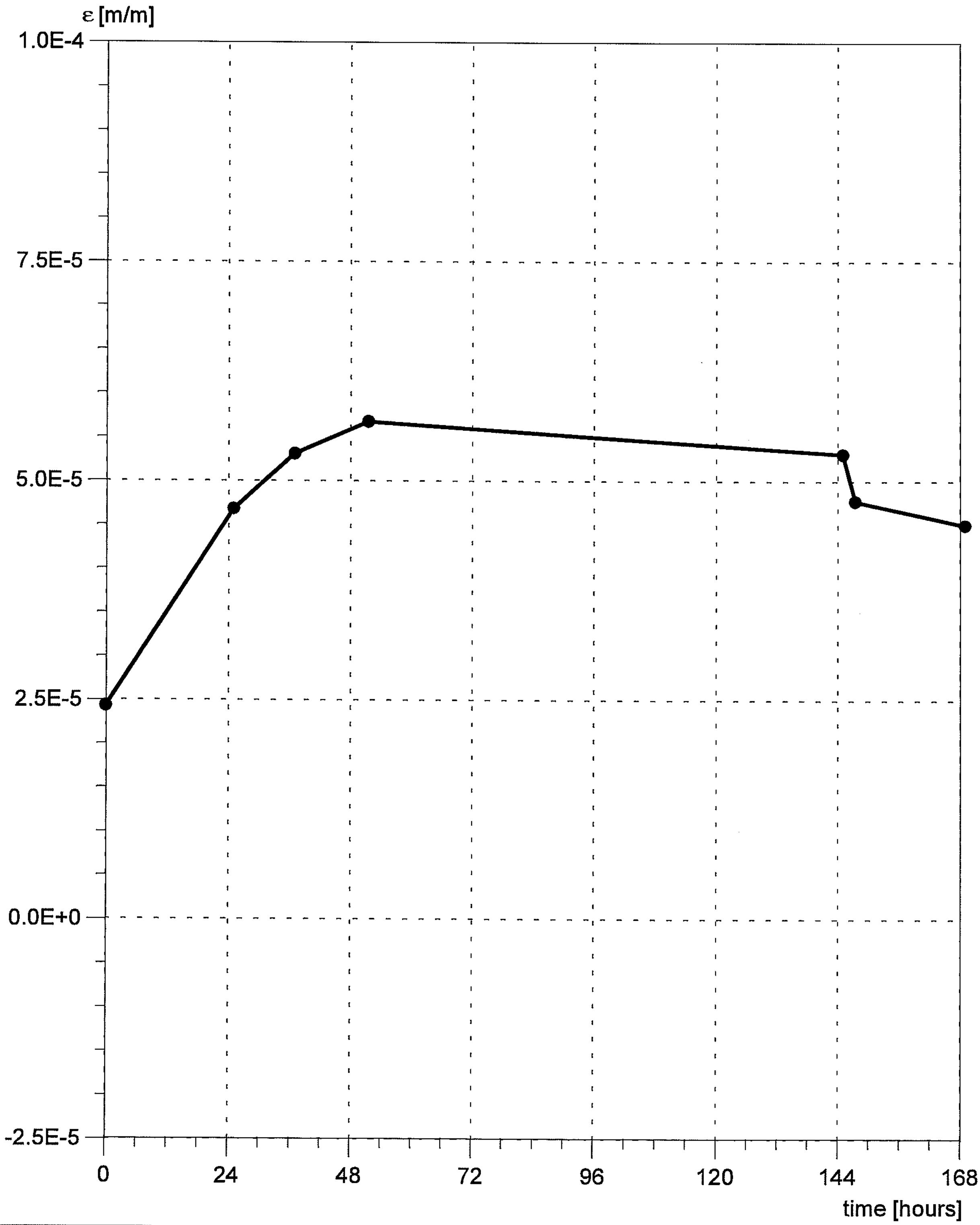

Thermal deformation based on measured temperature is calculated as

$\varepsilon = 0.9E\text{-}5 \cdot \Delta T_{measured}$

—●— corresponding to measured mean temp.

DTI Building Technology Gregersensvej, 2630 Taastrup	Project A - section 6 Temperatures No. 4-6

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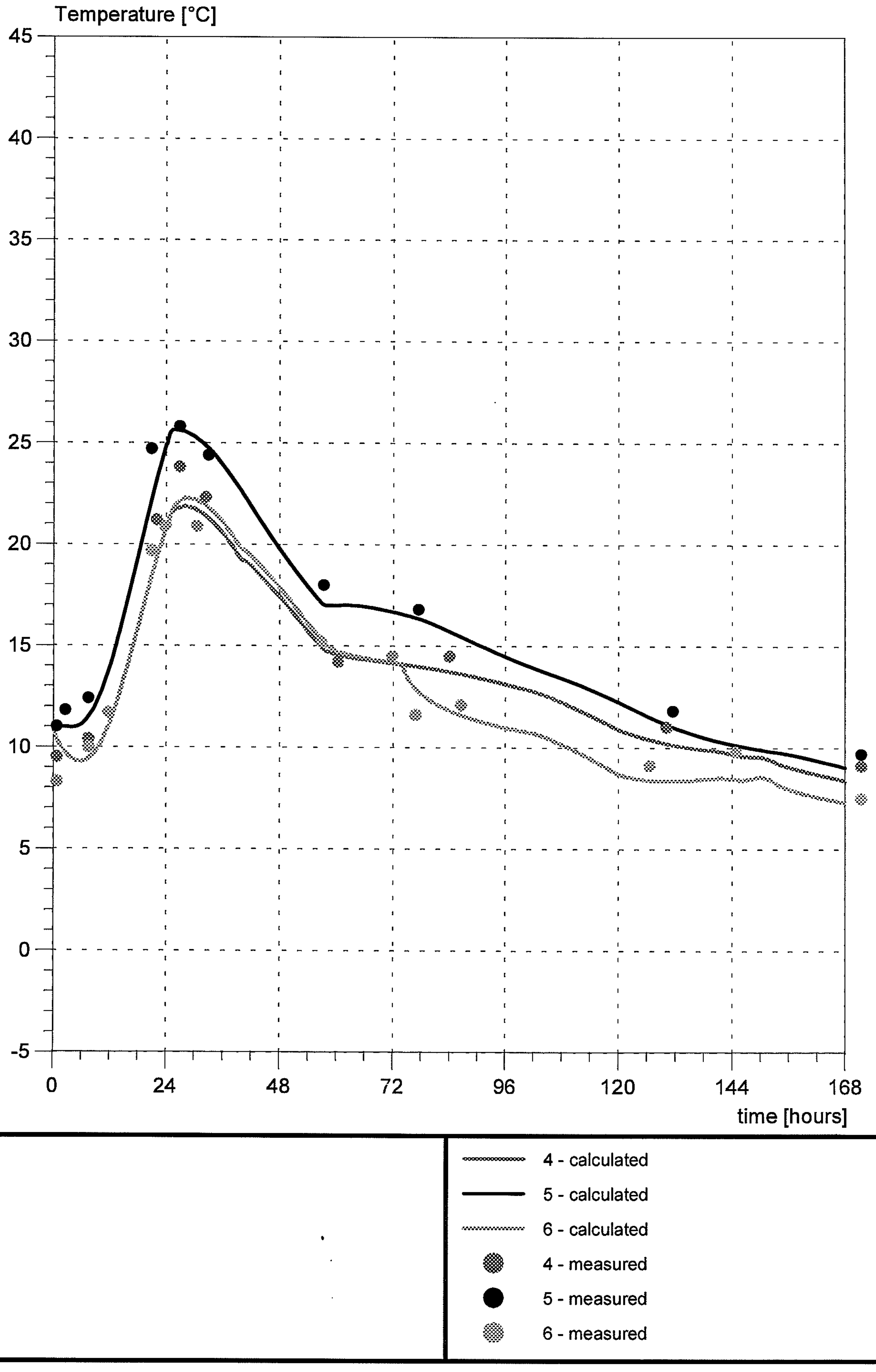
Name: Phase 9	Date: 04/22/97	



DTI Building Technology Gregersensvej, 2630 Taastrup	Project A - section 6 Temperatures No. 7-9

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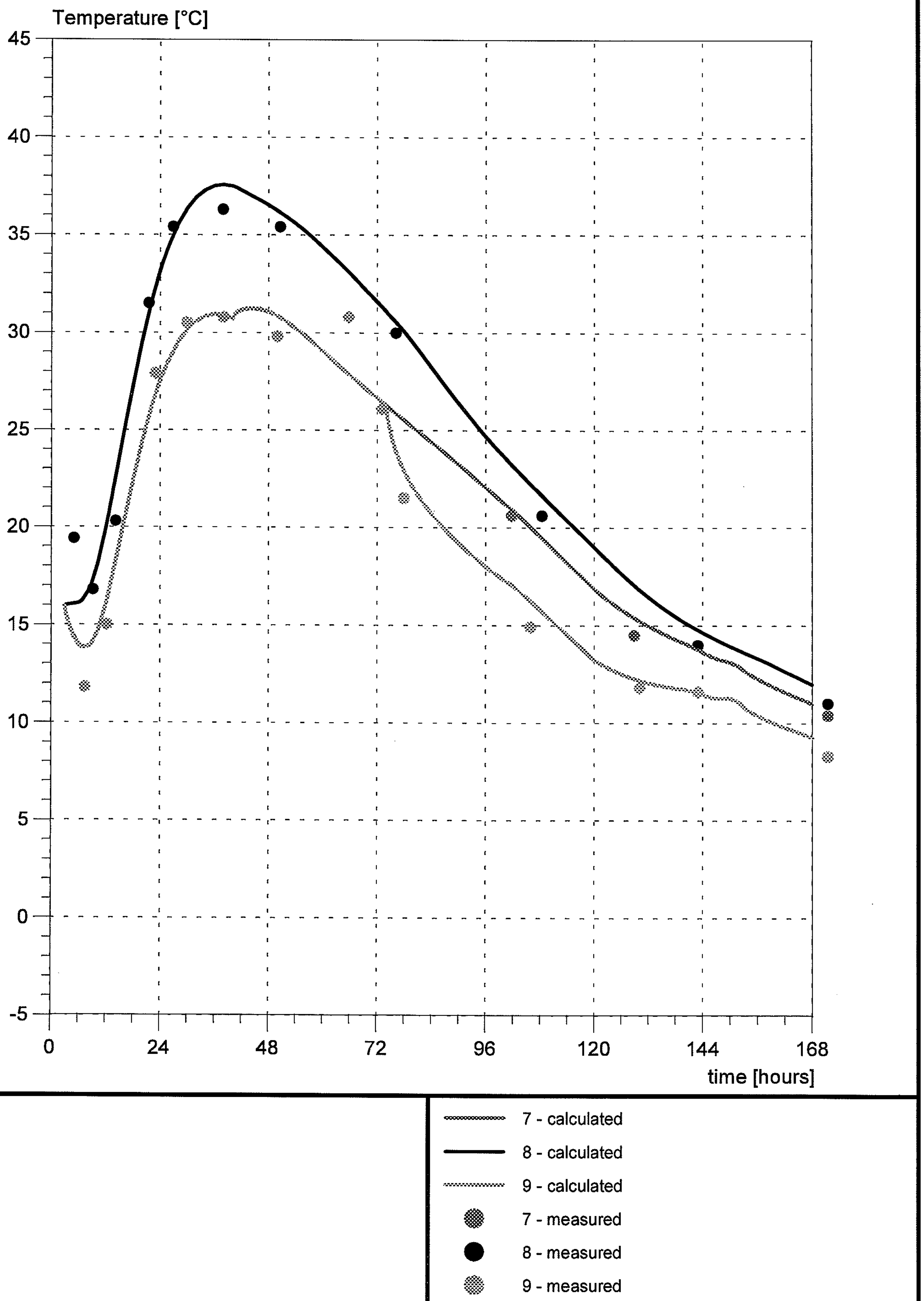
Name: Phase 9

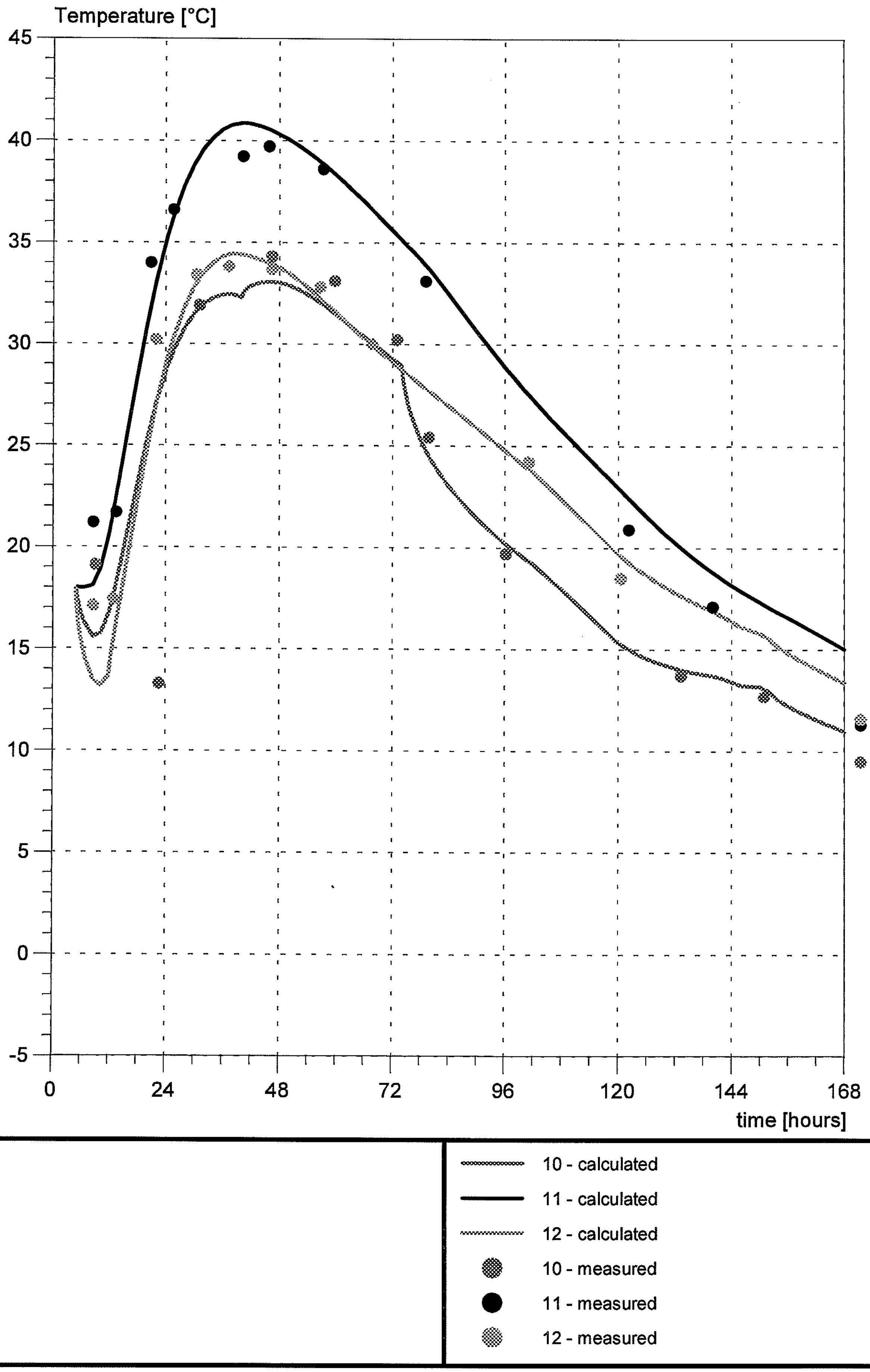
Ref.: 53461
Date: 04/22/97
Init.:



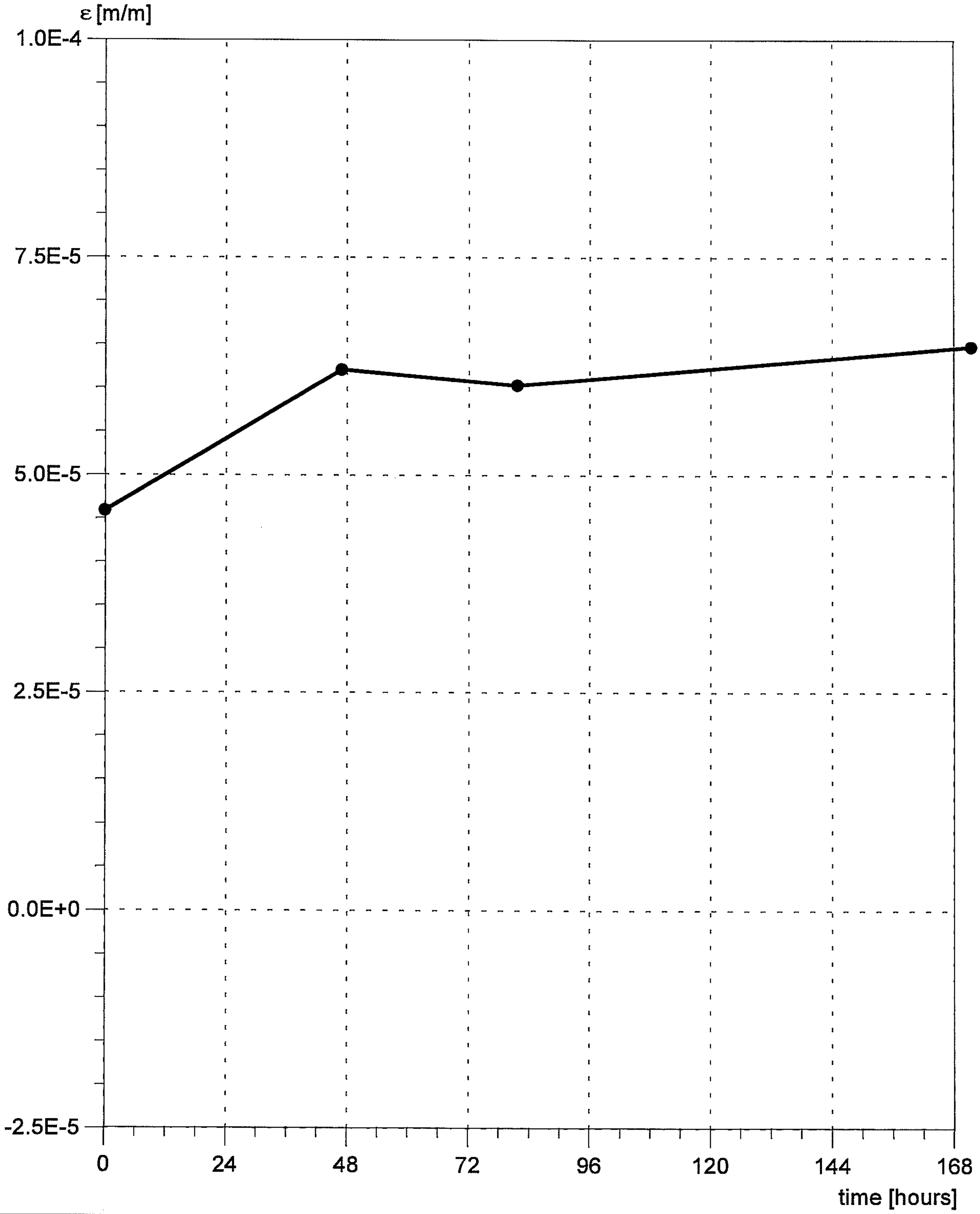
DTI Building Technology Gregersensvej, 2630 Taastrup	**Project A - section 6** Temperatures No. 10-12

Client: HETEK 3 + 4 Ref.: 53461 Init.:

Name: Phase 9 Date: 04/22/97



DTI Building Technology Gregersensvej, 2630 Taastrup	Project A - section 6 Thermal deformations in foundation
Client: HETEK 3 + 4 Name: Phase 9	Ref.: 53461 Init.: Date: 04/22/97



Thermal deformation based on measured temperature is calculated as

$\varepsilon = 0.9E\text{-}5 \cdot \Delta T_{measured}$

corresponding to measured mean temp.

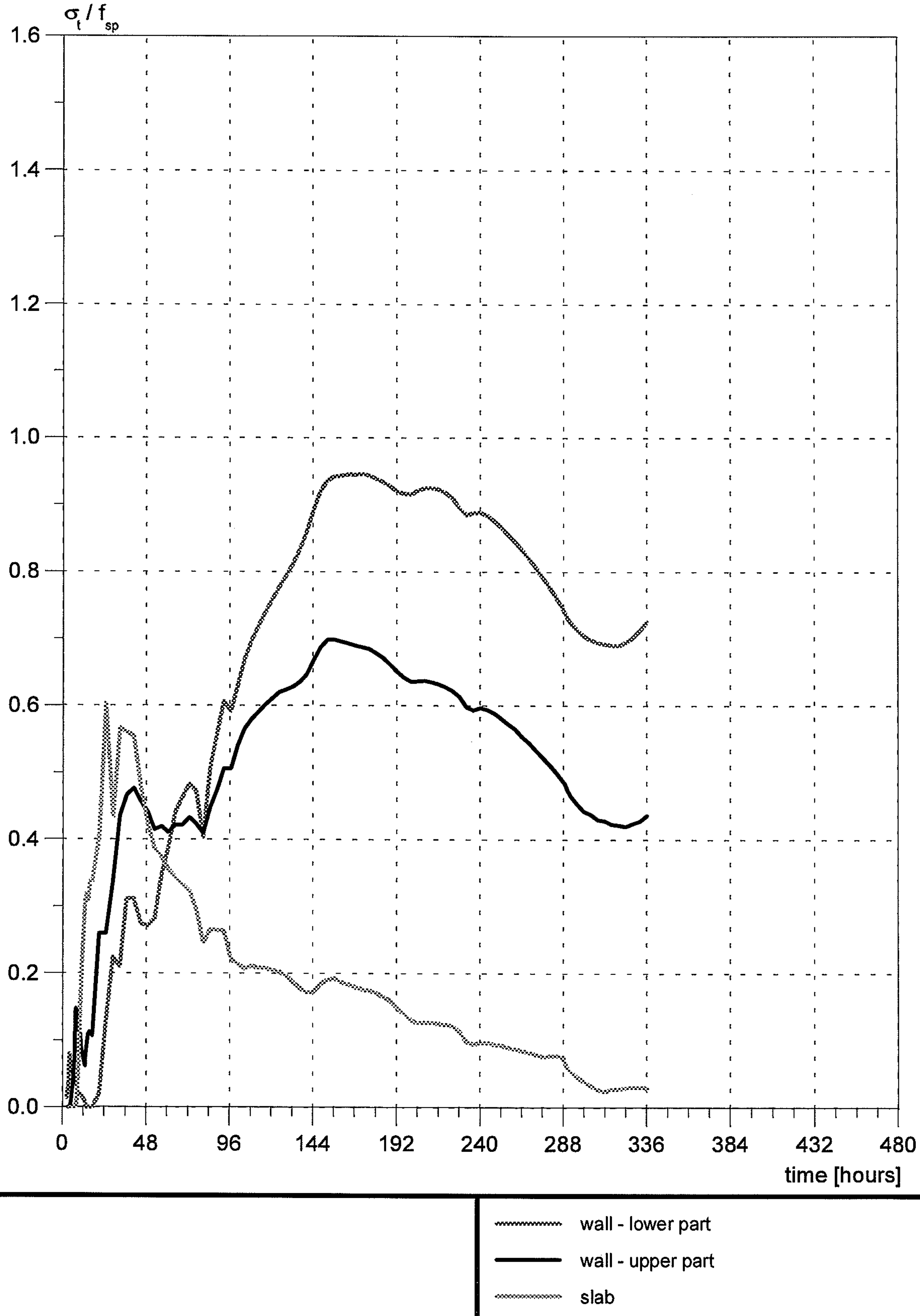
Appendix III

Splitting tensile strength utilization

DTI Building Technology Gregersensvej, 2630 Taastrup	Project A - section 1 maximum utilization

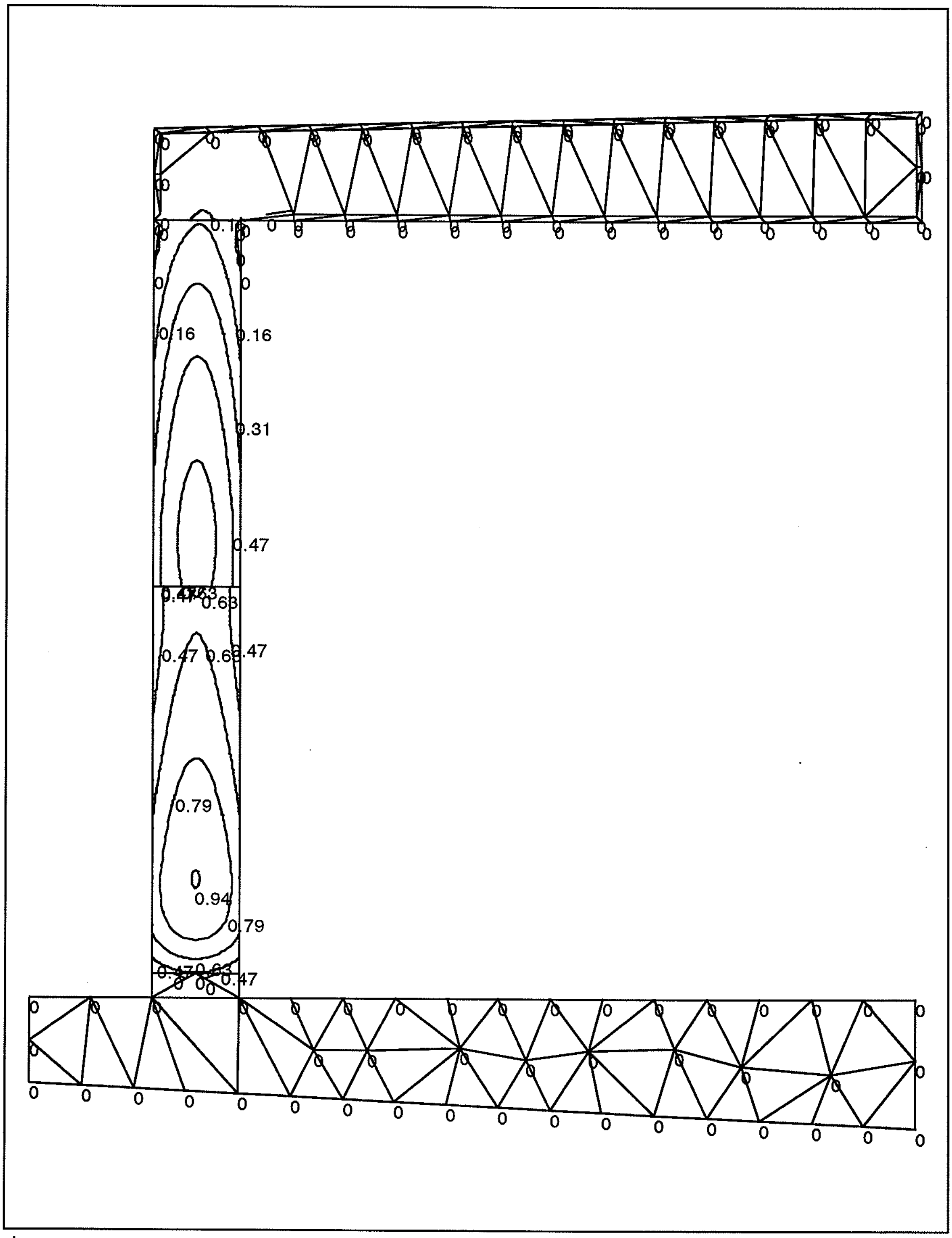
Client: HETEK 3 + 4
Name: Phase 9

Ref.: 53461
Date: 04/17/97
Init.:



DTI Building Technology Gregersensvej, DK 2630 Taastrup		CALCULATION RESULTS Documentation sheet	
Client:	Ref. nr.:	Project: proj-a-1	Date: 23-04-97
Name:	Initials :	Id. nr. : VE-AA1367	Time: 13.22

Stress App. Analysis



DATA:

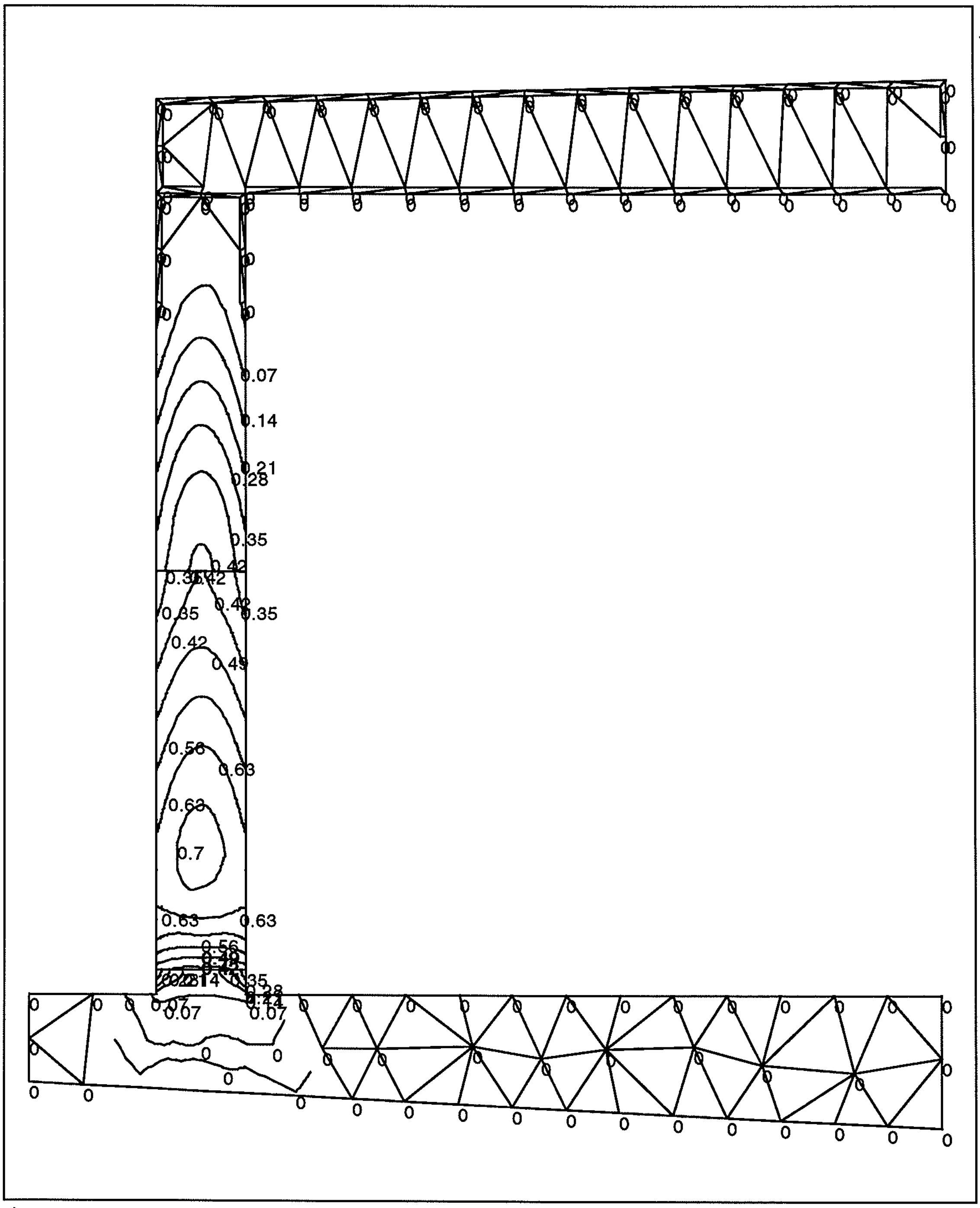
Time	168.00
Min	0.00
Max	0.94

Isocurve
Main tensile stress / tensile strength ratio

DTI Building Technology Gregersensvej, DK 2630 Taastrup	CALCULATION RESULTS Documentation sheet

Client:	Ref. nr.:	Project: proj-a-1	Date: 17-04-97
Name:	Initials :	Id. nr. : VE-AA1367	Time: 10.04

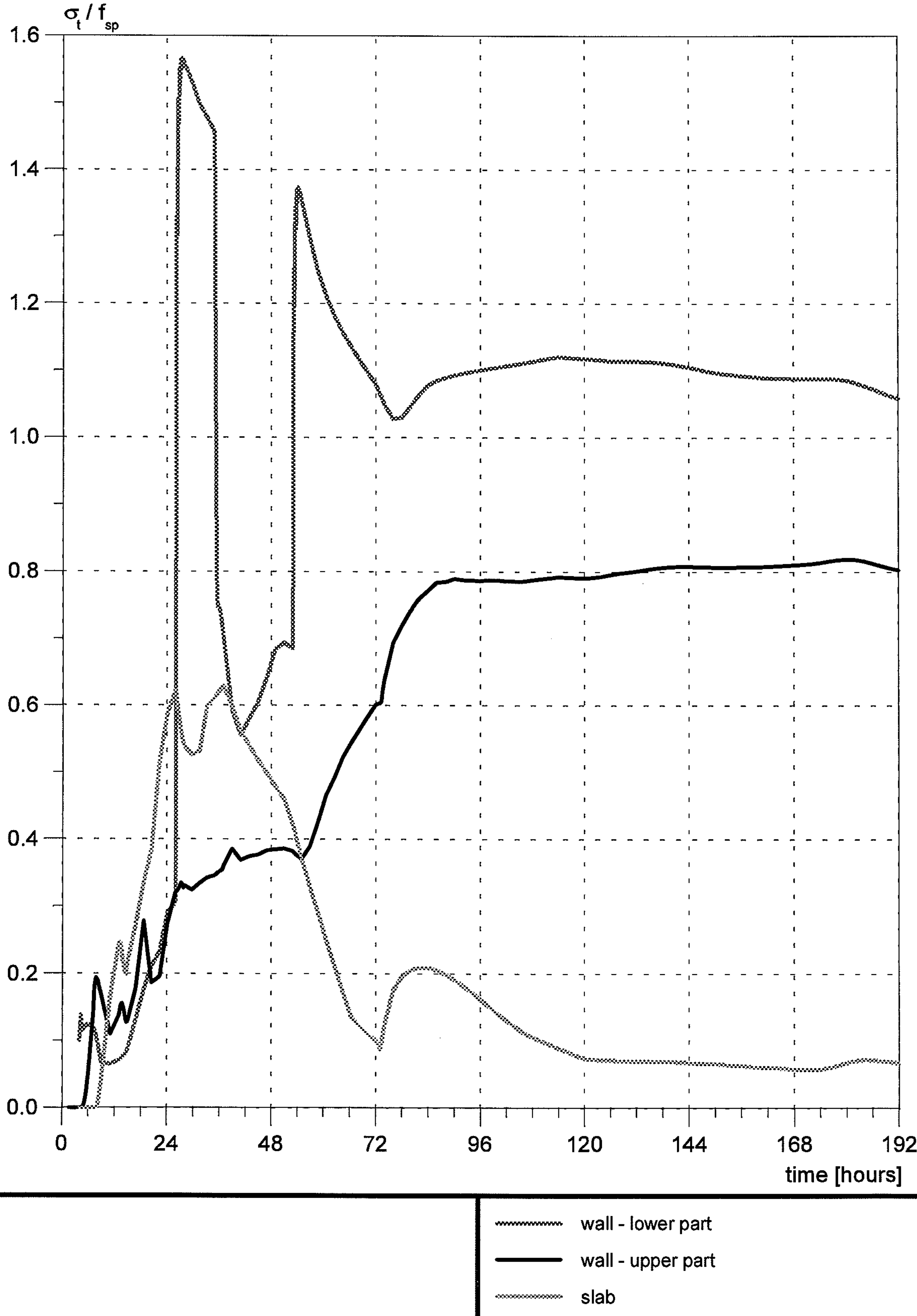
Stress Approximation Analysis



DATA:
Time 336.00
Min 0.00
Max 0.72

Isocurve
Main tensile stress / tensile strength ratio

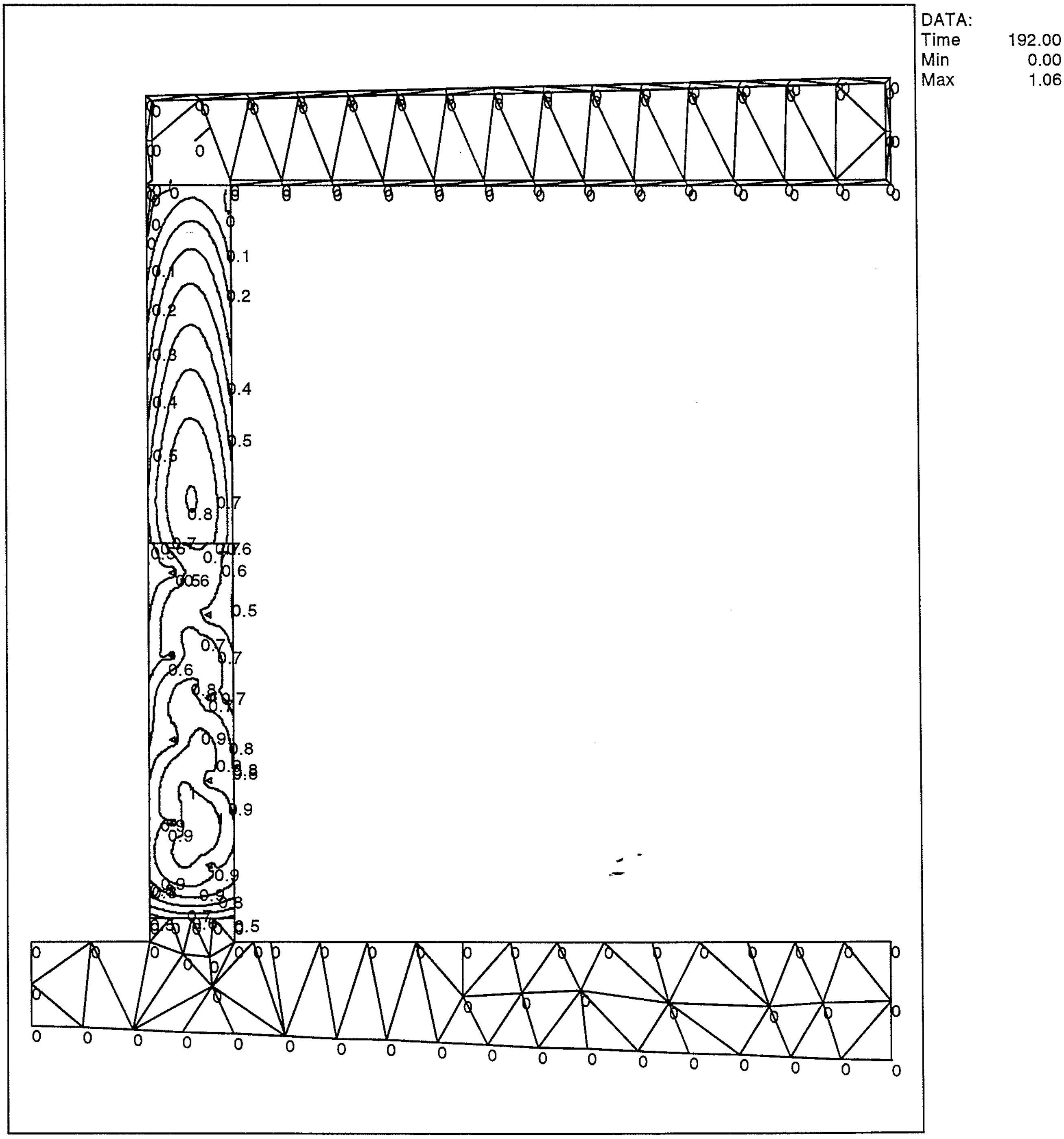
DTI Building Technology Gregersensvej, 2630 Taastrup	Project A - section 2 maximum utilization
Client: HETEK 3 + 4 Name: Phase 9	Ref.: 53461 Init.: Date: 04/17/97



DTI Building Technology	CALCULATION RESULTS
Gregersensvej, DK 2630 Taastrup	Documentation sheet

Client:	Ref. nr.:	Project: proj-a-2	Date: 17-04-97
Name:	Initials :	Id. nr. : VE-AA1490	Time: 10.04

Stress Approximation Analysis



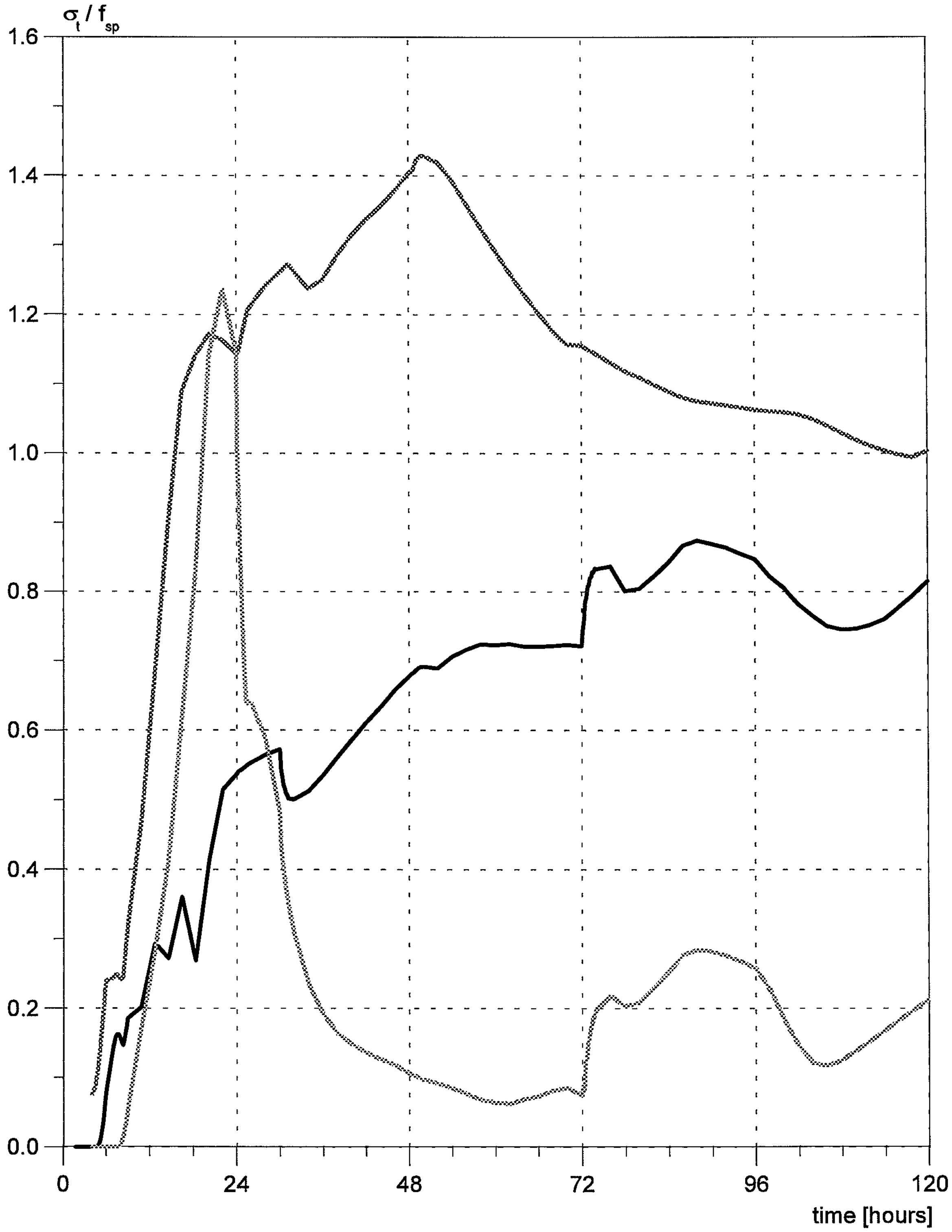
Isocurve
Main tensile stress / tensile strength ratio

DTI Building Technology
Gregersensvej, 2630 Taastrup

Project A - section 3
maximum utilization

Client: HETEK 3 + 4
Name: Phase 9

Ref.: 53461
Date: 04/17/97
Init.:

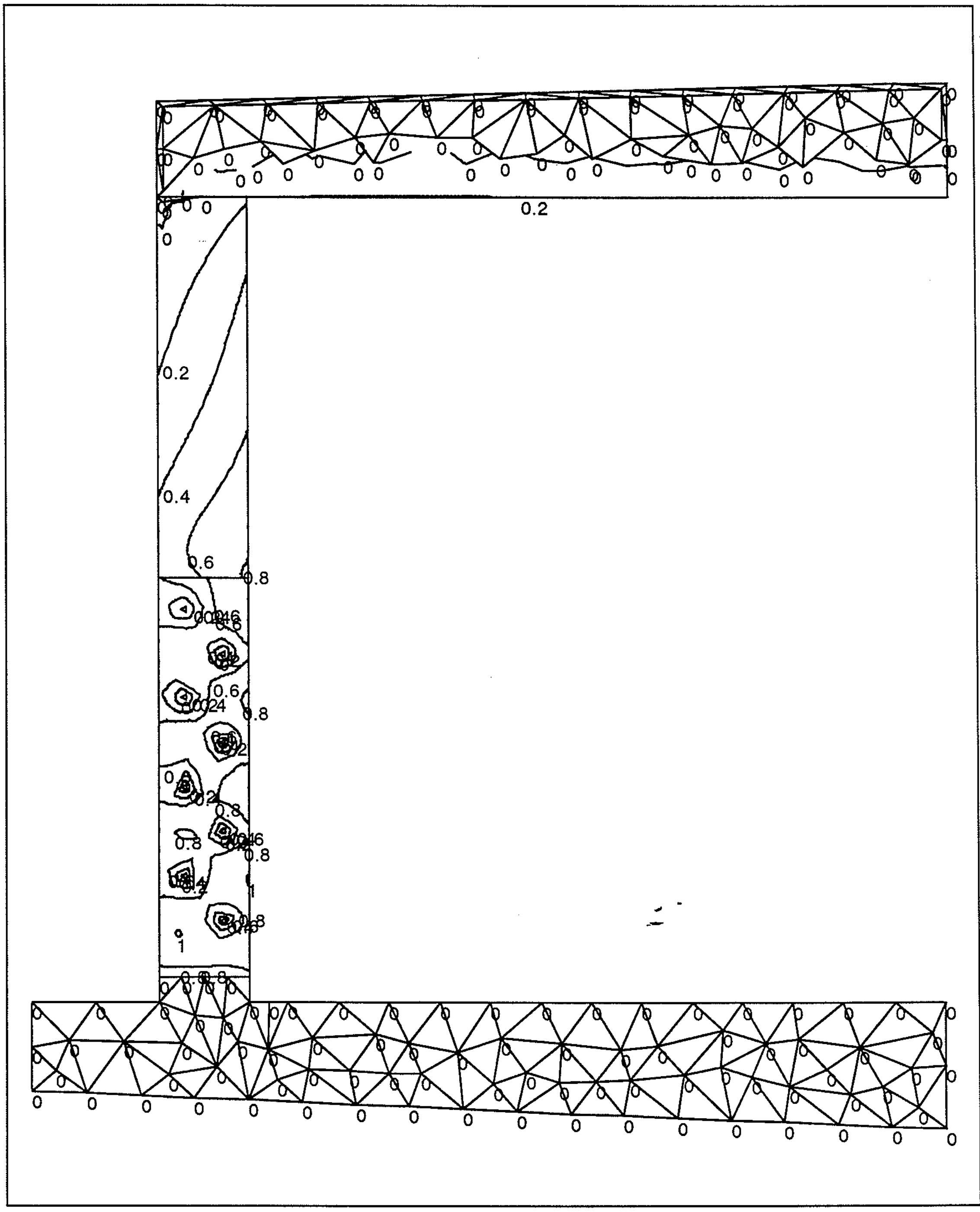


wall - lower part
wall - upper part
slab

DTI Building Technology Gregersensvej, DK 2630 Taastrup	CALCULATION RESULTS Documentation sheet

Client:	Ref. nr.:	Project: proj-a-3	Date: 17-04-97
Name:	Initials :	Id. nr. : VE-AA1449	Time: 10.05

Stress Approximation Analysis

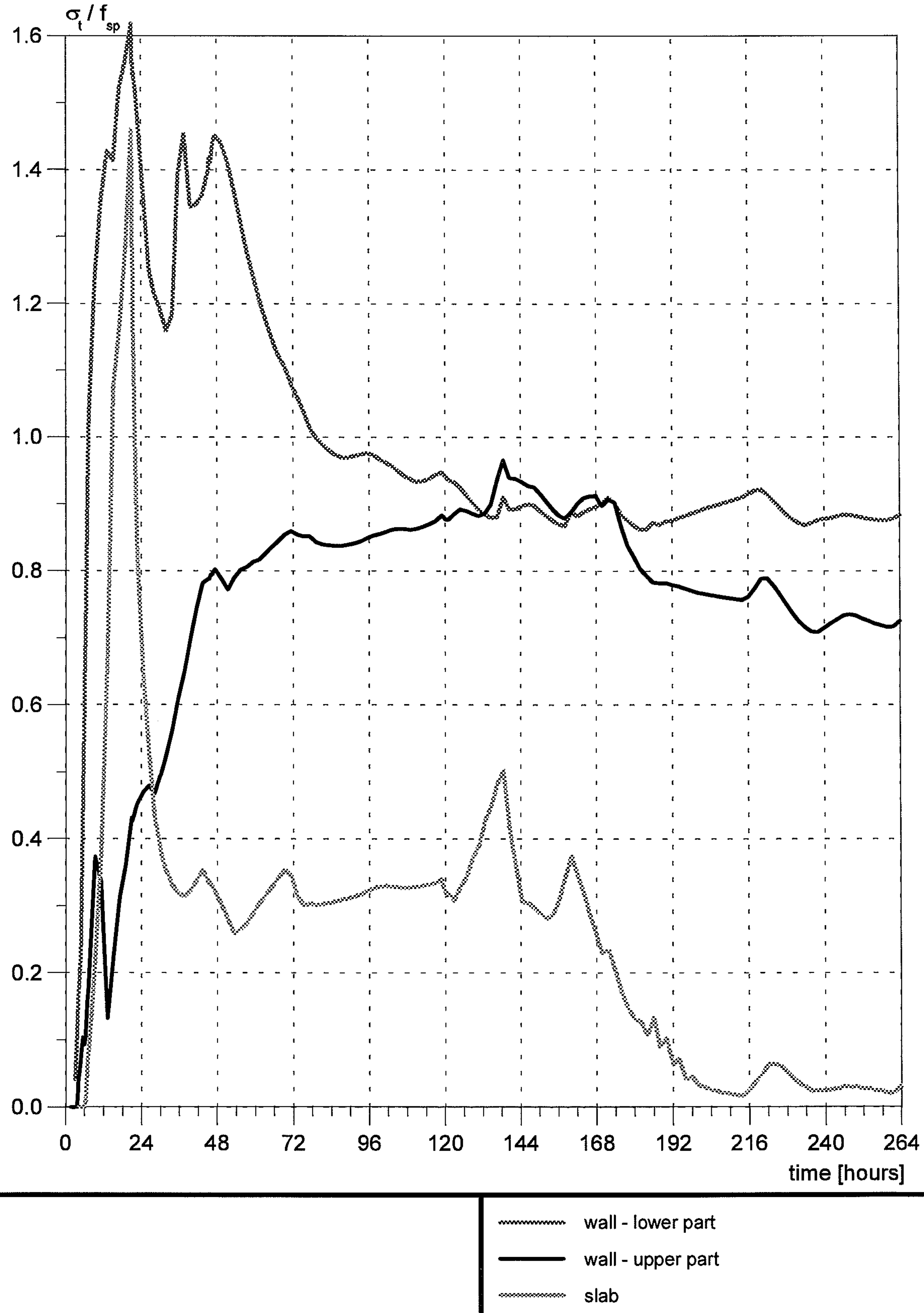


DATA:
Time 120.00
Min 0.00
Max 1.00

Isocurve
Main tensile stress / tensile strength ratio

DTI Building Technology Gregersensvej, 2630 Taastrup	Project A - section 4 maximum utilization

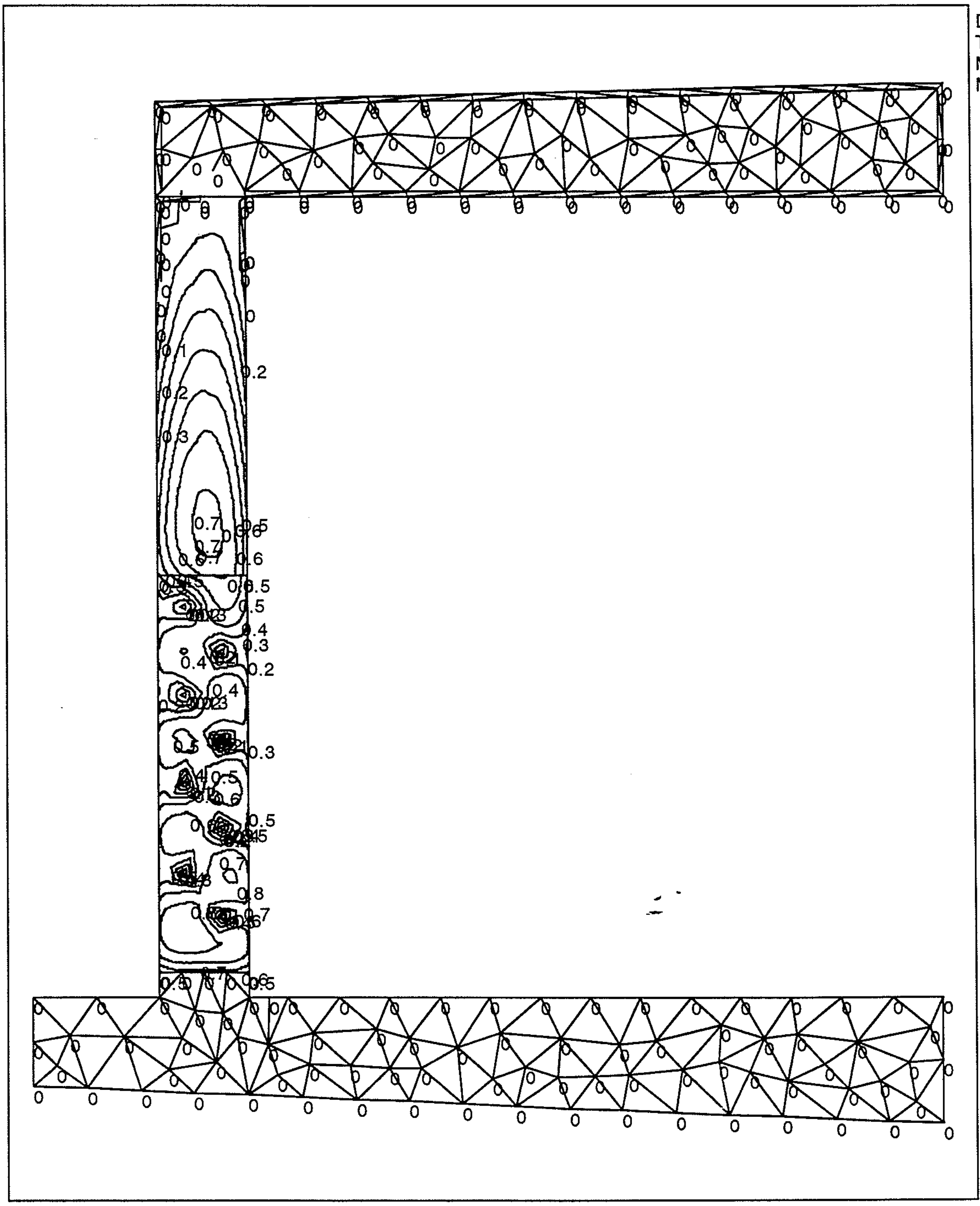
Client: HETEK 3 + 4	Ref.: 53461	Init.:
Name: Phase 9	Date: 04/17/97	



DTI Building Technology Gregersensvej, DK 2630 Taastrup	CALCULATION RESULTS Documentation sheet

Client:	Ref. nr.:	Project: proj-a-4	Date: 17-04-97
Name:	Initials :	Id. nr. : VE-AA1475	Time: 10.07

Stress Approximation Analysis

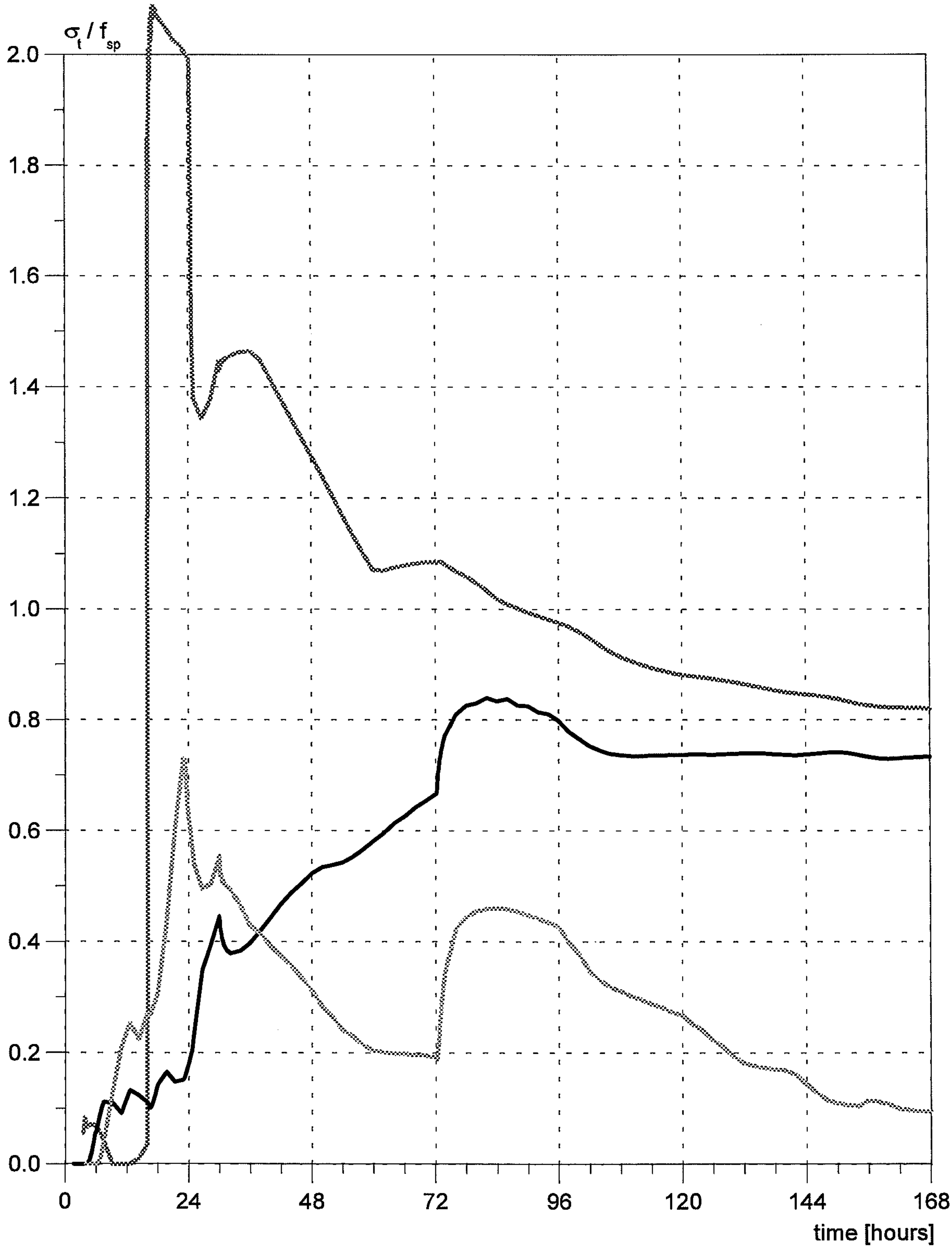


DATA:	
Time	264.00
Min	0.00
Max	0.88

Isocurve
Main tensile stress / tensile strength ratio

DTI Building Technology Gregersensvej, 2630 Taastrup	Project A - section 5 maximum utilization

Client: HETEK 3 + 4	Ref.: 53461	Init.:
Name: Phase 9	Date: 04/21/97	

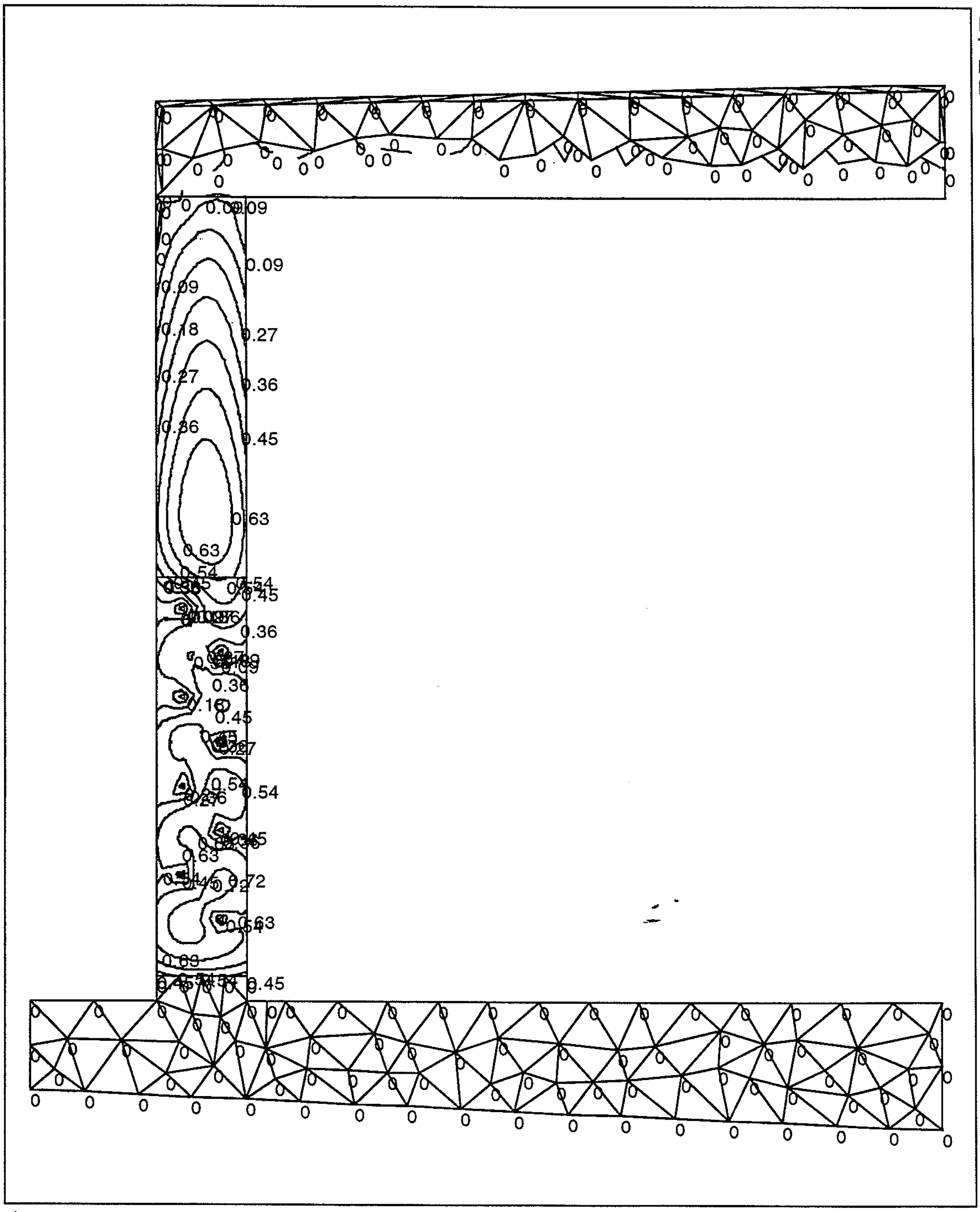


wall - lower part
wall - upper part
slab

DTI Building Technology Gregersensvej, DK 2630 Taastrup	CALCULATION RESULTS Documentation sheet

Client:	Ref. nr.:	Project: proj-a-5	Date: 21-04-97
Name:	Initials :	Id. nr. : VE-AA1540	Time: 15.03

Stress Approximation Analysis

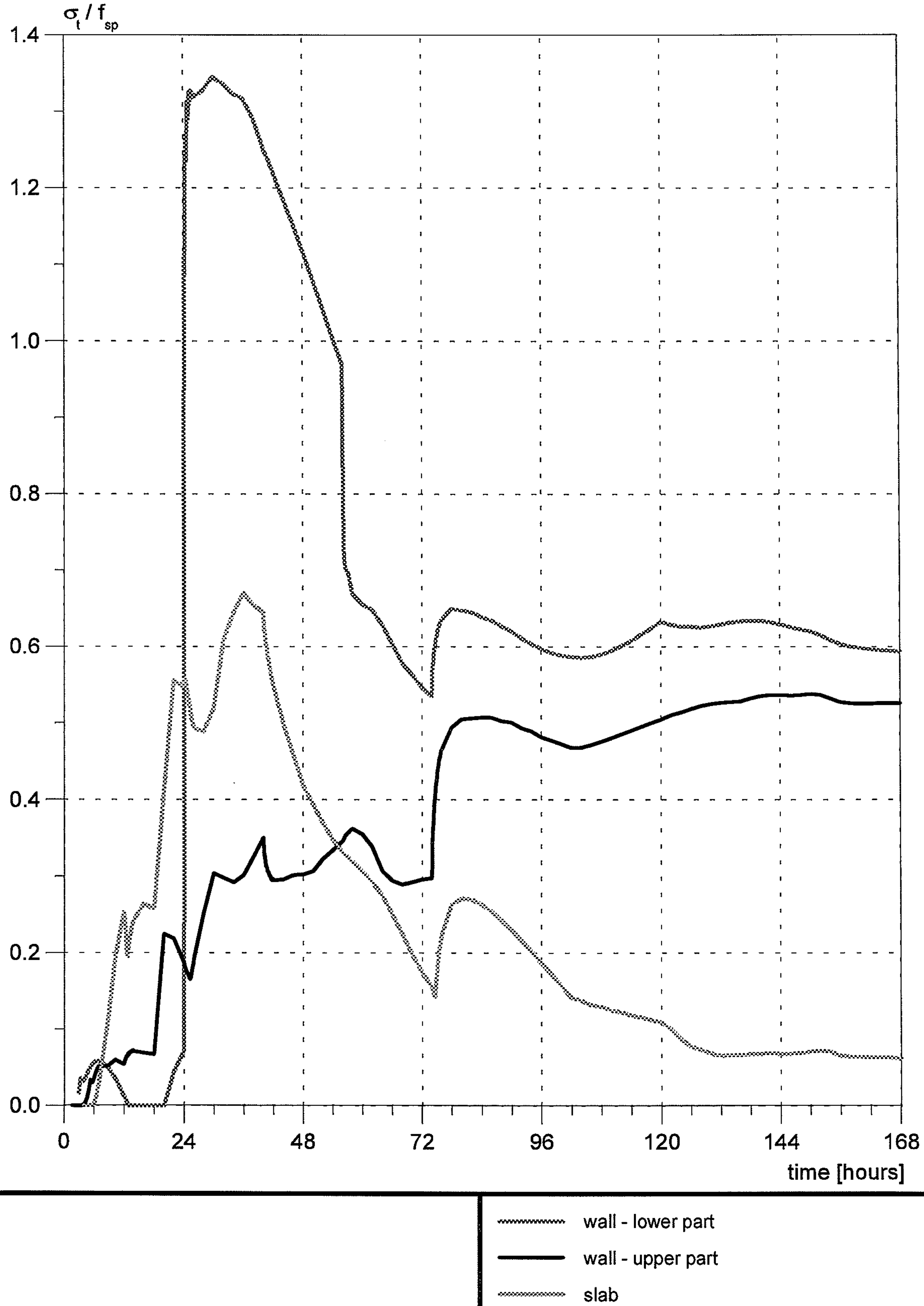


DATA:	
Time	168.00
Min	0.00
Max	0.76

Isocurve
Main tensile stress / tensile strength ratio

DTI Building Technology Gregersensvej, 2630 Taastrup	Project A - section 6 maximum utilization

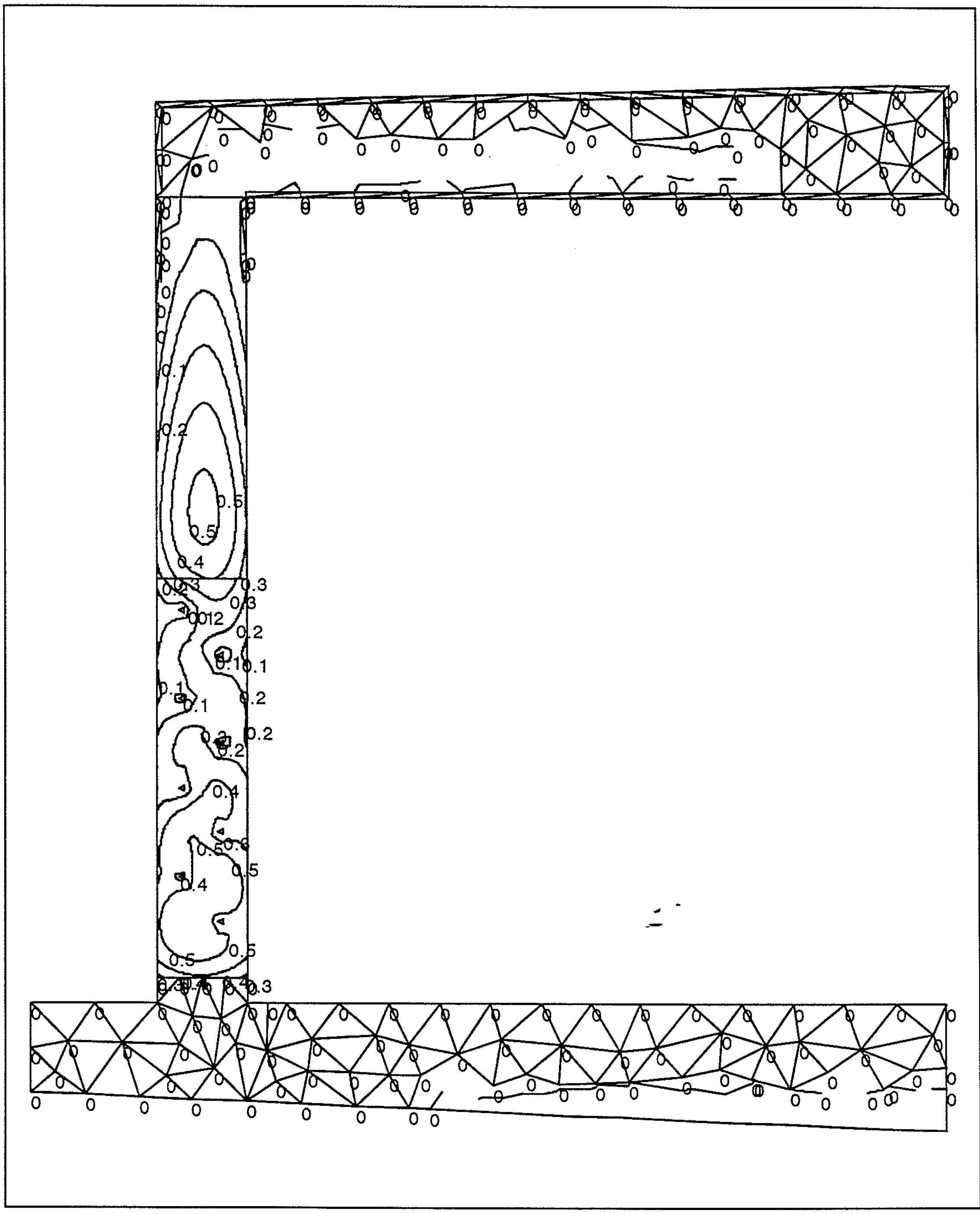
Client: HETEK 3 + 4	Ref.: 53461	Init.:
Name: Phase 9	Date: 04/22/97	



DTI Building Technology Gregersensvej, DK 2630 Taastrup	CALCULATION RESULTS Documentation sheet

Client:	Ref. nr.:	Project: proj-a-6	Date: 22-04-97
Name:	Initials :	Id. nr. : VE-AA1565	Time: 13.14

Stress Approximation Analysis



DATA:

Time	168.00
Min	0.00
Max	0.59
Tunnelbund	
Min	0.00
Max	0.03
Tunnel væg	
Min	0.02
Max	0.59
Tunnel dæk	
Min	0.00
Max	0.06
Vtop	
Min	0.00
Max	0.53

Isocurve
Main tensile stress / tensile strength ratio

Appendix IV

Calculation basis

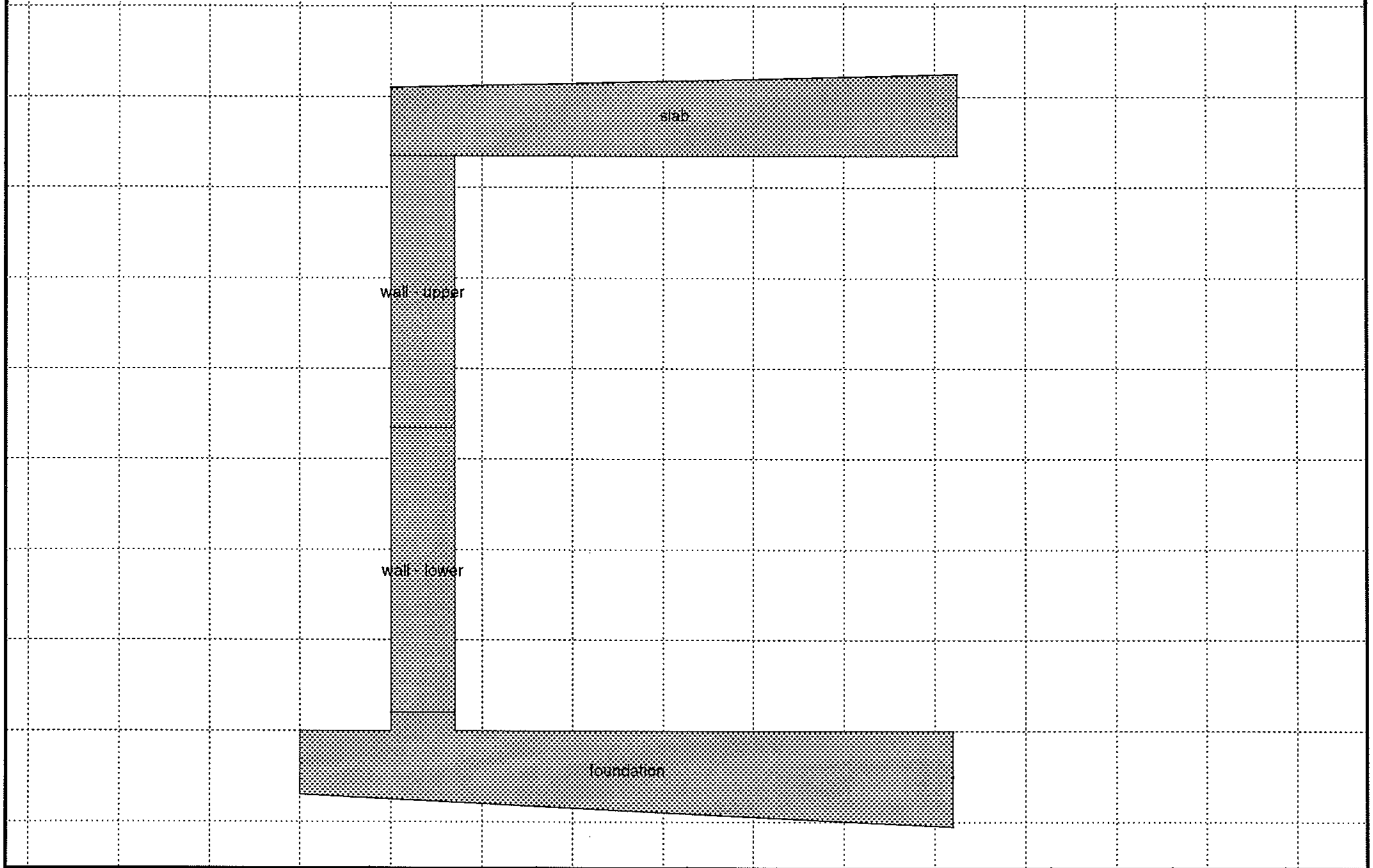
DTI Building Technology	CALCULATION BASIS
Gregersensvej, DK 2630 Taastrup	Documentation sheet

Client:	Ref. nr.:	Project: proj-a-1	Date: 24-04-97
Name:	Initials :	Id. nr. : VE-AA1568	Time: 14.12

Volumes

Scaling mode: mm

Rulers: [1000:1000]



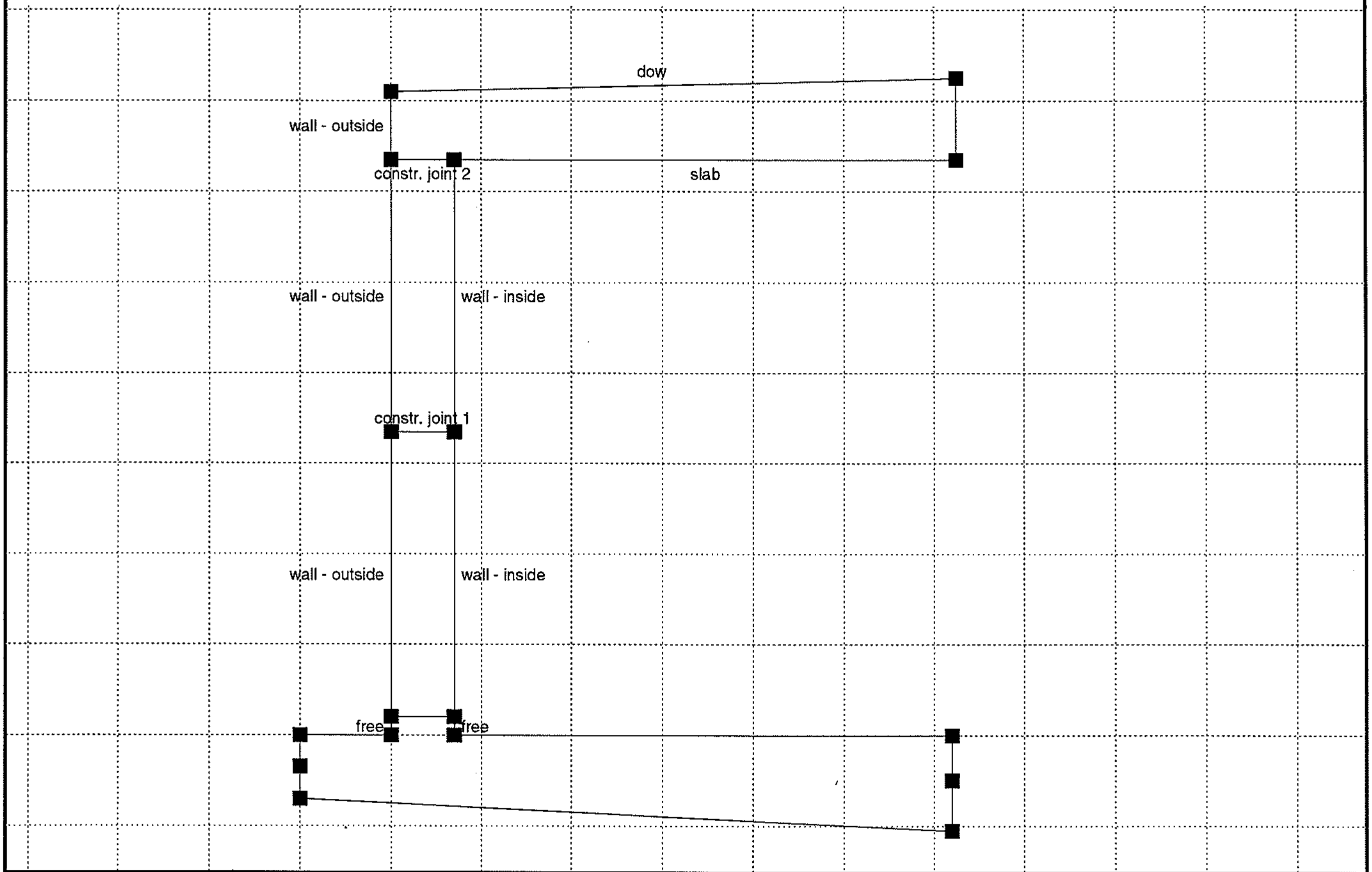
Volume	Size [mm]	Material type [-]	Material name [-]	Thickness [m]	Start time [h]	Temp. [°C]
foundation	7200 by 1250	Concrete	6002AB old shr 1	1.	0.	4.
wall - lower	700 by 3150	Concrete	6002AB wall	1.	0.	12.
slab	6250 by 900	Concrete	6002AB slab	1.	7.	18.
wall - upper	700 by 3000	Concrete	6002AB wall	1.	3.5	16.

DTI Building Technology Gregersensvej, DK 2630 Taastrup	CALCULATION BASIS Documentation sheet

Client:	Ref. nr.:	Project: proj-a-1	Date: 24-04-97
Name:	Initials :	Id. nr. : VE-AA1569	Time: 14.19

Faces

Scaling mode: mm
Rulers: [1000:1000]



Boundary condition	Functions				
	Temperature	Wind velocity	Shield definition	Coef. of transm.	Flux
slab	air temp.	-	-	slab	-
wall - inside	air temp.	-	-	wall - inside	-
wall - outside	air temp.	-	-	wall - outside	none
dow	air temp.	-	-	dow	none
free	air temp.	-	-	free	-
constr. joint 1	air temp.	-	-	constr. joint 1	-
constr. joint 2	air temp.	-	-	constr. joint 2	-

DTI Building Technology Gregersensvej, DK 2630 Taastrup	CALCULATION BASIS Documentation sheet

Client:	Ref. nr.:	Project: proj-a-1	Date: 24-04-97
Name:	Initials :	Id. nr. : VE-AA1569	Time: 14.19

Functions

Name	Type	Describtion	Unit	Function table Time [h] / Value
air temp.	Temperature	Linear curve	[°C]	0. / -2. - 6. / 0.5 - 20. / -2.5 - 28. / 1. - 40. / -0.5 - 51. / 1.5 - 74. / -3. - 78. / -0.5 - 90. / -6.5 - 102. / -1. - 123. / -2. - 138. / -8. - 150. / -2. - 168. / -2. - 174. / -1. - 184. / -1. - 198. / -5. - 222. / -1.5 - 230. / -5.5 - 234. / -4.5 - 240. / -3. - 280. / 0. - 312. / -3. - 336. / -7.5 - 1000. / -7.5
free	Transm. coef.	Piecewise	[kJ/m²/h/°C]	0. / 44. - 672. / 44.
slab	Transm. coef.	Piecewise	[kJ/m²/h/°C]	0. / 13. - 288. / 44. - 1000. / 44.
wall - outside	Transm. coef.	Piecewise	[kJ/m²/h/°C]	0. / 13. - 288. / 44. - 1000. / 44.
wall - inside	Transm. coef.	Piecewise	[kJ/m²/h/°C]	0. / 13. - 288. / 44. - 1000. / 44.
dow	Transm. coef.	Piecewise	[kJ/m²/h/°C]	0. / 44. - 13. / 6. - 624. / 44. - 1000. / 44.
constr. joint 1	Transm. coef.	Piecewise	[kJ/m²/h/°C]	0. / 21.4 - 3.5 / 0. - 1000. / 21.4
constr. joint 2	Transm. coef.	Piecewise	[kJ/m²/h/°C]	0. / 21.4 - 7. / 0. - 1000. / 21.4
none	Flux	Piecewise	[kJ/m²h]	0. / 0. - 1000. / 0.

DTI Building Technology	CALCULATION BASIS
Gregersensvej, DK 2630 Taastrup	Documentation sheet

Client:	Ref. nr.:	Project: proj-a-1	Date: 24-04-97
Name:	Initials :	Id. nr. : VE-AA1569	Time: 14.18

Calculation parameters

Thermal analysis	Transient	Circles	
Stress analysis	Based on thermal results	No. of faces	12
Dimensions			
2½-Dimensional	-	Self weight	
	-	Direction X	-
	No rotation around y-axis	Direction Y	-
Time specifications		Mesh, node generation	
Total process time	372.	Percentage of the largest extend	
Time step, desired	4.	Min. distance to border	2.00
Time step, factor	0.51	Density, internal nodes	5.00
		Density, border nodes	5.00
Nonlinear calculations		Density, around c-pipes	5.00
Convergence criteria	1.000e-03	Radius around c-pipes	20.00

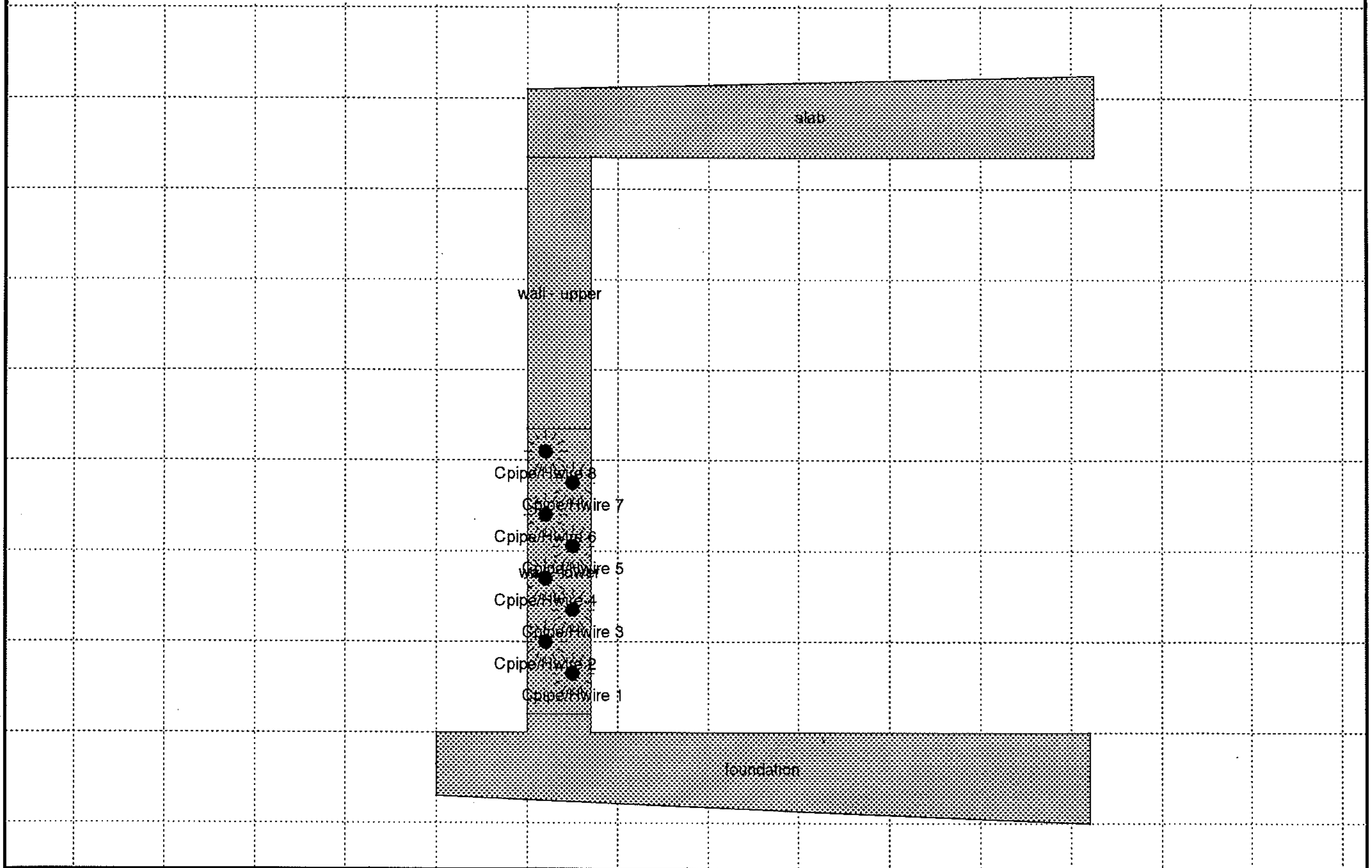
DTI Building Technology	CALCULATION BASIS
Gregersensvej, DK 2630 Taastrup	Documentation sheet

Client:	Ref. nr.:	Project: proj-a-2	Date: 24-04-97
Name:	Initials :	Id. nr. : VE-AA1572	Time: 14.26

Volumes

Scaling mode: mm

Rulers: [1000:1000]



Volume	Size [mm]	Material type [-]	Material name [-]	Thickness [m]	Start time [h]	Temp. [°C]
foundation	7200 by 1200	Concrete	6002AB old shr 2	1.	0.	1.
wall - lower	700 by 3150	Concrete	6002AB wall	1.	0.	16.
slab	6250 by 900	Concrete	6002AB slab	1.	7.	18.
wall - upper	700 by 3000	Concrete	6002AB wall	1.	4.	19.

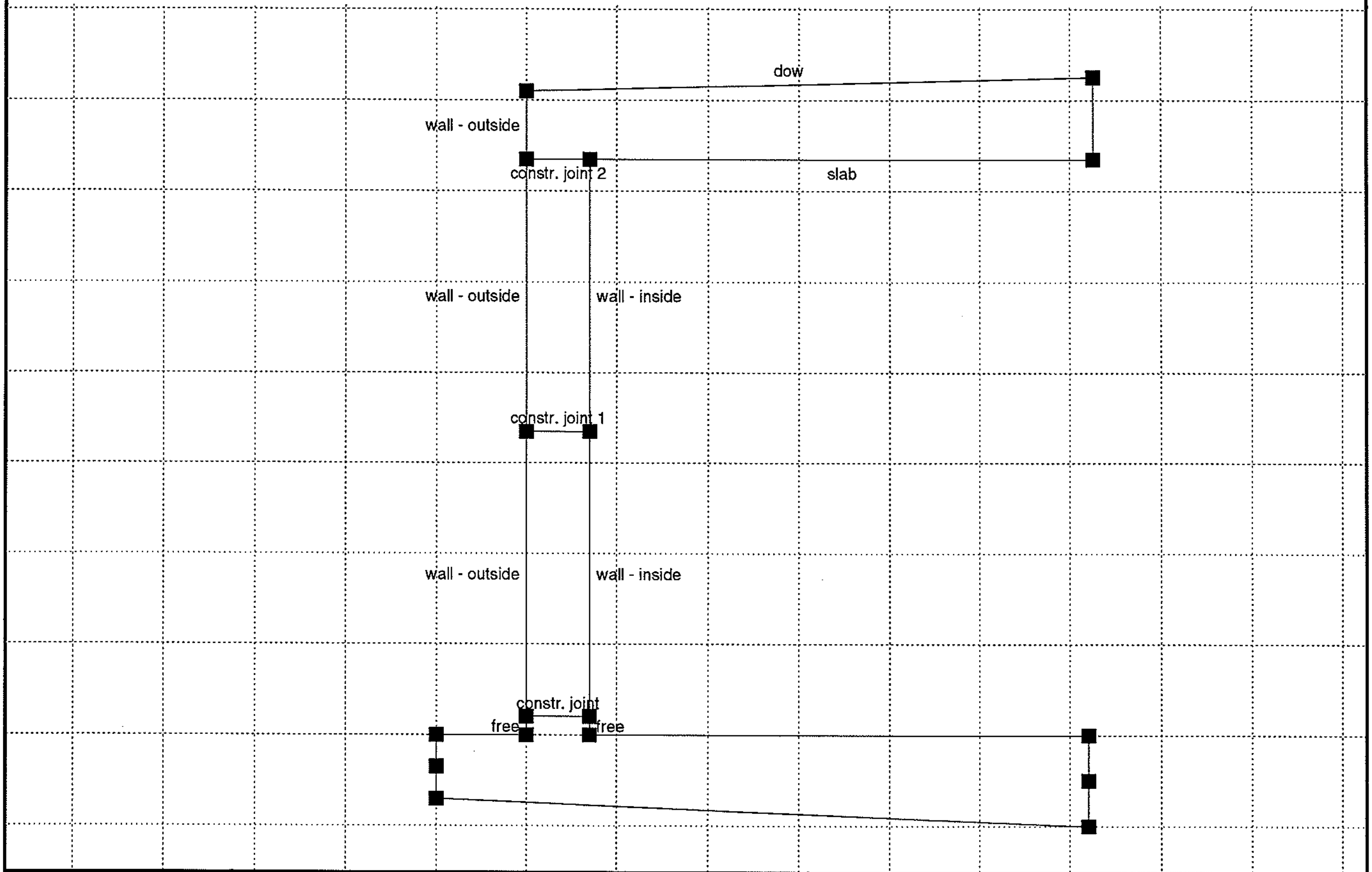
Cooling pipe definition	Diameter m	Faces	-	-	-	-
Cpipe/Hwire 1	0.032	3	-	-	-	-
Cpipe/Hwire 2	0.032	3	-	-	-	-
Cpipe/Hwire 3	0.032	3	-	-	-	-
Cpipe/Hwire 4	0.032	3	-	-	-	-
Cpipe/Hwire 5	0.032	3	-	-	-	-
Cpipe/Hwire 6	0.032	3	-	-	-	-
Cpipe/Hwire 7	0.032	3	-	-	-	-
Cpipe/Hwire 8	0.032	3	-	-	-	-

DTI Building Technology Gregersensvej, DK 2630 Taastrup	CALCULATION BASIS Documentation sheet

Client:	Ref. nr.:	Project: proj-a-2	Date: 24-04-97
Name:	Initials :	Id. nr. : VE-AA1571	Time: 14.25

Faces

Scaling mode: mm
Rulers: [1000:1000]



Boundary condition	Functions				
	Temperature	Wind velocity	Shield definition	Coef. of transm.	Flux
slab	air temp.	-	-	slab	-
wall - inside	air temp.	-	-	wall - inside	-
wall - outside	air temp.	-	-	wall - outside	none
constr. joint	air temp.	-	-	constr. joint	-
dow	air temp.	-	-	dow	none
free	air temp.	-	-	Unprotected	-
constr. joint 1	air temp.	-	-	constr. joint 1	-
constr. joint 2	air temp.	-	-	constr. joint 2	-

DTI Building Technology	CALCULATION BASIS
Gregersensvej, DK 2630 Taastrup	Documentation sheet

Client:	Ref. nr.:	Project: proj-a-2	Date: 24-04-97
Name:	Initials :	Id. nr. : VE-AA1572	Time: 14.26

Functions

Name	Type	Describtion	Unit	Function table Time [h] / Value
PEL	Temperature	Linear curve	[°C]	0. / 14. - 672. / 14.
air temp.	Temperature	Linear curve	[°C]	0. / 0. - 20. / 1. - 40. / 2. - 50. / 0. - 70. / 4. - 80. / 3. - 100. / 2. - 120. / 0. - 140. / 0. - 160. / -3. - 170. / -4. - 180. / -2. - 190. / -4. - 200. / -4.
Unprotected	Transm. coef.	Piecewise	[kJ/m²/h/°C]	0. / 44. - 672. / 44.
slab	Transm. coef.	Piecewise	[kJ/m²/h/°C]	0. / 10. - 72. / 20. - 288. / 20. - 672. / 20.
wall - outside	Transm. coef.	Piecewise	[kJ/m²/h/°C]	0. / 11. - 288. / 20. - 672. / 20.
constr. joint	Transm. coef.	Piecewise	[kJ/m²/h/°C]	0. / 0. - 1000. / 0.
wall - inside	Transm. coef.	Piecewise	[kJ/m²/h/°C]	0. / 11. - 72. / 20. - 288. / 20. - 672. / 20.
dow	Transm. coef.	Piecewise	[kJ/m²/h/°C]	0. / 20. - 13. / 10. - 624. / 20. - 672. / 20.
PEL	Transm. coef.	Piecewise	[kJ/m²/h/°C]	0. / 0. - 26. / 570. - 35. / 0. - 53. / 570. - 80. / 0. - 700. / 0.
constr. joint 1	Transm. coef.	Piecewise	[kJ/m²/h/°C]	0. / 21.4 - 4. / 0. - 1000. / 21.4
constr. joint 2	Transm. coef.	Piecewise	[kJ/m²/h/°C]	0. / 21.4 - 7. / 0. - 1000. / 21.4
none	Flux	Piecewise	[kJ/m²h]	0. / 0. - 672. / 0.

DTI Building Technology	CALCULATION BASIS
Gregersensvej, DK 2630 Taastrup	Documentation sheet

Client:	Ref. nr.:	Project: proj-a-2	Date: 24-04-97
Name:	Initials :	Id. nr. : VE-AA1572	Time: 14.26

Calculation parameters

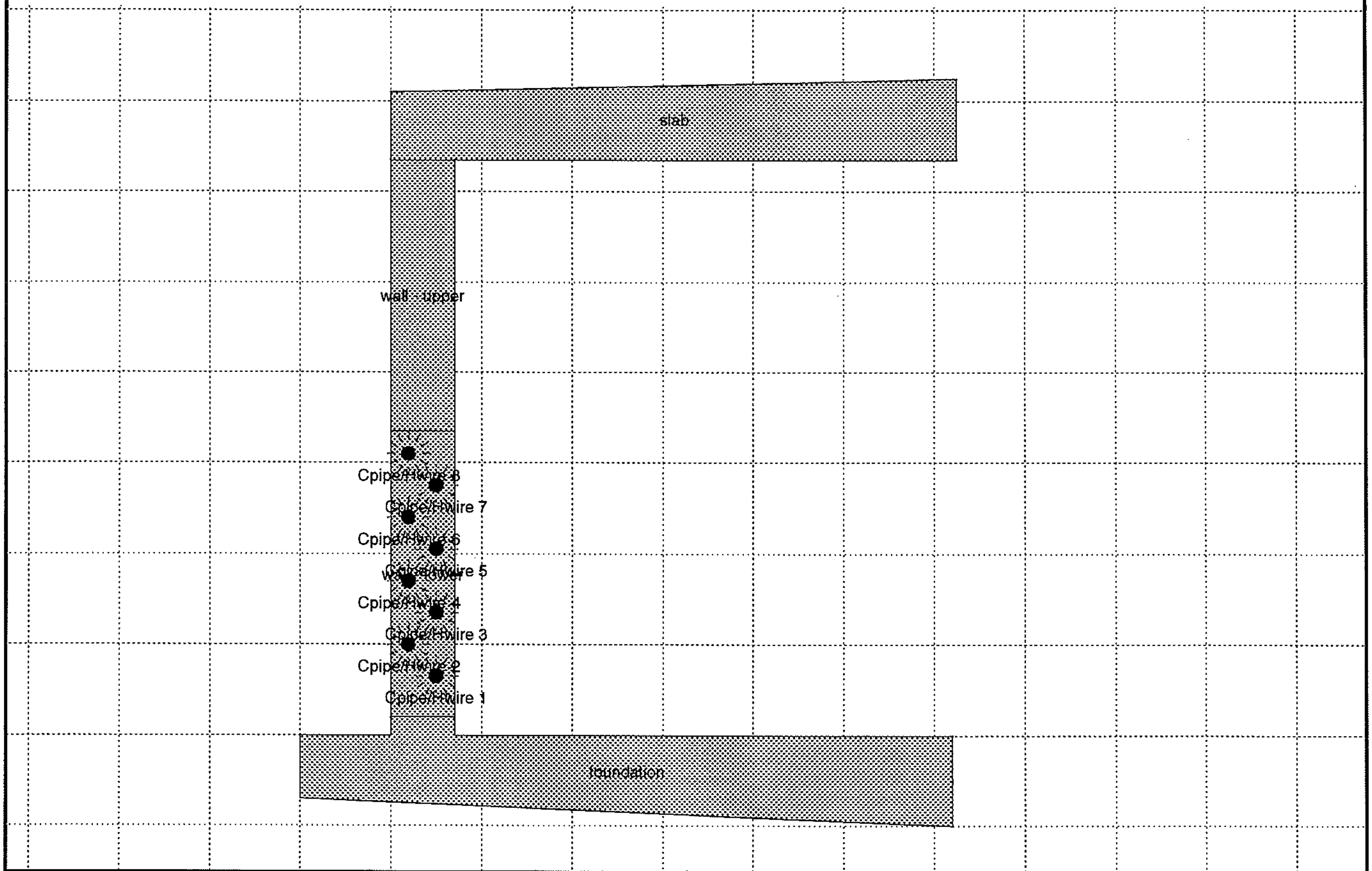
Thermal analysis	Transient	Circles	
Stress analysis	Based on thermal results	No. of faces	12
Dimensions			
2½-Dimensional	-	Self weight	
	-	Direction X	-
	No rotation around y-axis	Direction Y	-
Time specifications		Mesh, node generation	
Total process time	192.	Percentage of the largest extend	
Time step, desired	2.	Min. distance to border	2.00
Time step, factor	0.51	Density, internal nodes	5.00
		Density, border nodes	5.00
Nonlinear calculations		Density, around c-pipes	2.00
Convergence criteria	1.000e-03	Radius around c-pipes	10.00

DTI Building Technology Gregersensvej, DK 2630 Taastrup	CALCULATION BASIS Documentation sheet

Client:	Ref. nr.:	Project: proj-a-3	Date: 24-04-97
Name:	Initials :	Id. nr. : VE-AA1573	Time: 14.42

Volumes

Scaling mode: mm
Rulers: [1000:1000]



Volume	Size [mm]	Material type [-]	Material name [-]	Thickness [m]	Start time [h]	Temp. [°C]
foundation	7200 by 1200	Concrete	6002AB old shr 3	1.	0.	10.
wall - lower	700 by 3150	Concrete	6002AB wall 3	1.	0.	20.
slab	6250 by 900	Concrete	6002AB wall 3	1.	7.	19.
wall - upper	700 by 3000	Concrete	6002AB wall 3	1.	4.	17.5
Cooling pipe definition	Diameter m	Faces	-	-	-	-
Cpipe/Hwire 1	0.032	3	-	-	-	-
Cpipe/Hwire 2	0.032	3	-	-	-	-
Cpipe/Hwire 3	0.032	3	-	-	-	-
Cpipe/Hwire 4	0.032	3	-	-	-	-
Cpipe/Hwire 5	0.032	3	-	-	-	-
Cpipe/Hwire 6	0.032	3	-	-	-	-
Cpipe/Hwire 7	0.032	3	-	-	-	-
Cpipe/Hwire 8	0.032	3	-	-	-	-

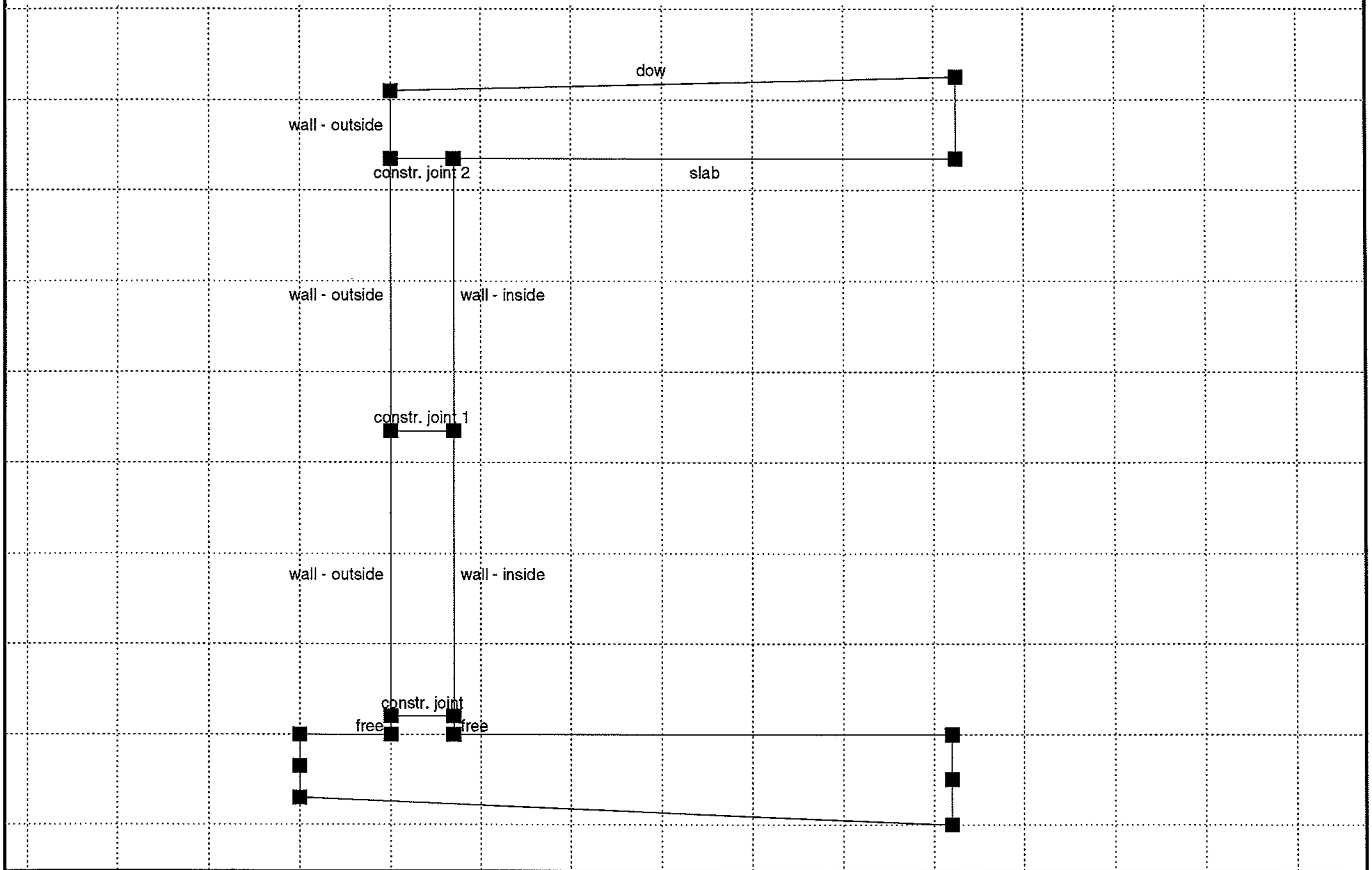
DTI Building Technology Gregersensvej, DK 2630 Taastrup	CALCULATION BASIS Documentation sheet

Client:	Ref. nr.:	Project: proj-a-3	Date: 24-04-97
Name:	Initials :	Id. nr. : VE-AA1580	Time: 15.01

Faces

Scaling mode: mm

Rulers: [1000:1000]



Boundary condition	Functions				
	Temperature	Wind velocity	Shield definition	Coef. of transm.	Flux
slab	air temp.	-	-	slab	-
wall - inside	air temp.	-	-	wall - inside	-
wall - outside	air temp.	-	-	wall - outside	none
constr. joint	air temp.	-	-	constr. joint	-
dow	air temp.	-	-	dow	none
free	air temp.	-	-	Unprotected	-
constr. joint 1	air temp.	-	-	constr. joint 1	-
constr. joint 2	air temp.	-	-	constr. joint 2	-

DTI Building Technology	CALCULATION BASIS
Gregersensvej, DK 2630 Taastrup	Documentation sheet

Client:	Ref. nr.:	Project: proj-a-3	Date: 24-04-97
Name:	Initials :	Id. nr. : VE-AA1580	Time: 15.02

Functions

Name	Type	Describtion	Unit	Function table Time [h] / Value
PEL	Temperature	Linear curve	[°C]	0. / 11.5 - 672. / 11.5
air temp.	Temperature	Linear curve	[°C]	0. / 11. - 9. / 16. - 22. / 9. - 30. / 15. - 46. / 8.5 - 60. / 11.5 - 69. / 7. - 78. / 14. - 86. / 8.5 - 96. / 8.5 - 102. / 14.5 - 120. / 4. - 126. / 9. - 132. / 8. - 144. / 5.5 - 150. / 7.5 - 168. / 7.5 - 240. / 7.5
Unprotected	Transm. coef.	Piecewise	[kJ/m²/h/°C]	0. / 44. - 672. / 44.
slab	Transm. coef.	Piecewise	[kJ/m²/h/°C]	0. / 13. - 30. / 8. - 72. / 20. - 672. / 20.
wall - outside	Transm. coef.	Piecewise	[kJ/m²/h/°C]	0. / 13. - 30. / 8. - 128. / 44. - 672. / 44.
constr. joint	Transm. coef.	Piecewise	[kJ/m²/h/°C]	0. / 0. - 672. / 0.
wall - inside	Transm. coef.	Piecewise	[kJ/m²/h/°C]	0. / 13. - 30. / 8. - 72. / 20. - 672. / 20.
dow	Transm. coef.	Piecewise	[kJ/m²/h/°C]	0. / 44. - 24. / 8. - 144. / 44. - 672. / 44.
PEL	Transm. coef.	Piecewise	[kJ/m²/h/°C]	0. / 570. - 48. / 0. - 700. / 0.
constr. joint 1	Transm. coef.	Piecewise	[kJ/m²/h/°C]	0. / 21.4 - 4. / 0. - 1000. / 21.4
constr. joint 2	Transm. coef.	Piecewise	[kJ/m²/h/°C]	0. / 21.4 - 7. / 0. - 1000. / 21.4
none	Flux	Piecewise	[kJ/m²h]	0. / 0. - 672. / 0.

DTI Building Technology Gregersensvej, DK 2630 Taastrup	CALCULATION BASIS Documentation sheet

Client:	Ref. nr.:	Project: proj-a-3	Date: 24-04-97
Name:	Initials :	Id. nr. : VE-AA1573	Time: 14.42

Calculation parameters

Thermal analysis	Transient	Circles	
Stress analysis	Based on thermal results	No. of faces	12
Dimensions			
2½-Dimensional	-	Self weight	
	-	Direction X	-
	No rotation around y-axis	Direction Y	-
Time specifications		Mesh, node generation	
Total process time	168.	Percentage of the largest extend	
Time step, desired	2.	Min. distance to border	0.10
Time step, factor	0.5	Density, internal nodes	3.00
		Density, border nodes	5.00
Nonlinear calculations		Density, around c-pipes	2.00
Convergence criteria	1.000e-03	Radius around c-pipes	10.00

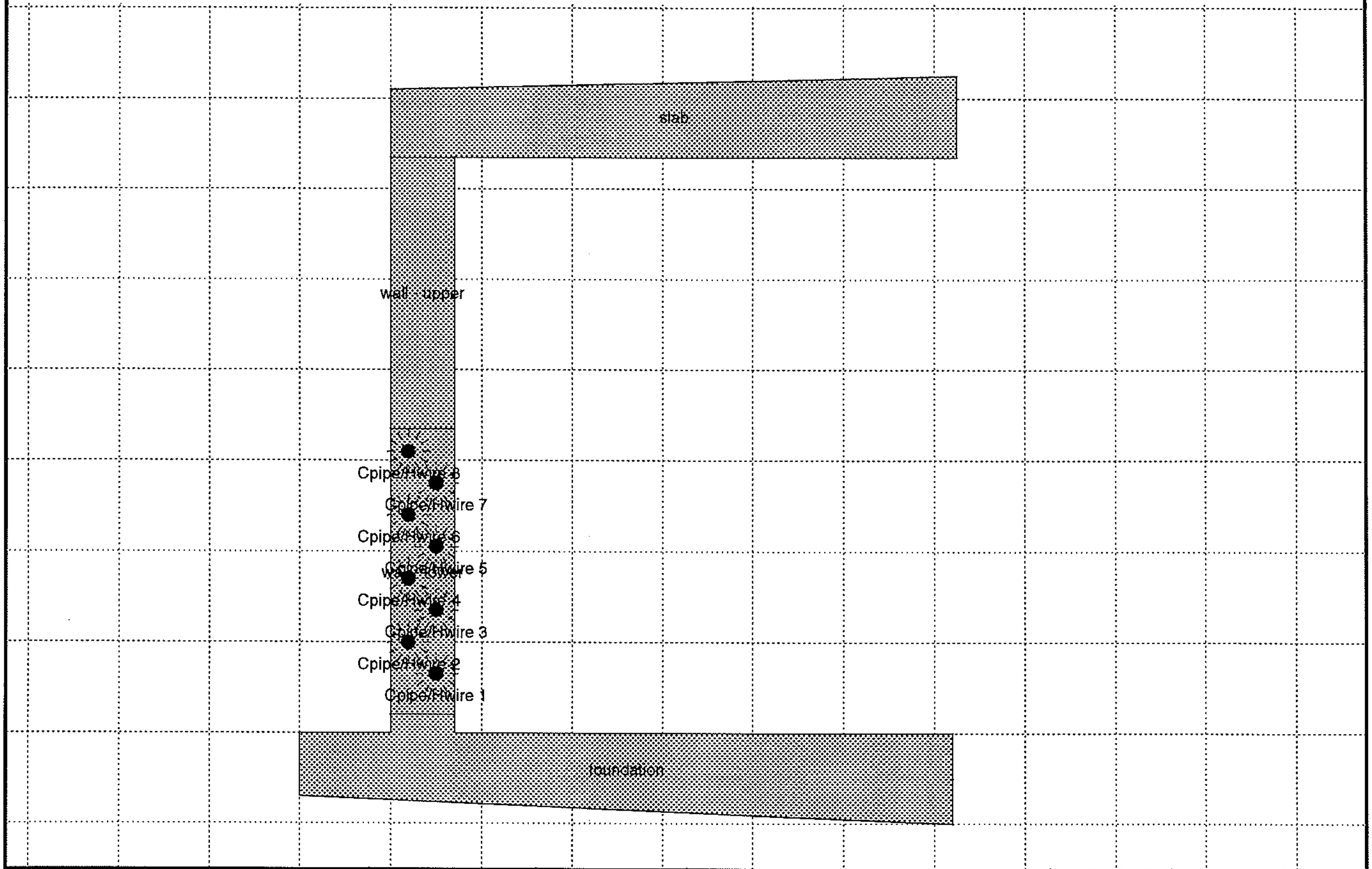
DTI Building Technology	CALCULATION BASIS
Gregersensvej, DK 2630 Taastrup	Documentation sheet

Client:	Ref. nr.:	Project: proj-a-4	Date: 24-04-97
Name:	Initials :	Id. nr. : VE-AA1574	Time: 14.41

Volumes

Scaling mode: mm

Rulers: [1000:1000]



Volume	Size [mm]	Material type [-]	Material name [-]	Thickness [m]	Start time [h]	Temp. [°C]
foundation	7200 by 1200	Concrete	6002AB old shr 4	1.	0.	20.
wall - lower	700 by 3150	Concrete	6002AB wall	1.	0.	28.
slab	6250 by 900	Concrete	6002AB slab	1.	5.5	29.
wall - upper	700 by 3000	Concrete	6002AB wall	1.	3.	28.
Cooling pipe definition	Diameter m	Faces	-	-	-	-
Cpipe/Hwire 1	0.032	3	-	-	-	-
Cpipe/Hwire 2	0.032	3	-	-	-	-
Cpipe/Hwire 3	0.032	3	-	-	-	-
Cpipe/Hwire 4	0.032	3	-	-	-	-
Cpipe/Hwire 5	0.032	3	-	-	-	-
Cpipe/Hwire 6	0.032	3	-	-	-	-
Cpipe/Hwire 7	0.032	3	-	-	-	-
Cpipe/Hwire 8	0.032	3	-	-	-	-

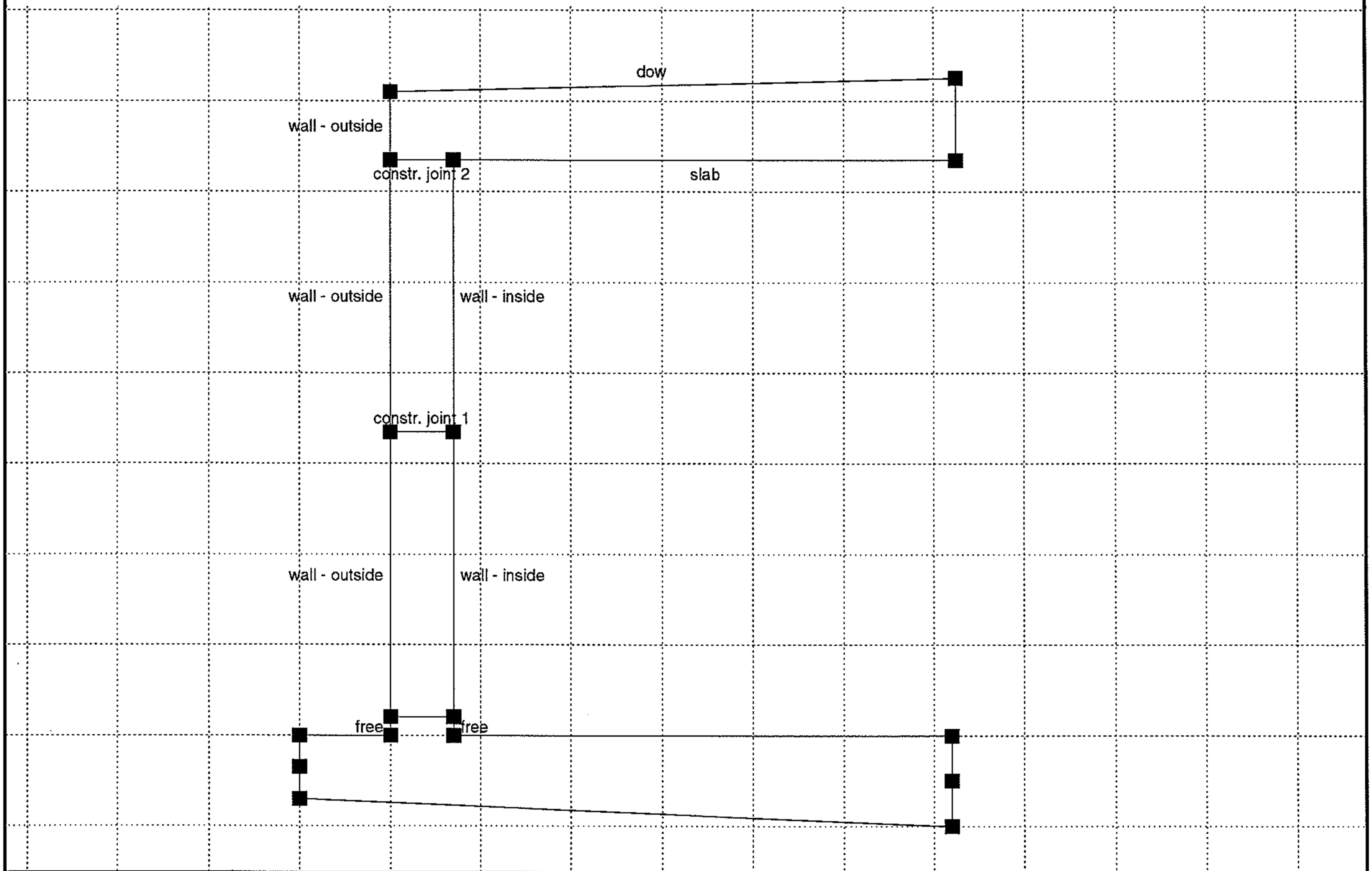
DTI Building Technology Gregersensvej, DK 2630 Taastrup	CALCULATION BASIS Documentation sheet

Client:	Ref. nr.:	Project: proj-a-4	Date: 24-04-97
Name:	Initials :	Id. nr. : VE-AA1574	Time: 14.41

Faces

Scaling mode: mm

Rulers: [1000:1000]



Boundary condition	Functions				
	Temperature	Wind velocity	Shield definition	Coef. of transm.	Flux
slab	air temp.	-	-	slab	-
wall - inside	air temp.	-	-	wall - inside	-
wall - outside	air temp.	-	-	wall - outside	none
dow	air temp.	-	-	dow	none
free	air temp.	-	-	Unprotected	-
constr. joint 1	air temp.	-	-	constr. joint 1	-
constr. joint 2	air temp.	-	-	constr. joint 2	-

DTI Building Technology Gregersensvej, DK 2630 Taastrup	CALCULATION BASIS Documentation sheet

Client: Name:	Ref. nr.: Initials :	Project: proj-a-4 Id. nr. : VE-AA1574	Date: 24-04-97 Time: 14.41

Functions

Name	Type	Describtion	Unit	Function table Time [h] / Value
PEL	Temperature	Linear curve	[°C]	0. / 25. - 4.5 / 25. - 7.5 / 18. - 12.5 / 15.4 - 20. / 15.4 - 26.5 / 19.5 - 32.6 / 19.5 - 36.8 / 15.1 - 672. / 15.1
air temp.	Temperature	Linear curve	[°C]	0. / 26.5 - 2.5 / 26.5 - 20. / 18.3 - 27.6 / 28. - 42.4 / 20.8 - 52.6 / 28.8 - 69.3 / 20.4 - 76. / 28.5 - 92.7 / 21.4 - 101. / 27.4 - 116.1 / 20.4 - 122.5 / 28.8 - 137.8 / 19.8 - 146.2 / 28.1 - 159.6 / 18.9 - 169.6 / 22.4 - 170.5 / 30.3 - 174.6 / 22.7 - 184.6 / 18.3 - 213.9 / 16.7 - 218.5 / 23.9 - 234.8 / 14.9 - 245.6 / 18.1 - 260.7 / 14.3 - 262. / 17.2 - 672. / 17.2
Unprotected	Transm. coef.	Piecewise	[kJ/m²/h/°C]	0. / 44. - 672. / 44.
slab	Transm. coef.	Piecewise	[kJ/m²/h/°C]	0. / 13. - 30. / 8. - 119. / 44. - 672. / 44.
wall - outside	Transm. coef.	Piecewise	[kJ/m²/h/°C]	0. / 13. - 30. / 13. - 336. / 44. - 672. / 44.
wall - inside	Transm. coef.	Piecewise	[kJ/m²/h/°C]	0. / 13. - 119. / 44. - 672. / 44.
dow	Transm. coef.	Piecewise	[kJ/m²/h/°C]	0. / 44. - 21. / 6. - 168. / 44. - 672. / 44.
PEL	Transm. coef.	Piecewise	[kJ/m²/h/°C]	0. / 570. - 45.5 / 0. - 700. / 0.
constr. joint 1	Transm. coef.	Piecewise	[kJ/m²/h/°C]	0. / 21.4 - 3. / 0. - 1000. / 21.4
constr. joint 2	Transm. coef.	Piecewise	[kJ/m²/h/°C]	0. / 21.4 - 5.5 / 0. - 1000. / 21.4
none	Flux	Piecewise	[kJ/m²h]	0. / 0. - 672. / 0.

DTI Building Technology Gregersensvej, DK 2630 Taastrup	CALCULATION BASIS Documentation sheet

Client:	Ref. nr.:	Project: proj-a-4	Date: 24-04-97
Name:	Initials :	Id. nr. : VE-AA1574	Time: 14.41

Calculation parameters

Thermal analysis	Transient	Circles	
Stress analysis	Based on thermal results	No. of faces	12
Dimensions			
2½-Dimensional	-	Self weight	
	-	Direction X	-
	No rotation around y-axis	Direction Y	-
Time specifications		Mesh, node generation	
Total process time	264.	Percentage of the largest extend	
Time step, desired	2.	Min. distance to border	0.10
Time step, factor	0.5	Density, internal nodes	3.00
		Density, border nodes	5.00
Nonlinear calculations		Density, around c-pipes	2.00
Convergence criteria	1.000e-03	Radius around c-pipes	10.00

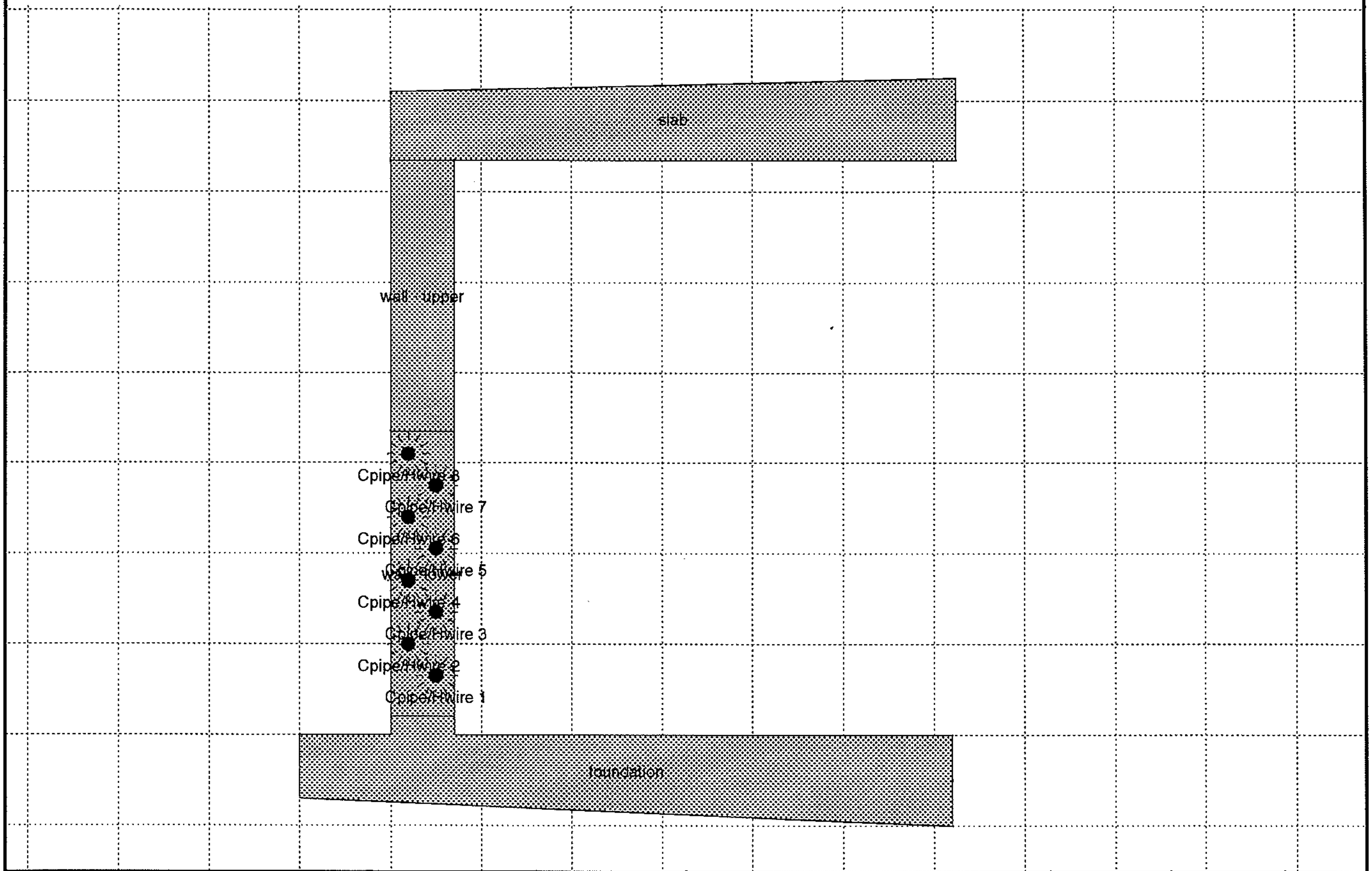
DTI Building Technology Gregersensvej, DK 2630 Taastrup	CALCULATION BASIS Documentation sheet

Client:	Ref. nr.:	Project: proj-a-5	Date: 24-04-97
Name:	Initials :	Id. nr. : VE-AA1576	Time: 14.44

Volumes

Scaling mode: mm

Rulers: [1000:1000]



Volume	Size [mm]	Material type [-]	Material name [-]	Thickness [m]	Start time [h]	Temp. [°C]
foundation	7200 by 1200	Concrete	6002AB old shr 5	1.	0.	3.
wall - lower	700 by 3150	Concrete	6002AB wall	1.	0.	15.
slab	6250 by 900	Concrete	6002AB slab	1.	5.5	18.
wall - upper	700 by 3000	Concrete	6002AB wall	1.	3.5	18.

Cooling pipe definition	Diameter m	Faces	-	-	-	-
Cpipe/Hwire 1	0.032	3	-	-	-	-
Cpipe/Hwire 2	0.032	3	-	-	-	-
Cpipe/Hwire 3	0.032	3	-	-	-	-
Cpipe/Hwire 4	0.032	3	-	-	-	-
Cpipe/Hwire 5	0.032	3	-	-	-	-
Cpipe/Hwire 6	0.032	3	-	-	-	-
Cpipe/Hwire 7	0.032	3	-	-	-	-
Cpipe/Hwire 8	0.032	3	-	-	-	-

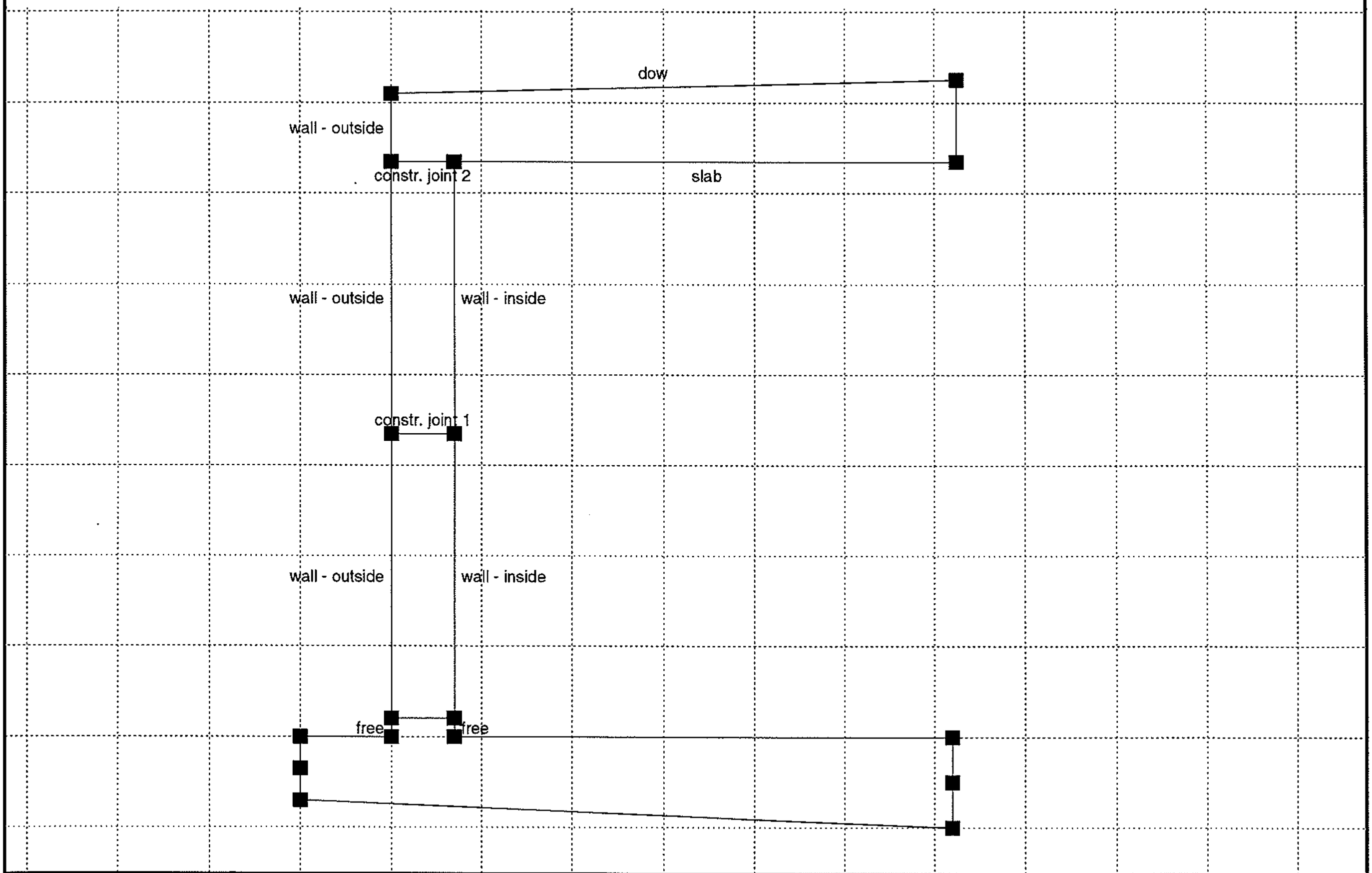
DTI Building Technology	CALCULATION BASIS
Gregersensvej, DK 2630 Taastrup	Documentation sheet

Client:	Ref. nr.:	Project: proj-a-5	Date: 24-04-97
Name:	Initials :	Id. nr. : VE-AA1581	Time: 14.55

Faces

Scaling mode: mm

Rulers: [1000:1000]



Boundary condition	Functions				
	Temperature	Wind velocity	Shield definition	Coef. of transm.	Flux
slab	air temp.	-	-	slab	-
wall - inside	air temp.	-	-	wall - inside	-
wall - outside	air temp.	-	-	wall - outside	none
dow	air temp.	-	-	dow	none
free	air temp.	-	-	Unprotected	-
constr. joint 1	air temp.	-	-	constr. joint 1	-
constr. joint 2	air temp.	-	-	constr. joint 2	-

DTI Building Technology Gregersensvej, DK 2630 Taastrup	CALCULATION BASIS Documentation sheet

Client:	Ref. nr.:	Project: proj-a-5	Date: 24-04-97
Name:	Initials :	Id. nr. : VE-AA1581	Time: 14.55

Functions

Name	Type	Describtion	Unit	Function table Time [h] / Value
air temp.	Temperature	Linear curve	[°C]	0. / 1.6 - 2. / 1.6 - 3.2 / 3.4 - 25.6 / 3.4 - 26.8 / 4.7 - 32.8 / 4.5 - 41.9 / 2.7 - 47. / 2.7 - 52.7 / 4.2 - 71. / 2.7 - 76.3 / 3.2 - 95. / 1.9 - 102.2 / 4.5 - 119. / 2.4 - 131.2 / 3.3 - 140.3 / 1.4 - 148.7 / 3.2 - 156. / 0.1 - 168.1 / 0.3 - 171. / 2.1 - 1000. / 2.1
PEL	Temperature	Linear curve	[°C]	0. / 1. - 2. / 1.6 - 3.2 / 3.4 - 24.4 / 3.4 - 24.5 / 10. - 1000. / 10.
Unprotected	Transm. coef.	Piecewise	[kJ/m²/h/°C]	0. / 44. - 672. / 44.
slab	Transm. coef.	Piecewise	[kJ/m²/h/°C]	0. / 8. - 30. / 6. - 72. / 20. - 672. / 20.
wall - outside	Transm. coef.	Piecewise	[kJ/m²/h/°C]	0. / 13. - 30. / 10. - 336. / 20. - 672. / 20.
wall - inside	Transm. coef.	Piecewise	[kJ/m²/h/°C]	0. / 13. - 30. / 10. - 72. / 20. - 672. / 20.
dow	Transm. coef.	Piecewise	[kJ/m²/h/°C]	0. / 25. - 23. / 10. - 30. / 8. - 168. / 20. - 672. / 20.
PEL	Transm. coef.	Piecewise	[kJ/m²/h/°C]	0. / 0. - 16. / 570. - 72. / 0. - 1000. / 0.
constr. joint 1	Transm. coef.	Piecewise	[kJ/m²/h/°C]	0. / 21.4 - 3.5 / 0. - 1000. / 21.4
constr. joint 2	Transm. coef.	Piecewise	[kJ/m²/h/°C]	0. / 21.4 - 5.5 / 0. - 1000. / 21.4
none	Flux	Piecewise	[kJ/m²h]	0. / 0. - 672. / 0.

DTI Building Technology Gregersensvej, DK 2630 Taastrup	CALCULATION BASIS Documentation sheet

Client:	Ref. nr.:	Project: proj-a-5	Date: 24-04-97
Name:	Initials :	Id. nr. : VE-AA1576	Time: 14.44

Calculation parameters

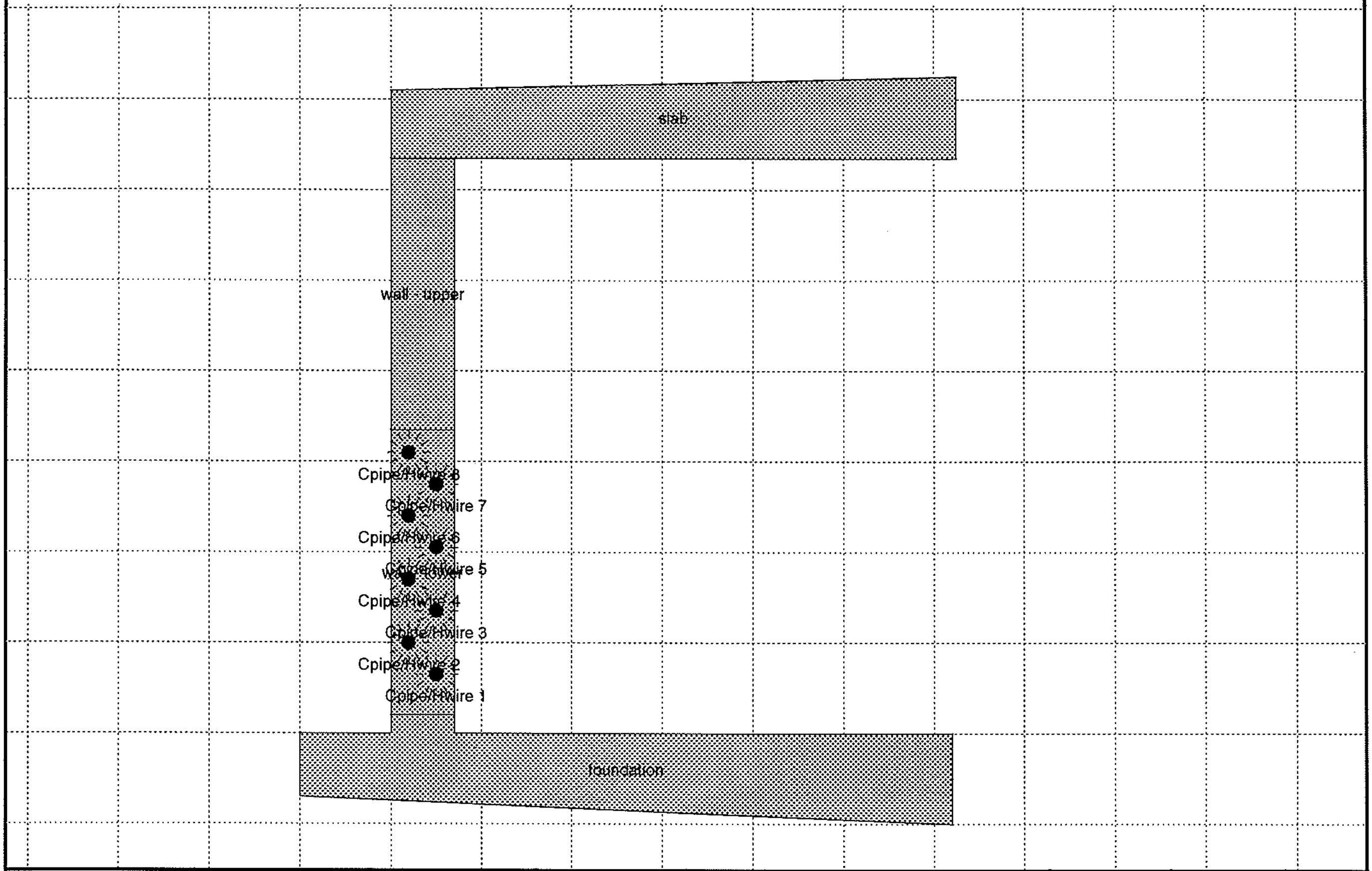
Thermal analysis	Transient	Circles	
Stress analysis	Based on thermal results	No. of faces	12
Dimensions			
2½-Dimensional	-	Self weight	
	-	Direction X	-
	No rotation around y-axis	Direction Y	-
Time specifications		Mesh, node generation	
Total process time	168.	Percentage of the largest extend	
Time step, desired	2.	Min. distance to border	0.10
Time step, factor	0.5	Density, internal nodes	3.00
		Density, border nodes	5.00
Nonlinear calculations		Density, around c-pipes	2.00
Convergence criteria	1.000e-03	Radius around c-pipes	10.00

DTI Building Technology	CALCULATION BASIS
Gregersensvej, DK 2630 Taastrup	Documentation sheet

Client:	Ref. nr.:	Project: proj-a-6	Date: 24-04-97
Name:	Initials :	Id. nr. : VE-AA1579	Time: 14.51

Volumes

Scaling mode: mm
Rulers: [1000:1000]



Volume	Size [mm]	Material type [-]	Material name [-]	Thickness [m]	Start time [h]	Temp. [°C]
foundation	7200 by 1200	Concrete	6002AB old shr 6	1.	0.	3.
wall - lower	700 by 3150	Concrete	6002AB wall	1.	0.	11.
slab	6250 by 900	Concrete	6002AB slab	1.	5.	18.
wall - upper	700 by 3000	Concrete	6002AB wall	1.	3.	16.

Cooling pipe definition	Diameter m	Faces	-	-	-	-
Cpipe/Hwire 1	0.032	3	-	-	-	-
Cpipe/Hwire 2	0.032	3	-	-	-	-
Cpipe/Hwire 3	0.032	3	-	-	-	-
Cpipe/Hwire 4	0.032	3	-	-	-	-
Cpipe/Hwire 5	0.032	3	-	-	-	-
Cpipe/Hwire 6	0.032	3	-	-	-	-
Cpipe/Hwire 7	0.032	3	-	-	-	-
Cpipe/Hwire 8	0.032	3	-	-	-	-

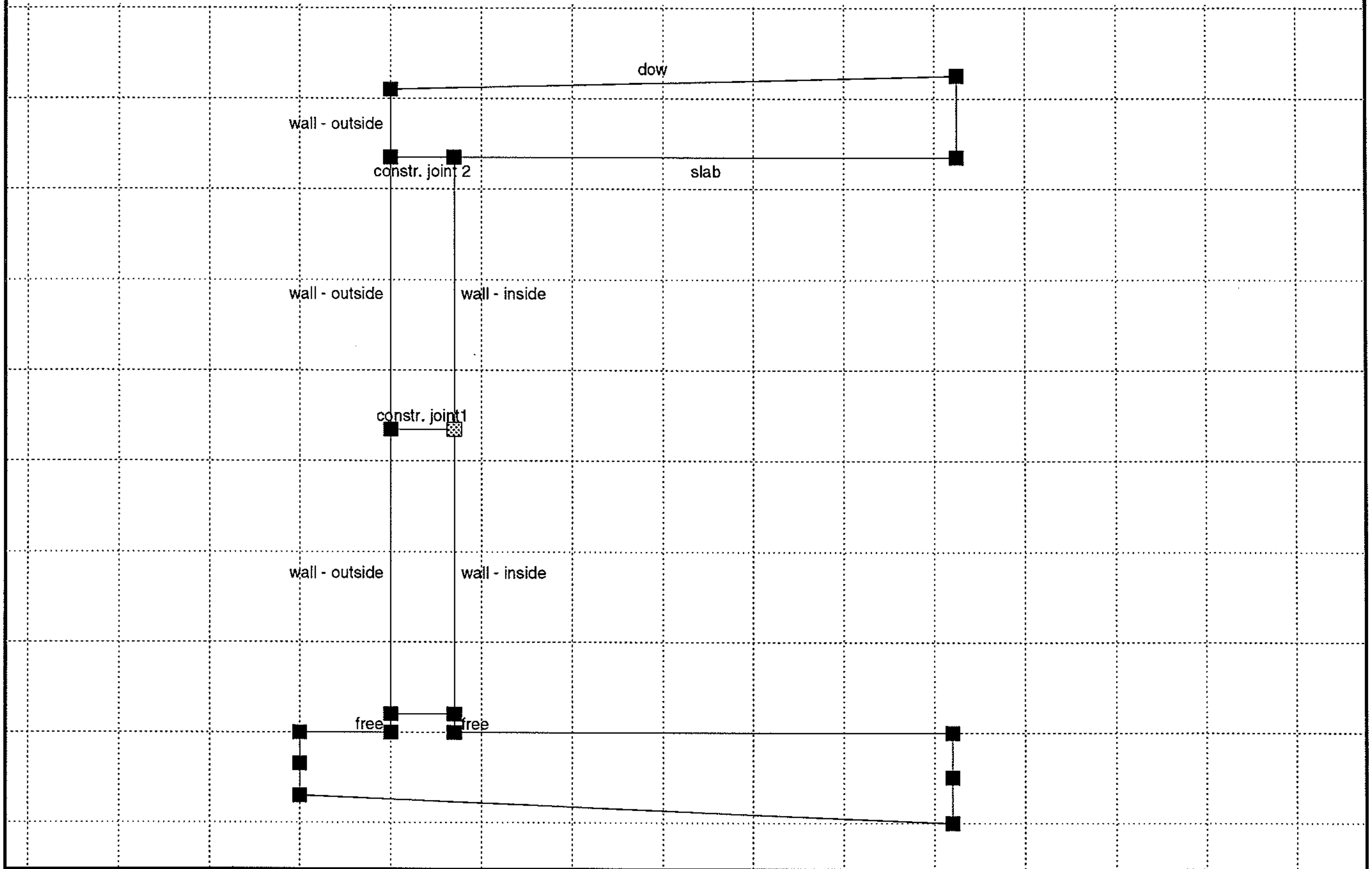
DTI Building Technology Gregersensvej, DK 2630 Taastrup	CALCULATION BASIS Documentation sheet

Client:	Ref. nr.:	Project: proj-a-6	Date: 24-04-97
Name:	Initials :	Id. nr. : VE-AA1579	Time: 14.51

Faces

Scaling mode: mm

Rulers: [1000:1000]



Boundary condition	Functions				
	Temperature	Wind velocity	Shield definition	Coef. of transm.	Flux
slab	air temp.	-	-	slab	-
wall - inside	air temp.	-	-	wall - inside	-
wall - outside	air temp.	-	-	wall - outside	none
dow	air temp.	-	-	dow	none
free	air temp.	-	-	Unprotected	-
constr. joint1	air temp.	-	-	constr. joint 1	-
constr. joint 2	air temp.	-	-	constr. joint 2	-

DTI Building Technology Gregersensvej, DK 2630 Taastrup	CALCULATION BASIS Documentation sheet

Client:	Ref. nr.:	Project: proj-a-6	Date: 24-04-97
Name:	Initials :	Id. nr. : VE-AA1579	Time: 14.51

Functions

Name	Type	Describtion	Unit	Function table Time [h] / Value
air temp.	Temperature	Linear curve	[°C]	0. / 0.8 - 8.1 / 1.1 - 28.2 / 3.4 - 36.7 / 3.1 - 37.9 / 1.9 - 43.4 / 1.9 - 47. / 2.5 - 62.2 / 0.3 - 101.1 / 4. - 119. / 0.6 - 140. / 5.4 - 144.8 / 4.9 - 149.7 / 6.6 - 153.3 / 3.7 - 171.6 / 3.4 - 1000. / 3.4
PEL	Temperature	Linear curve	[°C]	0. / 0.8 - 8.1 / 1.1 - 9.3 / 8.1 - 23. / 9.1 - 56.7 / 8.9 - 1000. / 8.9
Unprotected	Transm. coef.	Piecewise	[kJ/m²/h/°C]	0. / 44. - 672. / 44.
slab	Transm. coef.	Piecewise	[kJ/m²/h/°C]	0. / 13. - 40. / 10. - 74. / 20. - 672. / 20.
wall - outside	Transm. coef.	Piecewise	[kJ/m²/h/°C]	0. / 13. - 40. / 10. - 336. / 20. - 672. / 20.
wall - inside	Transm. coef.	Piecewise	[kJ/m²/h/°C]	0. / 13. - 40. / 10. - 74. / 20. - 672. / 20.
dow	Transm. coef.	Piecewise	[kJ/m²/h/°C]	0. / 25. - 12. / 10. - 40. / 10. - 168. / 20. - 672. / 20.
PEL	Transm. coef.	Piecewise	[kJ/m²/h/°C]	0. / 0. - 24. / 570. - 56. / 0. - 1000. / 0.
constr. joint 1	Transm. coef.	Piecewise	[kJ/m²/h/°C]	0. / 21.4 - 3. / 0. - 1000. / 21.4
constr. joint 2	Transm. coef.	Piecewise	[kJ/m²/h/°C]	0. / 21.4 - 5. / 0. - 1000. / 21.4
none	Flux	Piecewise	[kJ/m²h]	0. / 0. - 672. / 0.

DTI Building Technology	CALCULATION BASIS
Gregersensvej, DK 2630 Taastrup	Documentation sheet

Client:	Ref. nr.:	Project: proj-a-6	Date: 24-04-97
Name:	Initials :	Id. nr. : VE-AA1579	Time: 14.51

Calculation parameters

Thermal analysis	Transient	Circles	
Stress analysis	Based on thermal results	No. of faces	12
Dimensions			
2½-Dimensional	-	Self weight	
	-	Direction X	-
	No rotation around y-axis	Direction Y	-
Time specifications		Mesh, node generation	
Total process time	168.	Percentage of the largest extend	
Time step, desired	2.	Min. distance to border	0.10
Time step, factor	0.5	Density, internal nodes	3.00
		Density, border nodes	5.00
Nonlinear calculations		Density, around c-pipes	2.00
Convergence criteria	1.000e-03	Radius around c-pipes	10.00