PROGRESS REPORT

CONTRACT N° : G1RD-CT-2002-00782

PROJECT N° : -

ACRONYM : ECOServe – Cluster 2 – R(esearch)

TITLE : **EUROPEAN CONSTRUCTION IN SERVICE OF SOCIETY (ECOServe)**
CLUSTER 2:Production and Application of Blended Cements

<u>Research Activities</u>

PROJECT CO-ORDINATOR: Verein Deutscher Zementwerke e. V. (VDZ) (D)
(German Cement Works Association)

PARTNERS :

CTG SpA (I)
Norcem A.S. (NO)
Titan Cement Company (EL)

REPORTING PERIOD : FROM 01.10.2003 TO 30.09.2004

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ECO-Serve-C2-R-0010

EUROPEAN CONSTRUCTION IN SERVICE OF SOCIETY

ECO-SERVE NETWORK

CLUSTER 2
Production and Application of Blended Cements

Research Activities

<u>Contract No. G1RD-CT-2002-00782</u>

Technical Report related to the first cost statement

Period under review: 01.10.2003 - 30.09.2004

10.02.2005

Edited by Dr.-Ing. Christoph Müller
Verein Deutscher Zementwerke, Düsseldorf - Germany

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2 Executive publishable summary

On November 15th 2002, the European Thematic Network “EUROPEAN CONSTRUCTION IN SERVICE OF SOCIETY” (ECOServe) was established. One of the technical clusters of the ECOServe Network, ***cluster 2***, deals with the ***production and application of blended cements***. The cement production process is intensive in energy as well as raw material demand. Limits of technical improvements to lower the environmental impact of the cement production have been reached in the European cement industry. Remaining potential to reduce environmental impacts is provided by the reduction of the clinker content in cement (blended cements). Other main constituents for cement like granulated blastfurnace slag, fly ashes from power plants, natural and industrial pozzolanas or limestone can be used. The production of blended cements results in lower emission and lower energy consumption of the clinker burning process. This reduction is obvious, because less clinker from the energy-intensive process is needed to produce such blended cements. Experience in the production of blended cements already exists. However, the new European cement standard EN 197-1 now allows more different types of these cements to be produced than before. The use of many of these cements in concrete is currently restricted only to a few climatic or environmental conditions in some of the various European countries respectively these cements have not been produced at all.

The collection of data within the network activities should lead to an Europeanwide exchange of knowledge on the properties, the capability, the availability and the application of blended cements with the objective of a broader application of blended cements in Europe. In addition the production and testing of cements with maximum amounts of main constituents besides clinker acc. to EN 197-1 and the production and testing of cements with a composition beyond the limits of EN 197-1 will lead to a broader knowledge about the behaviour of such cements in mortar and concrete an therefore can contribute to a broader application of blended cements in Europe.

Within the first reporting period, the partners from Germany, Greece, Italy and Norway produced blended cements containing blastfurnace slag, brick, glass, limestone, fly ash and natural pozzolana. All constituents where characterized with regard to there chemical and physical properties. Cement properties have been determined and first concrete test on workability, strength development, chloride penetration and the resistance against freezing and thawing have been carried out.

Partners use constituents, which are relevant for the particular part of Europe. The work with blended cements in cluster 2 comprises cement types included in and beyond the limits of EN 197-1. Some of the cements according to EN 197-1 would, however, be new in a particular region, containing a new constituent (e. g. limestone in Norway), or greater quantities of substitutes (more fly ash), or mixes of additional constituents (fly ash and limestone). Ground brick has been successfully used as pozzolanic material in Italy. Nevertheless mortars and concretes in which the cement has been partially substituted by ground brick showed high water demand and low durability. The use of a third recycled pozzolanic material will be investigated in order to reduce the aforesaid problems. For the greek market 2,5 million tons/a of fly ash from power plants are of special interest. The high CaO content of these fly ashes (> 10%) renders them unsuitable for the manufacturing of concrete, according to the EN 450. Currently, they are being used for the production of cement but their implementation requires some precaution because they exhibit problems regarding inhomogenity and high SO_3 values. Investigations within the cluster should give hints, to what extend these fly ashes can be used for the production of blended cements. Building practice experience with Portland-limestone cements of up to 35 mass.% is not available in Germany. Currently they may not yet be used for concrete with high resistance to freeze thaw or freeze thaw with de-icing salt. Investigations should give hints, to what extend the limestone qualities available in the region, can be used for the production of blended cements. For the comparability and the reproducibility of the investigations and their results, it is essential, that the partners agree on some mortar- and concrete compositions as well as the test methods. Corresponding aggrements have been made.

3 Objectives and strategic aspects

On November 15th 2002, the European Thematic Network “EUROPEAN CONSTRUCTION IN SERVICE OF SOCIETY” (ECOServe) was established. One of the technical clusters of the ECOServe Network, ***cluster 2***, deals with the ***production and application of blended cements***.

The cement production process is intensive in energy as well as raw material demand. Limits of technical improvements to lower the environmental impact of the cement production have been reached in the European cement industry. Remaining potential to reduce environmental impacts is provided by the reduction of the clinker content in cement (blended cements). Other main constituents for cement like granulated blastfurnace slag, fly ashes from power plants, natural and industrial pozzolanas or limestone can be used. The production of blended cements results in lower emission and lower energy consumption of the clinker burning process. This reduction is obvious, because less clinker from the energy-intensive process is needed to produce such blended cements. Experience in the production of blended cements already exists. However, the new European cement standard EN 197-1 now allows more different types of these cements to be produced than before. The use of many of these cements in concrete is currently restricted only to a few climatic or environmental conditions in some of the various European countries respectively these cements have not been produced at all.

The cluster consists of network (N) and research activities (R) in 6 inter-related tasks. In the network part, the exchange of knowledge about the production and especially the application of blended cements ist the main objective. The expected outcome of the network acivities is a Europeanwide exchange of knowledge on the properties, the capability, the availability and the application of blended cements with the objective of a broader application of blended cements in Europe. The collection and evaluation of application rules for blended cements is one of the integral parts of the work in cluster 2 of the network.

Besides the data collection investigations on blended cements and their behaviour in mortar and concrete and consequential new perceptions about the influence of blended cements especially on the durability can enhance the use of these cements. As the use of many of the blended cements with the maximum content of main constituents besides clinker according to EN 197-1 in concrete is currently restricted only to a few climatic or environmental conditions in some of the European countries respectively these cements have not even been produced, the innovative aspects of the research activities in cluster 2 are

- the production and testing of cements with maximum amounts of main constituents besides clinker acc. to EN 197-1 and
- the production and testing of cements with a composition beyond the limits of EN 197-1.

Research activities focus - besides investigations on the interaction between the main constituents - on concrete durability.

Participants in the resarch activities of cluster 2 are:

Partner No. *	Name	Short name
1	Verein Deutscher Zementwerke	VDZ
2	CTG SpA	CTG
3	Norcem A.S.	Norcem
5	Titan Cement Company	Titan
*: ref. to Annex 1 „Description of work“ to Contract No. G1RD-CT-2002-00782		

4 Scientific and technical performance

4.1 Summary of the specific objectives for the relevant period

This report summarises the **research activities** of cluster 2 for the reporting period 01.10.2003 - 30.09.2004. During that period, the specific objectives were:

- Fixing of final work plan (cement compositions, concrete mixtures etc.);
- Provision and characterisation of starting materials;
- production of laboratory cements;
- determination of cement, mortar and concrete properties.

4.2 Overview of technical progress

During the first cluster meeting meeting dated 05.09.2003 partners finally discussed the workplan and agreed on the commitments given in tables 1 - 4 with regard to the cements, that will be investigated by the partners.

The Partners decided not to use silica-fume because no benefit is expected within the ECO-Serve scope.

Remark:	Sub-task 1.4 “Silica-Fume” was canceled and sub-task 1.5 “Limestone” was expanded (comp. tables 8 and 13)

The planned strength for all cements is 45 - 50 MPa acc. to EN 197-1. Every partner uses a typically used cement of his region for comparative tests. If the strength of the tested cement is significantly lower than 45 - 50 MPa, partners use a reference cement with a reduced strength.

Table 1: Overview of the cements, that will be investigated by the partners: Partner 1 – VDZ

Partner:	Name	No.
	VDZ	1

Constituent			Cement No.																			
			1	2	3	4	5	6	7	8	9	10	11	12	13							
Clinker	K	M.-%	65	65	65	90	80	70	70	65	65	65	55	50	30							
Blast furnace slag	S									10	15	20		30	50							
Natural pozzolana	P																					
Fly ash	V																					
	W					10	20	30	30	25	20	15										
Limestone	L																					
	LL		35	35	35								45	20	20							
Total			100	100	100	100	100	100	100	100	100	100	100	100	100							

Explanations:		
Cement	1	Limestone A
	2	Limestone B
	3	Limestone C
	4-6	Fly ash x
	7	Fly ash y
	8-10	Fly ash x, Blast furnace slag z
	11	Limestone A
	12-13	Limestone A, Blast furnace slag z

Table 2: Overview of the cements, that will be investigated by the partners: Partner 2 – CTG

Partner:	Name	No.
	CTG	2

Constituent			Cement No.																			
			1	2	3	4																
Clinker	K	M.-%	50	55	40	55																
Blast furnace slag	S		50		40																	
Natural pozzolana	P																					
Fly ash	V																					
	W																					
Limestone	L																					
	LL			45	20																	
Other (specify !)																						
ground glass						30																
ground brick						15																
Total			100	100	100	100																

Explanations:		
Cement	1	CEM III BS
	2	CEM Limestone
	3	CEM Limestone-slag
	4	CEM recycled pozz. Material

Table 3: Overview of the cements, that will be investigated by the partners: Partner 3 – NORCEM

Partner:	Name	No.
	NORCEM	3

Constituent			Cement No.							
			1	2	3	4	5	6	7	8
Clinker	K	M.-%	80	80	70	50	80	100	65	50
Blast furnace slag	S									
Natural pozzolana	P									
Fly ash	V		20	20	20	30			35	50
	W									
Limestone	L									
	LL				10	20	20			
Total			100	100	100	100	100	100	100	100

Explanations:	1	Norcem Standard FA CEM II A-V 42,5 R Reference
Cement	2	Fly ash A
	3	Fly ash A + Limestone X
	4	Fly ash A + Limestone X
	5	Limestone X
	6	Cement I 42,5 R Reference
	7	Fly ash A
	8	Fly ash B

Table 4: Overview of the cements, that will be investigated by the partners: Partner 5 – TITAN

Partner:	Name	No.
	TITAN	5

Constituent			Cement No.					
			1	2	3	4	5	6
Clinker	K	M.-%	65	55	65	55	58	69
Blast furnace slag	S							
Natural pozzolana	P						12	17
Fly ash	V							
	W		35	45			15	6
Limestone	L							
	LL				35	45	15	8
Total			100	100	100	100	100	100

Explanations:
Cement

All partners carried out the provision of the starting materials and started with the production of laboratory cements (Sub-tasks 1.1, 1.1, 1.3, 1.5).

Physical and chemical properties of the starting materials and the cements were determined (Sub-task 2.1) and cements have been modified if necessary (Sub-task 2.2).

All partners started with the determination of mortar and concrete properties (Sub-tasks 1.1, 1.1, 1.3, 1.5) according to the workplan.

4.3 Comparison of planned activities and actual work

Tables 8 to 11 give, per task and per partner, the actual and scheduled manpower allocation for the first year.

The following ammendments / modifications have to be taken into account:

All partners:	Sub-task 1.4 “Silica-Fume” was canceled and sub-task 1.5 “Limestone” was expanded (comp. tables 8 and 13)
Partner 1: (VDZ)	Investigations on fly ashes have been reduced due to the quality of calcareus fly ashes in Germany (Sub-task 1.3). A lot more modifications have been made with cements containing slag and limestone (Sub-task 2.2). VDZ will make investigations on chloride penetration for NORCEM (Sub-task 3.3).
Partner 2: (CTG)	The selection and analysis of the starting materials has consumed more time than expected. The planned activities have been postponed.
Partner 3: (NORCEM)	The production of trial mixes was originally planned for May/June 2004. Due to capacity problems and internal restructuring of work tasks, as well as other strategic issues, led to a re-scheduling of the laboratory programme. The concrete mixes are now planned for november/december 2004. VDZ will make investigations on chloride penetration for NORCEM (Sub-task 3.3).
Partner 5:	No remarks.

In general, the ammendments / modifications will not lead to any change of the overall budget or limitations of the perceptions and the exspected outcome of the project.

4.4 State of the art review

During the period under review, no developments became apparent, which prompt changes in the work plan or cast doubts on the objectives.

4.5 Planned activities for the next period

Partners will continue with their investigations according to the workplan fixed within the meeting dated 18.10.2003 with slight revisions acc. to this report.

At present, partners see no necessity for further revisions of the workplan.

5 List of deliverables

According to the workplan (Annex 1 „Description of work“ to Contract No. G1RD-CT-2002-00782) the deliverables and milestones specified in tables 5 and 6 have to be delivered and maintained during the period under review.

Table 5: Overview of deliverables in research activities of cluster 2

Deliver-able No.	Delivery month	Output from Task/ sub task No.	Nature of Deliverable and brief description		Status
D3-D6	**04/2004-09/2004**	R1.1-R1.5	Data/Re /Mat	• Process data from the production of blended cements and blended cements (data and materials of 4 partners)	according to schedule
D7-D11	**09/2005**	R3.1-R3.5	Data/Re	• Basic concrete properties (data of 4 partners) • Carbonation (data of 4 partners) • Penetration of chlorides (data of 2 partners) • Freeze-thaw-durability (data of 3 partners) • Chemical resistance (data of 4 partners)	not included in the period under review ☞ first results are included in this report (modifications of the time table: comp. chapter 4.3)
D12	**09/2004**	…	Data/Re	• Evaluation of D3-D6	according to schedule (modifications of the time table: comp. chapter 4.3)

Table 6: Overview of Milestones in research activities of cluster 2

Milestone No.	Month	Brief description of milestone / objectives	Status
M3	18	Fixing of final work plan (cement compositions, concrete mixtures, etc.)	according to schedule ☞ ECO-Serve-C2-R-0008
M4	**09/2004**	Evaluation of D3-D6	according to schedule

Legend to tables 5 and 6:

- (green) Milestone/deliverable completely achieved
- (yellow) Milestone/deliverable partly achieved or achieved with changes
- (red) Milestone/deliverable not achieved

As indicated in tables 5 and 6, deliverables and milestones during the period under review have been delivered and maintained according to the workplan.

6 Exploitation and dissemination of results

Dissemination and exploitation of the results will mainly be done in the “Network dissemination task”. The results of derived from the research activities will directly be transferred into the network. The reports will be available within the data collection of the network.

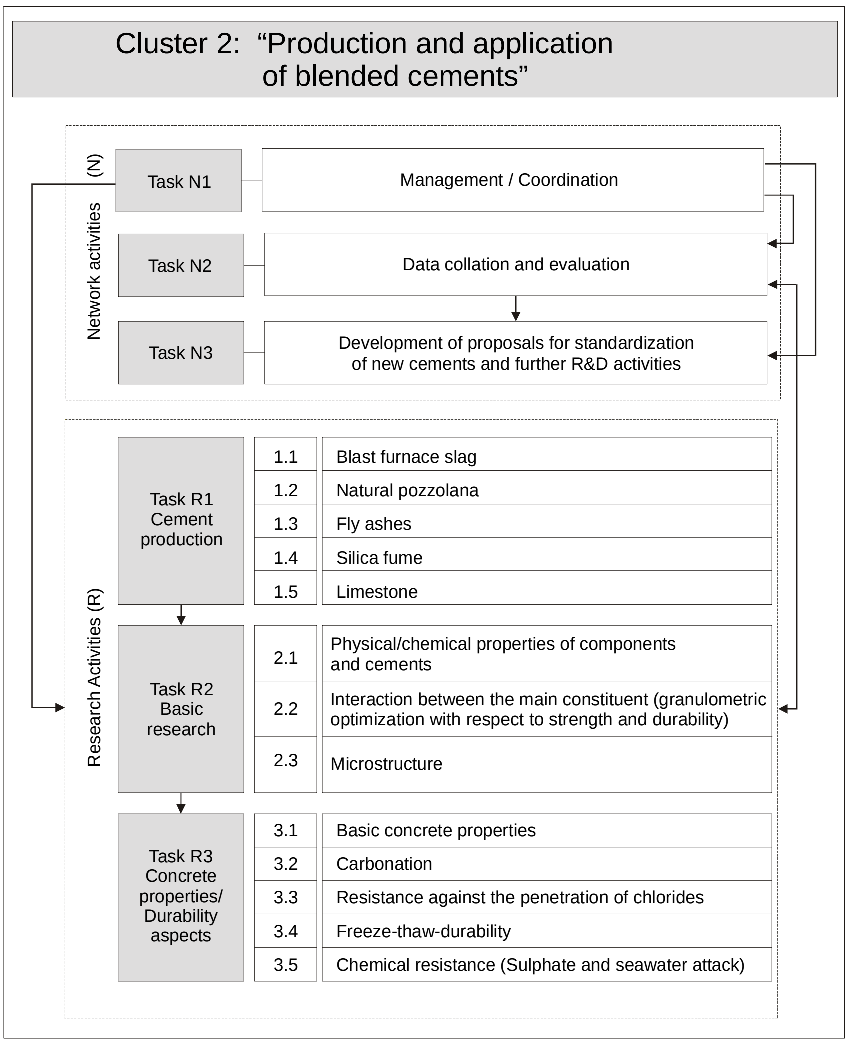


Figure 1: Structure of cluster 2

On top of that the cluster will directly support standardisation, as most of the partners of cluster 2 are members in national and European standardization committees. Results of data collation and the laboratory tests can be used to revise and harmonize national application rules for cements according to EN 197-1. In addition pre-normative research work will be done concerning cements with compositions beyond EN 197-1. The results will be directly useful for the standardisation work taking place in CEN. In addition all partners of cluster 2 will take part in the dissemination of the results from publications and lectures as well as discussions with end-users of cement i. e. concrete producers, building authorities and construction standardization committees. For example VDZ offers a range of one day or several day seminars in the areas of cement production, quality assurance, environmental protection, concrete constituents, concrete manufacture and the performance of concrete. In these seminars VDZ will inform the cement industry about the possibilities concerning the production of blended cements.

7 Management and co-ordination aspects

In the period under review two cluster meetings took place on 05.09.2003 and 18.10.2003 at the Research Institute of the Cement Industry, Düsseldorf, Germany. During the meetinga, partners agreed on the final operational description of work including the schedule for the procedures and the test methods. The results of the discussion are summarised in table 7.

Table 7: Overview of test methods

Task	Subject	Test method / Concrete composition	
2.1	Physical and chemical properties of com-ponents and cements	Particle size distribution, Blaine, EN 196	
2.2	Interaction between the main constituents	No Test method required	
2.3	Microstructure	Standard: Water uptake under atmospheric pressure and 15 MPa. REMARK: Pore size distribution with Hg-Intrusion is optional.	
3.1	Basic concrete properties	Fresh concrete: EN 12350 Hardened concrete: EN 12390 Compressive strength 2d, 7d, 28d, 90d	c = 280 kg/m^3 w/c = 0,60 c = 320 kg/m^3 w/c = 0,50
3.2	Carbonation	Beams 100 x 100 x 400 mm^3 1d moulded, 6d water storage, (20±2) °C / (65±5) % r. H. Evaporation in the climate chamber: (45±15) g/(m^2·h)	c = 280 kg/m^3 w/c = 0,60
3.3	Penetration of chlorides	Rapid chloride migration method (RCM) - comp. Brite EuRam III project DuraCrete	c = 320 kg/m^3 w/c = 0,50

Table 7: Continuation

Task	Subject	Test method / Concrete composition	
3.4	Freeze-thaw resistance	Beam test	c = 320 kg/m^3 w/c = 0,50
	Freeze-thaw resistance with de-icing salt	Slab test	c = 320 kg/m^3 w/c = 0,50, AE
3.5	Sulphate resistance	There is no Europeanwide accepted test method for the determination of the sulphate resistance of mortar or concrete. Partners will use the test methods, which are commonly used in their countries.	

The minutes of the meetings are given in annex B (Documents ECO-Serve-C2-R-0005 and ECO-Serve-C2-N-0019). Scheduled meeting for November 2004 was postponed to spring 2005. It is planned to have the meeting together with the network group. Necessary arrangements between the meetings have been made by emial and telefone.

Table 8: Man Power and Progress Follow-up Table – Task R1

		- - - - - - - - - Man-Month - - - - - - - - - - -									- - - - - - Technical Progress % - - - - - -			
Task/Subtask (N°/title)	**Partner (Name/ abbrev.)**	**Planned efforts - at start of period (MM)**				**Actual effort (MM)**	**Forecast effort (MM)**			***Devia-tion (MM)***	**Planned (%)**	**Assessed* (%)**	***Devia-tion (%)***	***Comments on major deviations and/or modifications of planned efforts.***
		Year 1	**Year 2**	**Year 3**	**Total**	**Year 1**	**Year 2**	**Year 3**	**Total**	***Totals***	**Year 1**	**Year 1**	***Year (now)***	
		a	b	c	d	a1	b1	c1	d1	d1-d				
Task R1 Cement production														
Sub-task 1.1	1	1			**1**	1			**1**		100%	100%		
Blast furnace slag	2	0,9			**0,9**	0,9			**0,9**		100%	100%		
	3	0,3			**0,3**	0,3			**0,3**		100%	100%		
	5													
	Total	**2,2**			**2,2**	**2,2**			**2,2**		**100%**	**100%**		
Sub-task 1.2	1													
Natural pozzolana	2	0,9			**0,9**	0,9			**0,9**		100%	100%		
	3													
	5	0,5			**0,5**	0,5			**0,5**		100%	100%		
	Total	**1,4**			**1,4**	**1,4**			**1,4**		**100%**	**100%**		
Sub-task 1.3	1	1			**1**	0,5			**0,5**	***-0,5***	100%	100%		Investigations on fly ashes have been reduced.
Fly ashes	2													
	3	0,3			**0,3**	0,3			**0,3**		100%	100%		
	5	0,3			**0,3**	0,3			**0,3**		100%	100%		
	Total	**1,6**			**1,6**	**1,1**			**1,1**	***-0,5***	**100%**	**100%**		
Sub-task 1.4	1	1			**1**					***-1***	100%	#DIV/0!	*#DIV/0!*	Investigations on silica fume were canceled.
Silica fume	2													
	3	0,3			**0,3**					***-0,3***	100%	#DIV/0!	*#DIV/0!*	Investigations on silica fume were canceled.
	5	0,3			**0,3**					***-0,3***	100%	#DIV/0!	*#DIV/0!*	Investigations on silica fume were canceled.
	Total	**1,6**			**1,6**					***-1,6***	**100%**	**#DIV/0!**	***#DIV/0!***	
Sub-task 1.5	1	1			**1**	2			**2**	***1***	100%	100%		Investigations on limestone were expanded.
Limestone	2	0,9			**0,9**	0,9			**0,9**		100%	100%		
	3	0,3			**0,3**	0,6			**0,6**	***0,3***	100%	100%		Investigations on limestone were expanded.
	5	0,3			**0,3**	0,6			**0,6**	***0,3***	100%	100%		Investigations on limestone were expanded.
	Total	**2,5**			**2,5**	**4,1**			**4,1**	***1,6***	**100%**	**100%**		
TOTALS	**1**	**4**			**4**	**3,5**			**3,5**	**-0,5**	**100%**	**100%**		
	2	**2,7**			**2,7**	**2,7**			**2,7**		**100%**	**100%**		
	3	**1,2**			**1,2**	**1,2**			**1,2**		**100%**	**100%**		
	5	**1,4**			**1,4**	**1,4**			**1,4**		**100%**	**100%**		
	TOTAL	**9,3**			**9,3**	**8,8**			**8,8**	**-0,5**	**100%**	**100%**		

Table 9: Man Power and Progress Follow-up Table – Task R2

Task/Subtask (N°/title)	Partner (Name/ abbrev.)	--------- Man-Month ----------- Planned efforts - at start of period (MM) Year 1 (a)	Year 2 (b)	Year 3 (c)	Total (d)	Actual effort (MM) Year 1 (a1)	Forecast effort (MM) Year 2 (b1)	Year 3 (c1)	Total (d1)	*Deviation (MM) Totals* (d1-d)	------- Technical Progress % ------- Planned (%) Year 1	Assessed* (%) Year 1	*Deviation (%) Year (now)*	***Comments on major deviations and/or modifications of planned efforts.***
Task R2 Basic Research														
Sub-task 2.1	1	1	1		**2**	1	1		**2**		50%	50%		
Physical and chemical	2	0,5	0,5		**1**	0,5	0,5		**1**		50%	50%		
properties of components	3	0,5	0,5		**1**	0,5	0,5		**1**		50%	50%		
and cements	5	1	1		**2**	1	1		**2**		50%	50%		
	Total	**3**	**3**		**6**	**3**	**3**		**6**		**50%**	**50%**		
Sub-task 2.2	1	1	1		**2**	2,5	2		**4,5**	***2,5***	50%	56%	*6%*	More modifications with regard to the cement composition were necessary.
Interaction between	2	0,5	0,5		**1**	0,5	0,5		**1**		50%	50%		
main constituents	3	0,5	0,5		**1**	0,5	0,5		**1**		50%	50%		
	5	1	1		**2**	1	1		**2**		50%	50%		
	Total	**3**	**3**		**6**	**4,5**	**4**		**8,5**	***2,5***	**50%**	**53%**	***3%***	
Sub-task 2.3	1	1	1		**2**	1	1		**2**		50%	50%		
Microstructure	2	0,5	0,5		**1**	0,5	0,5		**1**		50%	50%		
	3	0,5	0,5		**1**	0,5	0,5		**1**		50%	50%		
	5	1	1		**2**	1	1		**2**		50%	50%		
	Total	**3**	**3**		**6**	**3**	**3**		**6**		**50%**	**50%**		
	1													
	2													
	3													
	5													
	Total													
	1													
	2													
	3													
	5													
	Total													
TOTALS	**1**	**3**	**3**		**6**	**4,5**	**4**		**8,5**	**2,5**	**50%**	**53%**	**3%**	
	2	**1,5**	**1,5**		**3**	**1,5**	**1,5**		**3**		**50%**	**50%**		
	3	**1,5**	**1,5**		**3**	**1,5**	**1,5**		**3**		**50%**	**50%**		
	5	**3**	**3**		**6**	**3**	**3**		**6**		**50%**	**50%**		
	TOTAL	**9**	**9**		**18**	**10,5**	**10**		**20,5**	**2,5**	**50%**	**51%**	**1%**	

Table 10: Man Power and Progress Follow-up Table – Task R3

Task/Subtask (N°/title)	Partner (Name/ abbrev.)	Planned efforts - at start of period (MM) Year 1	Year 2	Year 3	Total	Actual effort (MM) Year 1	Forecast effort (MM) Year 2	Year 3	Total	*Deviation (MM) Totals*	Planned (%) Year 1	Assessed* (%) Year 1	*Deviation (%) Year (now)*	***Comments on major deviations and/or modifications of planned efforts.***
		- - - - - - - - - Man-Month	- - - - - - - - - - -								- - - - - - Technical Progress % - - - - - -			
		a	b	c	d	a1	b1	c1	d1	d1-d				
Task R3 Concrete Properties / Durability aspects														
Sub-task 3.1	1	2	2		**4**	2	2		**4**		50%	50%		
Basic concrete properties	2	0,5	0,5		**1**		1,5		**1,5**	***0,5***	50%		*-50%*	Production of trial mixes was postponed to the next period. Investigations will be expanded.
	3	0,5	0,5		**1**		1		**1**		50%		*-50%*	Production of trial mixes was postponed to the next period.
	5	0,5	0,5		**1**	0,5	0,5		**1**		50%	50%		
	Total	**3,5**	**3,5**		**7**	**2,5**	**5**		**7,5**	***0,5***	**50%**	**33%**	***-17%***	
Sub-task 3.2	1	2	2		**4**	2	2		**4**		50%	50%		
Carbonation	2	0,5	0,5		**1**		0,5		**0,5**	***-0,5***	50%		*-50%*	Production of trial mixes was postponed to the next period.Investigations will be reduced.
	3	0,5	0,5		**1**		1		**1**		50%		*-50%*	Production of trial mixes was postponed to the next period.
	5	0,5	0,5		**1**	0,5	0,5		**1**		50%	50%		
	Total	**3,5**	**3,5**		**7**	**2,5**	**4**		**6,5**	***-0,5***	**50%**	**38%**	***-12%***	
Sub-task 3.3	1	2	2		**4**	2	2,5		**4,5**	***0,5***	50%	44%	*-6%*	VDZ will make investigations on chloride penetration for NORCEM
Penetration of chlorides	2	0,5	0,5		**1**		1		**1**		50%		*-50%*	Production of trial mixes was postponed to the next period. VDZ will make investigations on chloride penetration for NORCEM
	3	0,5	0,5		**1**		0,5		**0,5**	***-0,5***	50%		*-50%*	Production of trial mixes was postponed to the next period.
	5													
	Total	**3**	**3**		**6**	**2**	**4**		**6**		**50%**	**33%**	***-17%***	
Sub-task 3.4	1	2	2		**4**	2	2		**4**		50%	50%		
Freeze-thaw durability	2	0,5	0,5		**1**		1		**1**		50%		*-50%*	Production of trial mixes was postponed to the next period.
	3	0,5	0,5		**1**		1		**1**		50%		*-50%*	Production of trial mixes was postponed to the next period.
	5													
	Total	**3**	**3**		**6**	**2**	**4**		**6**		**50%**	**33%**	***-17%***	
Sub-task 3.5	1	2	2		**4**	1	1		**2**	***-2***	50%	50%		Investigations on chemical resistance was reduced
Chemical resistance	2	0,5	0,5		**1**		1		**1**		50%		*-50%*	Production of trial mixes was postponed to the next period.
	3	0,5	0,5		**1**		1		**1**		50%		*-50%*	Production of trial mixes was postponed to the next period.
	5	0,5	0,5		**1**	0,5	0,5		**1**		50%	50%		
	Total	**3,5**	**3,5**		**7**	**1,5**	**3,5**		**5**	***-2***	**50%**	**30%**	***-20%***	
TOTALS	**1**	**10**	**10**		**20**	**9**	**9,5**		**18,5**	**-1,5**	**50%**	**49%**	**-1%**	
	2	**2,5**	**2,5**		**5**		**5**		**5**		**50%**		**-50%**	
	3	**2,5**	**2,5**		**5**		**4,5**		**4,5**	**-0,5**	**50%**		**-50%**	
	5	**1,5**	**1,5**		**3**	**1,5**	**1,5**		**3**		**50%**	**50%**		
	TOTAL	**16,5**	**16,5**		**33**	**10,5**	**9**		**31**	**-2**	**50%**	**34%**	**-16%**	

Table 11: Man Power and Progress Follow-up Table – Total Research

		- - - - - - - - - Man-Month - - - - - - - - - - -									- - - - - - Technical Progress % - - - - - -			
Task/Subtask (N°/title)	**Partner** (Name/ abbrev.)	**Planned efforts - at start of period (MM)**				**Actual effort (MM)**	**Forecast effort (MM)**			***Devia-tion (MM)***	**Planned (%)**	**Assessed* (%)**	***Devia-tion (%)***	***Comments on major deviations and/or modifications of planned efforts.***
		Year 1	**Year 2**	**Year 3**	**Total**	**Year 1**	**Year 2**	**Year 3**	**Total**	***Totals***	**Year 1**	**Year 1**	***Year (now)***	
		a	b	c	d	a1	b1	c1	d1	d1-d				
TOTALS	**1**	**17**	**13**		**30**	**17**	**13,5**		**30,5**	**0,5**	**57%**	**56%**	**-1%**	
	2	**6,7**	**4**		**10,7**	**4,2**	**6,5**		**10,7**		**63%**	**39%**	**-23%**	
	3	**5,2**	**4**		**9,2**	**2,7**	**6**		**8,7**	**-0,5**	**57%**	**31%**	**-25%**	
	5	**5,9**	**4,5**		**10,4**	**5,9**	**4,5**		**10,4**		**57%**	**57%**		
	TOTAL	**34,8**	**25,5**		**60,3**	**29,8**	**30,5**		**60,3**		**58%**	**49%**	**-8%**	

Table 12: Man Power and Progress Follow-up Table – Co-ordination

		- - - - - - - - - Man-Month - - - - - - - - - - -									- - - - - - - Technical Progress % - - - - - - -			
Task/Subtask (N°/title)	**Partner** (Name/ abbrev.)	**Planned efforts - at start of period (MM)**				**Actual effort (MM)**	**Forecast effort (MM)**			***Devia-tion (MM)***	**Planned (%)**	**Assessed* (%)**	***Devia-tion (%)***	***Comments on major deviations and/or modifications of planned efforts.***
		Year 1	**Year 2**	**Year 3**	**Total**	**Year 1**	**Year 2**	**Year 3**	**Total**	***Totals***	**Year 1**	**Year 1**	***Year (now)***	
		a	b	c	d	a1	b1	c1	d1	d1-d				
Co-ordination														
Co-ordination	1 2 3 5	1	1		**2**	0,9	1,1		**2**		50%	45%	-5%	
	Total	**1**	**1**		**2**	**0,9**	**1,1**		**2**		**50%**	**45%**	**-5%**	
TOTALS	**1** **2** **3** **5**	**1**	**1**		**2**	**0,9**	**1,1**		**2**		**50%**	**45%**	**-5%**	
	TOTAL	**1**	**1**		**2**	**0,9**	**1,1**		**2**		**50%**	**45%**	**-5%**	

Table 13: Time table and manpower distribution

CLUSTER 2 - Research — MANPOWER BARCHART

Task-/Sub-task descriptions			1st year (Month) 3	6	9	12	2nd year 15	18	21	24	3rd year 27	30	33	36	4th year 39	42	45	48
Task	**R1**	**Cement production**																
Sub-task	1.1	Blast furnace slag																
Sub-task	1.2	Natural pozzolana																
Sub-task	1.3	Fly ashes																
Sub-task	1.4	Silica fume																
Sub-task	1.5	Limestone																
Total																		
Task	**R2**	**Basic research**																
Sub-task	2.1	Physical and chemical properties of components and cements																
Sub-task	2.2	Interaction between the main constituents																
Sub-task	2.3	Microstructure																
Total																		
Task	**R3**	**Concrete properties / Durability aspects**																
Sub-task	3.1	Basic concrete properties																
Sub-task	3.2	Carbonation																
Sub-task	3.3	Penetration of chlorides																
Sub-task	3.4	Freeze-thaw-durability																
Sub-task	3.5	Chemical resistance																
Total																		
Total																		
Major Milestones			M			M		M		M						M		

MANMONTH

Task-/Sub-task descriptions			1st year Partner 1	2	3	4	5	6	7	2nd year Partner 1	2	3	4	5	6	7	3rd year Partner 1	2	3	4	5	6	7	4th year Partner 1	2	3	4	5	6	7	Total	Partner 1	2	3	4	5	6	7
Task	**R1**	**Cement production**																																				
Sub-task	1.1	Blast furnace slag								1,0	0,9	0,3																			2,2	1,0	0,9	0,3				
Sub-task	1.2	Natural pozzolana									0,9			0,5																	1,4		0,9			0,5		
Sub-task	1.3	Fly ashes								0,5		0,3		0,3																	1,1	0,5		0,3		0,3		
Sub-task	1.4	Silica fume								0,0		0,0		0,0																								
Sub-task	1.5	Limestone								**2,0**	0,9	**0,6**		**0,6**																	4,1	2,0	0,9	0,6		0,6		
Total										3,5	2,7	1,2		1,4																	8,8	3,5	2,7	1,2		1,4		
Task	**R2**	**Basic research**																																				
Sub-task	2.1	Physical and chemical properties of components and cements								1,0	0,5	0,5		1,0			1,0	0,5	0,5		1,0										6,0	2,0	1,0	1,0		2,0		
Sub-task	2.2	Interaction between the main constituents								**2,5**	0,5	0,5		1,0			**2,0**	0,5	0,5		1,0										8,5	4,5	1,0	1,0		2,0		
Sub-task	2.3	Microstructure								1,0	0,5	0,5		1,0			1,0	0,5	0,5		1,0										6,0	2,0	1,0	1,0		2,0		
Total										4,5	1,5	1,5		3,0			4,0	1,5	1,5		3,0										20,5	8,5	3,0	3,0		6,0		
Task	**R3**	**Concrete properties / Durability aspects**																																				
Sub-task	3.1	Basic concrete properties								2,0	0,0	0,0		0,5			2,0	**1,5**	**1,0**		0,5										7,5	4,0	1,5	1,0		1,0		
Sub-task	3.2	Carbonation								2,0	0,0	0,0		0,5			2,0	**0,5**	**1,0**		0,5										6,5	4,0	0,5	1,0		1,0		
Sub-task	3.3	Penetration of chlorides								2,0	0,0	0,0					**2,5**	**1,0**	**0,5**												6,0	4,5	1,0	0,5				
Sub-task	3.4	Freeze-thaw-durability								2,0	0,0	0,0					2,0	**1,0**	**1,0**												6,0	4,0	1,0	1,0				
Sub-task	3.5	Chemical resistance								1,0	0,0	0,0		0,5			1,0	**1,0**	**1,0**		0,5										5,0	2,0	1,0	1,0		1,0		
Total										9,0				1,5			9,5	5,0	4,5		1,5										31,0	18,5	5,0	4,5		3,0		
Total										17,0	4,2	2,7		5,9			13,5	6,5	6,0		4,5										60,3	30,5	10,7	8,7		10,4		
Major Milestones																															60,3							

Table 14: Budget Follow-up Table

-2002-00782 | **Project N°:** | **Date:**

Serve | *) total budget figures - not EC funding

Note: If less than 10 partners: Use "format" + "rows" + "hide" to hide the rows not used.

Cost Category	ORIGINAL *) BUDGET (EUR)	REVISED *) BUDGET (EUR)	ACTUAL COSTS (EUR) Year 1	Year 2	Year 3	Year 4	Total	Total Pct. Spent (%) Year 1	Year 2	Year 3	Year 4	Remaining Budget (EUR)	*Comments on major deviations from budget.*
	Request(R) / Accept(A):		R / A	R / A	R / A	R / A							
	e	e	a1	b1	c1	d1	e1	a1/e	a1+b1/e	a1+b1+c1 /e	a1+b1+ c1+d1/e	e-e1	
Manhours	**4640,2**	**4640,2**		**2581**			**2581**	**0%**	**56%**	**0%**	**0%**	**2059,2**	
Personnel	128253	128253		70.929,00			70929	0%	55%	0%	0%	57324,0	
Overheads	102602	102602		56.743,20			56743,2	0%	55%	0%	0%	45858,8	
Labour+Overheads	**230855**	**230855**	**0**	**127672,2**	**0**	**0**	**127672,2**	**0%**	**55%**	**0%**	**0%**	**103182,8**	
Durable equipment	7500	7500		3.535,32			3535,317	0%	47%	0%	0%	3964,7	
Subcontracting	0	0		0			0	0%	#DIV/0!	0%	0%	0,0	
Travel and subsistence	0	0		0			0	0%	#DIV/0!	0%	0%	0,0	
Consumables	5000	5000		2.124,98			2124,98	0%	42%	0%	0%	2875,0	
Computing	0	0		0			0	0%	#DIV/0!	0%	0%	0,0	
Protection of knowledge	0	0		0			0	0%	#DIV/0!	0%	0%	0,0	
Other specific costs	5000	5000		2.144,04			2144,04	0%	43%	0%	0%	2856,0	
Total (Req'st/Accept)	248355	248355	0	135476,5	0	0	135476,5	0%	55%	0%	0%	112878,5	
Total Requested:	248355	248355					0					248355,0	
Manhours	**1480**	**1480**		**275**			**275**	**0%**	**19%**	**0%**	**0%**	**1205,0**	
Personnel	33511	33511		7051,34			7051,34	0%	21%	0%	0%	26459,7	
Overheads	26810	26810		5641,07			5641,07	0%	21%	0%	0%	21168,9	
Labour+Overheads	**60321**	**60321**	**0**	**12692,41**	**0**	**0**	**12692,41**	**0%**	**21%**	**0%**	**0%**	**47628,6**	
Durable equipment	0	0					0	0%	#DIV/0!	0%	0%	0,0	
Subcontracting	0	0					0	0%	#DIV/0!	0%	0%	0,0	
Travel and subsistence	0	0					0	0%	#DIV/0!	0%	0%	0,0	
Consumables	0	0					0	0%	#DIV/0!	0%	0%	0,0	
Computing	0	0					0	0%	#DIV/0!	0%	0%	0,0	
Protection of knowledge	0	0					0	0%	#DIV/0!	0%	0%	0,0	
Other specific costs	0	0					0	0%	#DIV/0!	0%	0%	0,0	
Total (Req'st/Accept)	60321	60321	0	12692,41	0	0	12692,41	0%	21%	0%	0%	47628,6	
Total Requested:	60321	60321					0					60321,0	
Manhours	**986**	**986**		**333**			**333**	**0%**	**34%**	**0%**	**0%**	**653,0**	
Personnel	47472	47472		13738,33			13738,33	0%	29%	0%	0%	33733,7	
Overheads	37977	37977		10991,21			10991,21	0%	29%	0%	0%	26985,8	
Labour+Overheads	**85449**	**85449**	**0**	**24729,54**	**0**	**0**	**24729,54**	**0%**	**29%**	**0%**	**0%**	**60719,5**	
Durable equipment	0	0					0	0%	#DIV/0!	0%	0%	0,0	
Subcontracting	0	0					0	0%	#DIV/0!	0%	0%	0,0	
Travel and subsistence	0	0					0	0%	#DIV/0!	0%	0%	0,0	
Consumables	5000	5000					0	0%	0%	0%	0%	5000,0	
Computing	0	0					0	0%	#DIV/0!	0%	0%	0,0	
Protection of knowledge	0	0					0	0%	#DIV/0!	0%	0%	0,0	
Other specific costs	5000	5000					0	0%	0%	0%	0%	5000,0	
Total (Req'st/Accept)	95449	95449	0	24729,54	0	0	24729,54	0%	26%	0%	0%	70719,5	
Total Requested:	95449	95449					0					95449,0	

Table 14: Continuation

Partner 4 (5) TITAN	**Manhours**	**2080**	**2080**		**811,25**			**811,25**	**0%**	**39%**	**0%**	**0%**	**1268,8**
	Personnel	39434	39434		22372,08			22372,08	0%	57%	0%	0%	17061,9
	Overheads	23661	23661		13423,25			13423,25	0%	57%	0%	0%	10237,8
	Labour+Overheads	**63095**	**63095**	**0**	**35795,33**	**0**	**0**	**35795,33**	**0%**	**57%**	**0%**	**0%**	**27299,7**
	Durable equipment	0	0					0	0%	#DIV/0!	0%	0%	0,0
	Subcontracting	0	0					0	0%	#DIV/0!	0%	0%	0,0
	Travel and subsistence	0	0					0	0%	#DIV/0!	0%	0%	0,0
	Consumables	5000	5000					0	0%	0%	0%	0%	5000,0
	Computing	0	0					0	0%	#DIV/0!	0%	0%	0,0
	Protection of knowledge	0	0					0	0%	#DIV/0!	0%	0%	0,0
	Other specific costs	5000	5000					0	0%	0%	0%	0%	5000,0
	Total (Req'st/Accept)	73095	73095	0	35795,33	0	0	35795,33	0%	49%	0%	0%	37299,7
	Total Requested:	73095	73095					0					73095,0
TOTAL	**Manhours**	**9186,2**	**9186,2**	**0**	**4000,25**	**0**	**0**	**4000,25**	**0%**	**44%**	**0%**	**0%**	**5186,0**
	Personnel	248670	248670	0	114090,75	0	0	114090,75	0%	46%	0%	0%	134579,3
	Overheads	191050	191050	0	86798,73	0	0	86798,73	0%	45%	0%	0%	104251,3
	Labour+Overheads	**439720**	**439720**	**0**	**200889,48**	**0**	**0**	**200889,48**	**0%**	**46%**	**0%**	**0%**	**238830,5**
	Durable equipment	7500	7500	0	3535,317	0	0	3535,317	0%	47%	0%	0%	3964,7
	Subcontracting	0	0	0	0	0	0	0	0%	#DIV/0!	0%	0%	0,0
	Travel and subsistence	0	0	0	0	0	0	0	0%	#DIV/0!	0%	0%	0,0
	Consumables	15000	15000	0	2124,98	0	0	2124,98	0%	14%	0%	0%	12875,0
	Computing	0	0	0	0	0	0	0	0%	#DIV/0!	0%	0%	0,0
	Protection of knowledge	0	0	0	0	0	0	0	0%	#DIV/0!	0%	0%	0,0
	Other specific costs	15000	15000	0	2144,04	0	0	2144,04	0%	14%	0%	0%	12856,0
	Total (Req'st/Accept)	477220	477220	0	208693,817	0	0	208693,817	0%	44%	0%	0%	268526,2
	Total Requested:	477220	477220	0	0	0	0	0					477220,0

TOTAL PAYMENTS RECEIVED:	Total EC Funding	Advance	Year 1	Year 2	Year 3	Year 4	Total		Remaining
	238608	95441					95441		143167,0

Note: Year 1 of research = year 2 of the network

"Total requested" shows the originally requested amount of the
statements -
"Total Accepted/Requested" are the approved amounts - adjusted
reflect the approved costs according to the "Releve de Compte" !!

8 Annex A: Activities of the partners (Detailed reports)

8.1 Partner 1: VDZ

8.1.1 General

Accordung to the objectives of cluster 2 the investigations will include

- the production and testing of cements with maximum amounts of main constituents besides clinker acc. to EN 197-1 and
- the production and testing of cements with a composition beyond the limits of EN 197-1.

The following cements were planned to be investigated:

Table 15: Cements investigated by VDZ

Cements	Explanation
Cements with maximum amounts of main constituents besides clinker acc. to EN 197-1	
CEM II-W and CEM II-M (S-W)	• 2 Fly ashes (W): - 1 x Lusatian area - 1 x Mitteldeutsches Revier • 1 Clinker, 1 GBBS • 10, 20 or 30 % Fly ash (CEM II-W) • K/S/W = 65/10/25, 65/15/20, 65/20/15 (CEM II-M (S-W))
CEM II-LL	• 3 Limestone: Devon, Cretaceous, Jura • 65 % clinker, 35 % limestone
Cements with a composition beyond the limits of EN 197-1.	
CEM with LL	• Limestone: Devon • 55 % clinker, 45 % limestone
CEM V	• Limestone / GBBS - 30 % GBFS, 20 % limestone - 50 % GBFS, 20 % limestone

Besides clinker (K), granulated blastfurnace slag (GBFS), calcareous fly ash (W) and limestone (LL) will be used as main constituents.

8.1.2 Granulated blast furnace slag (GGBS)

In the year 2000, more than 66 % out of 7,53 Mio t blastfurnace slag were granulated and almost completely used as cementitious materials in Germany [8]. Middle European granulated blastfurnace slags usually consist of more than 95 % glassy particles. The EN 197-1 requires a glassy slag content of at least two-thirds by mass. Chemically, the slag has to consist of at least two-thirds of CaO, MgO and SiO_2, while the ratio of (CaO + MgO)/(SiO_2) shall exceed 1,0. The fulfilment of these requirements is seen to be the prerequisite for the slag to possess latent hydraulic properties and so be suitable for cement production.

Additional chemical parameters have been established in practice as hydraulic activity indexes to describe slag properties. The application experience reveals that a simple consideration of the CaO, MgO and SiO_2 content is not always sufficient. High amounts of Al_2O_3 can enhance the reactivity of slag, whereas high TiO_2 and MnO contents can reduce its hydraulic properties. Moreover, the glass content of GBS plays a key role in view of the reactivity. Evidently, not only the absolute glass content but also the glass structure, which can be influenced by the chemistry as well as by the quenching conditions during granulation, are of importance.

8.1.3 Calcareous fly ash

Due to their chemical composition, German lignite fly ashes basically correspond to the category of calcareous fly ash according to EN 197-1. They may be utilized as cement main constituents, if they contain at least 10,0 mass.-% reactive CaO. If the proportion of reactive CaO does not exceed 15,0 mass.-%, the ash has to contain at least 25,0 mass.-%. reactive SiO_2. Calcareous fly ash containing more than 15,0 mass.-% reactive CaO has to achieve a compressive strength of 10,0 MPa according to EN 196-1. For this test the fly ash has to be adequately ground and must replace the cement in the mortar by 100 %. The soundness of calcareous fly ash shall not exceed 10 mm when tested in accordance with EN 196-3 using a mixture of 30 wt-% of fly ash and 70 mass.-% of a CEM I cement.

In Germany 8 Mio t calcareous fly ash per year are produced, which are predominantly used to recultivate the exploited coal mining fields and mines. About 10 % of the ashes are available for alternative uses. Actually, German lignite fly ashes play only a minor role as cement main constituents, although developments of cementitious binders containing CFA have been in progress during the past five decades in Germany. In 1972 fly ash was established as a cement component by the standards of Eastern Germany [5, 6]. For the past years, selected calcareous fly ashes have been certified as concrete additions [3].

8.1.4 Limestone

In Germany Portland-limestone cements with a limestone content up to 20 wt-% were developed by the cement manufacturers during the 1980ies and were established then as cements with technical approval. After a practical experience of more than 10 years in building construction and structural engineering they were included in the national standard DIN 1164-1:1994 as CEM II/A-L. Limestone used in these cements meets the following requirements according to EN 197-1:2000:

The calcium carbonate ($CaCO_3$) content calculated from the calcium oxide content shall be at least 75 % by mass.

The clay content, determined by the methylene blue test in accordance with EN 933-9, shall not exceed 1,20 g/100 g. For this test the limestone shall be ground to a fineness of approximately 5000 cm^2/g determined as specific surface in accordance with EN 196-3 (Blaine).

The total organic carbon (TOC) content shall not exceed 0,20 mass.%. This type of limestone is marked with the letter „LL“ according to EN 197-1:2000. Therefore these Portland-limestone cements are now called CEM II/A-LL.

The performance of concrete manufactured from Portland-limestone cement CEM II/A-LL, in terms of fresh and hardened concrete properties and durability, has been verified by extensive laboratory investigations and practical experiences. In particular the freeze-thaw resistance of concretes, which fulfil the minimum requirements of the exposure class XF4 (freeze/thaw attack on concrete with high water saturation with de-icing salt or sea water) according to the German concrete standard DIN 1045-2, is generally high and can be compared to that of Portland cement concrete. In road construction Portland-limestone cement CEM II/A-LL may be used for the same applications as Portland cement. In general the strength development of concretes using Portland-limestone cement CEM II/A-LL is comparable to concretes with Portland cement CEM I of otherwise identical composition [7].

With the introduction of EN 197-1 further Portland-limestone cements have been standardized in addition to the CEM II/A-LL cements. Now it is possible to use limestone contents of up to 35 mass.% (CEM II/B-LL) as well as limestone with TOC contents of up to 0,50 mass.%. Portland-limestone cement with increased TOC contents in the limestone is labelled with the letter „L“.

Building practice experience with Portland-limestone cements of up to 35 mass.% is not available in Germany. Currently they may not yet be used for concrete with high resistance to freeze thaw or freeze thaw with de-icing salt.

8.1.5 Characterization of the starting materials

Laboratory cements on the one hand will be produced by mixing clinker, sulphate agent and the other main constituents. On the other hand, cements will be produced using Portland cements usual in the market mixing with the other main constituents.

The final selection of the two calcareous fly ashes has not yet been finished. Table 16 shows the chemical composition of representative calcareous fly ashes from the Rhenish and the Lusatian area (VDZ-data) and from the Mitteldeutsches Revier (literature). Particulary the Rhenish fly ash contains higher amounts of free lime. Also free magnesia (perclase) can be detected by X-ray diffraction. Probably the fly ash from the Lusatian area and onother fly ash from the Mitteldeutsches Revier will be used for further investigations.

Table 16: Chemical composition of two representative calcareous fly ashes from the Rhenish (R) and the Lusatian (L) area (VDZ-data) and from the Mitteldeutsches Revier [1]

Parameter	Unit	R1	L1	Mitteldeutsches Revier [1]
1	2	3	4	5
SiO_2	mass.-%	34,8	38,8	40 – 60
Al_2O_3		3,80	8,41	7 – 16
TiO_2		0,39	0,73	n. s.
P_2O_5		0,02	0,03	n. s.
Fe_2O_3		11,9	22,8	6 – 14
CaO		31,7	18,8	12 – 33
MgO		8,52	6,53	1 – 6
SO_3		7,04	2,70	1 – 7
K_2O		0,35	0,72	n. s.
Na_2O		1,21	0,17	n. s.
loss on ignition		1,76	0,66	n. s.
reactive CaO		27,0	17,3	n. s.
reactive SiO_2		7,79	12,8	n. s.
free lime		8,85	0,34	n. s.

Table 17 shows the chemical composition of the starting materials portland cement clinker, portland cement, granulated blastfurnace slag and limestone.

Table 17: Chemical composition of the starting materials for the production of blended cements

Parameter	Unit	C1	PC1	PC2	PC3	S1	LL1	LL2	LL3
1	2	3	4	5	6	7	8	9	10
SiO_2	mass.-%	21,2	23,6	22,5	22,5	35,3	0,15	3,47	0,43
Al_2O_3		5,91	3,90	3,65	3,71	12,1	0,01	0,59	0,43
TiO_2		0,27	0,22	0,21	0,21	0,76	0,03	0,05	0,17
P_2O_5		0,10	0,13	0,12	0,13	0,02	0,01	0,06	0,05
Fe_2O_3		2,61	1,31	1,23	1,26	0,38	0,01	0,16	0,03
CaO		66,1	64,7	65,5	65,8	40,6	55,5	53,4	56,3
MgO		1,44	0,76	0,76	0,73	8,88	0,42	0,28	0,16
SO_3		0,80	2,45	3,66	3,34	0,25	0,03	0,61	0,02
S^{2-}		n. d.	n. d.	n. d.	n. d.	0,78	n. d.	n. d.	n. d.
K_2O		0,95	0,73	0,73	0,64	0,44	0,02	0,15	0,02
Na_2O		0,18	0,16	0,16	0,16	0,31	0,02	0,04	0,01
Na_2O-eq.		0,81	0,64	0,64	0,58	0,60	0,03	0,14	0,02
CO_2		0,14	1,66	0,90	0,60	0,11	43,4	40,3	42,5
TOC		n. d.	n. d.	n. d.	n. d.	n. d.	0,013	0,074	0,013
Clay content	g/100g	n. d.	n. d.	n. d.	n. d.	n. d.	0,03	0,40	0,13
C_3S	mass.-% [1)]	64,5	52,5	62,7	63,3	-	-	-	-
C_2S		12,4	29,4	18,1	17,9	-	-	-	-
C_3A		11,3	8,28	7,69	7,82	-	-	-	-
C_4AF		7,97	4,08	3,80	3,90	-	-	-	-
C1: Portland cement clinker									
PC1 – PC3: Portland cement CEM I									
S1: Granulated blastfurnace slag (GBFS)									
LL1-LL3: Limestone									
1) acc. to Bogue									
R.f. = Results following									

8.1.6 Cements

During the period under review, the cements presented in tables 18 and 19 have been produced and/or investigated.

Partners aggreed (ECO-Serve-C2-R-0005), that the planned strength after 28 d for all cements is 45 - 50 MPa acc. to EN 197-1 as a rule. If the strength of the tested cement is significantly lower than 45 - 50 MPa, partners use a reference cement with a reduced strength (ECO-Serve-

C2-R-0019). It can be derived from tables 18 and 19, that this range of values was achieved by cements CEM 1-2, 3-2, 5b, 6, 7, 8-3, 12-1. The strength values of cements RefC, 2-2 are also in the typical range for cements of the strength class 32,5 R in Germany. The value for cement 9-3 is only slightly above the limit for that strength class.

8.1.7 Strength development

Figure 2 shows the strength development of concrete with c = 320 kg/m³ and w/c = 0,50 acc. to task 3.1 in table 7.

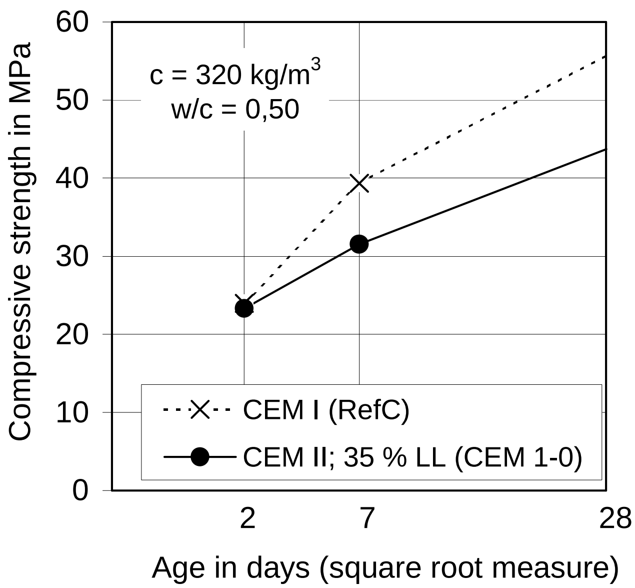


Figure 2: Strength development of concrete with Portland cement RefC and Portland limestone cement CEM 1-0

In accordance with the cement strength acc. to EN 197-1 the compressive strength of the concrete with the portland limestone cement CEM 1-0 at the age of 28 days was about 30 % lower compared with the compressive strength of the concrete with the reference cement.

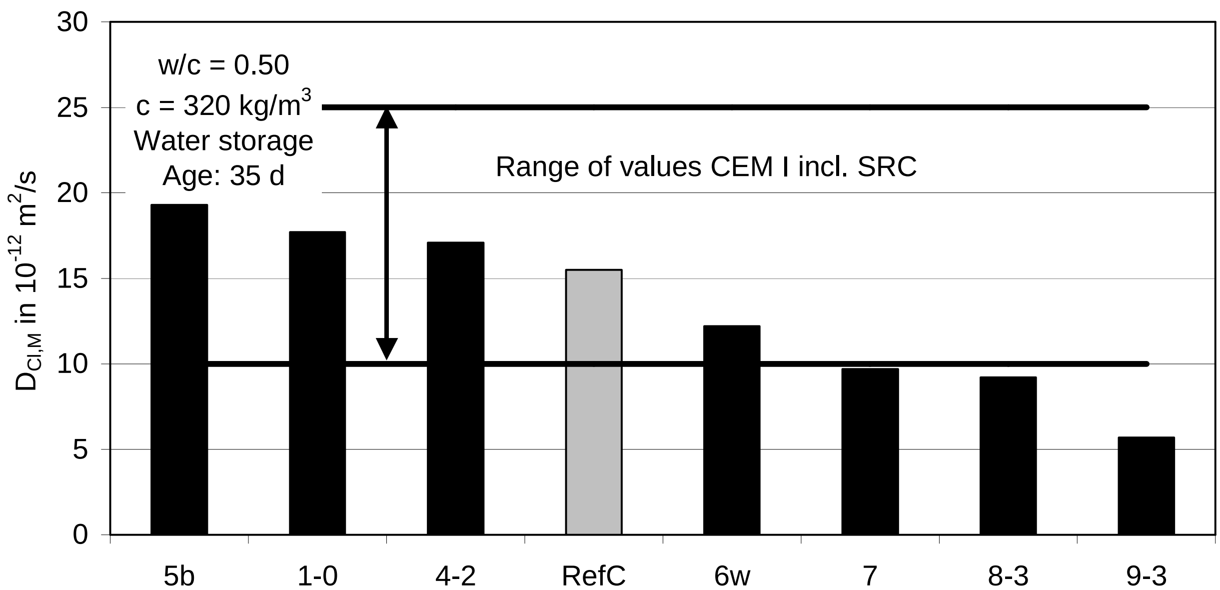
In general, all cements in accordance with EN 197-1 are suited for producing concrete acc. to European concrete standard EN 206-1. With regard to the durability of the concretes made with these cements, however, differences induced by the cement type used have to be taken into account depending on the area of application. The concrete standards of some European countries lay down correspondingly different application rules depending on the exposure class that a structural element is to be classified in. Restrictions regarding the applicability of cements have been imposed on a number of CEM II-M cements previously not standardised. These restrictions merely relate to application in structural elements exposed to freeze-thaw and chloride attack in particular. Therefore investigations on the durability of concrete with new blended cements are of great importance.

8.1.8 Penetration of chlorides

Figure 3 shows the influence of limestone and blastfurnace slag on the resistance of concrete against chloride penetration including some of the cements given in tables 18 and 19. In general the migration coefficients shown in figure 3 are comparable to diffusion coefficients but they are somewhat higher because the chloride penetration is accelerated using a potential of about 30 volts. The rapid chloride migration method (RCM) is decribed in the report on the Brite EuRam III project DuraCrete [2].

The exclusive use of limestone meal besides clinker in a range up to 35 % may lead to a resistance against chloride penetration in the range of Portland cement – as it can be seen in this example. On the other hand there is the benefit of slag – in this figure represented by Portland slag cement with a slag content of 35 %.

The combination of limestone meal and blastfurnace slag therefore offers the possibility to benefit from the advantages of both main constituents. The example shows, that concrete with cement with 25 % limestone and 10 % blast furnace slag shows a significant decrease of the chloride migration coefficient compared to the Portland cement of comparable strength.



SCR = Sulfate resisting cements

Clinker	65 K1	65 K1	70 K1	100 K1	65 K1	65 K1	65 K1	65 K1	%
Slag	-	-	-	-	5 S1	10 S1	15 S1	35 S1	%
Limestone	35 LL2	35 LL1	30 LL1	-	30 LL1	25 LL1	20 LL1	-	%
f_{cm} in MPa	52.2	43.7	46.0	56.7	53.4	49.6	50.8	57.0	-

Figure 3: Chlorid migration coefficient $D_{Cl,M}$ of concrete with w/c = 0.50 und c = 320 kg/m³ – Cements acc. to tables 18 and 19 - Water storage

8.1.9 Freeze-thaw resistance

Concrete structures must possess adequate resistance to environmental impacts during their service life. Depending on the types of exposure a structure or component undergoes, this includes adequate resistance to freeze-thaw or freeze-thaw with de-icing salt. The applicable regulations usually specify requirements to be met by constituents and concrete composition in accordance with the respective exposure classes assigned. These concrete technology specifications are based on many years of experience with normal strength concrete gathered in building practice. Many different test methods have been developed. No single test method can completely reproduce the conditions in the field in all individual cases. Nevertheless, any method should at least correlate to the practical situation and give consistent results. Such a test method may not be suitable for deciding whether the resistance is adequate in a specific instance but will provide data of the resistance of the concrete to freeze-thaw-attack and freeze-thaw-attack in the presence of de-icing agents. If the concrete has inadequate resistance then the freeze-thaw attack can lead to two different types of damage, namely to scaling (surface weathering) and to internal structural damage. The European prestandard prENV 12390-9 covers testing for scaling resistance. This European prestandard has one reference method (slab test) and two alternative methods (cube test and CF/CDF-test). A CEN Report describes the testing for internal structural damage. This CEN Report contains three different test methods, which are well proved in different parts of Europe: beam test, slab test and CIF-test. Always they produce consistent results. For that reason no single test method can be established as reference test method.

Freeze-thaw attack was at first simulated by the CF/CIF method [4]. The relative dynamic modulus of elasticity was calculated on the basis of the change in ultrasonic speed in the concrete. The water absorption of the concretes during freeze-thaw testing yielded additional information.

The results in figures 4 and 5 indicate, that concretes using cements acc. to tables 18 and 19 with up to 35 % blastfurnace slag or limestone can have an adequate resistance to freezing and thawing and cements with a mixture of limestone meal and blastfurnace slag are suitable for these applications as well.

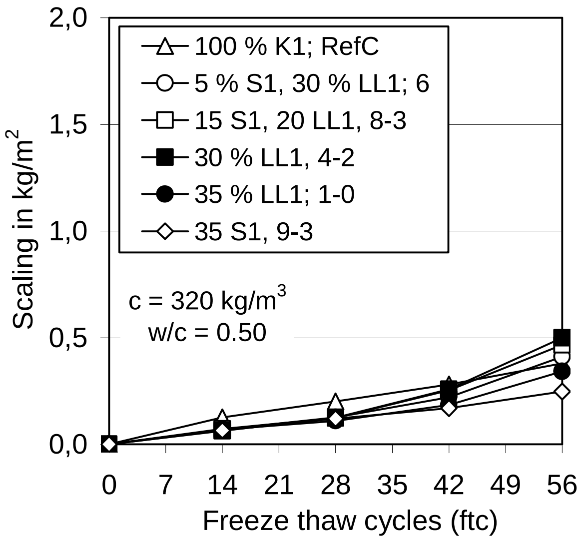


Bild 4: Scaling of concretes with Portland cement and portland composite cements with limestone (LL) and blastfurnace slag (S) – Discussed limit value in Germany: 2.0 kg/m^2 after 56 ftc – CF-Test

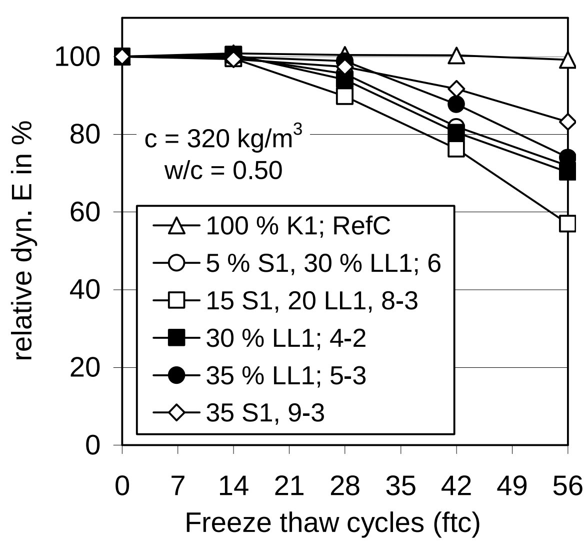
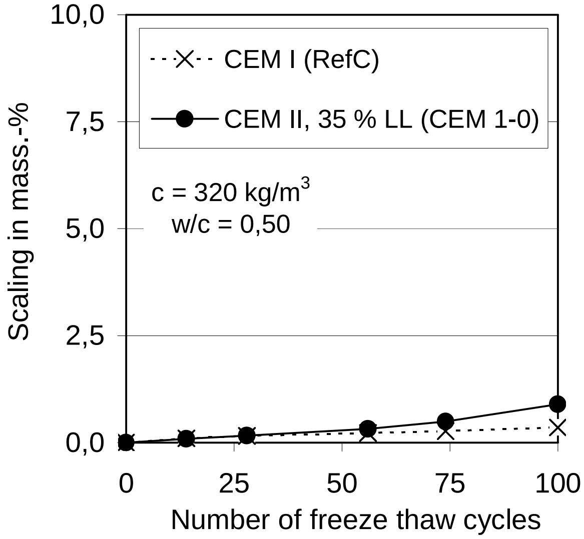


Bild 5: Relative modulus of elasticity of concretes with Portland cement and portland composite cements with limestone (LL) and blastfurnace slag (S) – Discussed limit value in Germany: 75 % after 28 ftc – CIF-Test

Figure 6 shows the scaling and the internal damge of concrete with c = 320 kg/m^3 and w/c = 0,50 acc. to task 3.1 in table 7 using the cube test acc. to EN V 12390-9.

These results confirm, that there are no significant differences concerening the scaling and the relative dynamic modulus of elasticity of concrete with Portland cement RefC and Portland limestone cement CEM 1-0 in the cube test. The results indicate, that concretes with these cements have an adequate freeze-thaw resistance for external components in building construction.



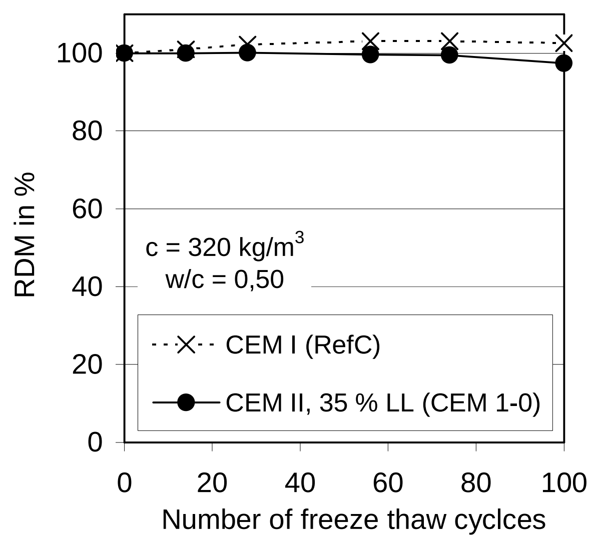
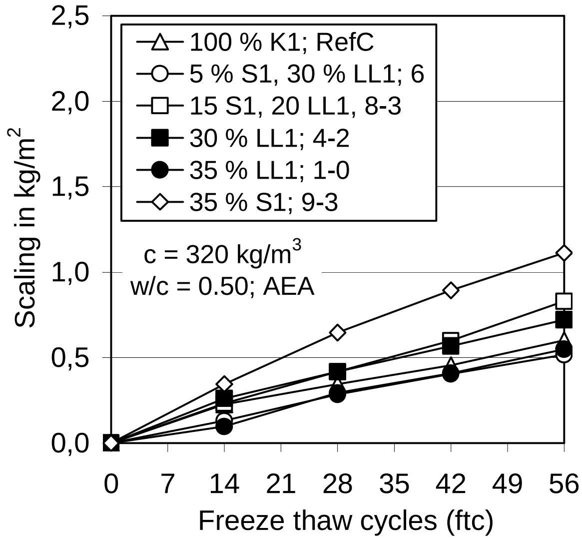


Figure 6: Scaling (left) and the internal damge (right) of concrete with Portland cement RefC and Portland limestone cement CEM 1-0 – cube test (Internal damage = RDM = **R**elative **D**ynamic **M**odulus of elasticity)

8.1.10 Freeze-thaw resistance with de-icing salts

Concretes exposed to chlorides are predominantly also loaded by freeze-thaw cycles. The CDF-test indicates the suitability of a concrete mixture for highly water saturated concrete exposed to significant attack by freeze-thaw cycles with de-icing salts, if a limit value for scaling of 1.5 kg/m^2 after 28 freeze-thaw cycles is not exceeded. Concretes made with blast furnace cements with high slag contents (> 50 %) mostly show a scaling above the limit value. The results in figures 7 and 8 indicate, that concretes using cements with up to 35 % blastfurnace slag or limestone can have an adequate resistance to freezing and thawing with de-icing salts and cements with a mixture of limestone meal and blastfurnace slag are suitable for these applications as well. Comparative investigations will be done using the slab test.



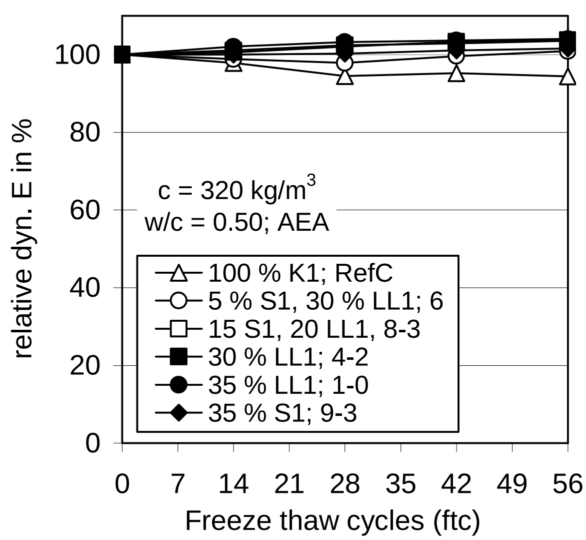


Bild 7: Scaling of air-entrained concretes with Portland cement and portland composite cements with limestone (LL) and blastfurnace slag (S) – Limit value for scaling: 1.5 kg/m^2 after 28 ftc – CDF-Test

Bild 8: Relative modulus of elasticity of air-entrained concretes with Portland cement and portland composite cements with limestone (LL) and blastfurnace slag (S) – CDF-Test

Table 18: Particle size distribution, specific surface area (Blaine), density, position parameter x', slope n, void content P and strength development of cements

Parameter	Unit	PC1	PC2	PC3	RefC	CEM 1-0	CEM 1-1	CEM 1-2	CEM 2-1	CEM 2-2	CEM 3-1	CEM 3-2
1	2	3	4	5	6	7	8	9	10	11	12	13
Particle size distribution (% Passing)												
0,1 µm	mass.-%	0,56	0,86	1,39	0,75	0,88	2,82	0,87	1,19	0,86	1,24	1,10
0,3 µm		2,33	3,81	5,88	3,00	3,12	9,70	3,86	5,46	4,06	5,49	4,63
0,5 µm		3,72	6,44	9,81	4,86	5,18	13,3	6,56	9,55	7,14	9,41	7,69
0,7 µm		5,04	8,83	13,2	6,44	7,75	15,1	9,00	13,2	10,0	12,8	10,4
1,0 µm		7,05	12,1	17,5	8,52	12,7	18,4	12,3	17,9	14,1	17,2	13,9
1,5 µm		10,1	17,2	24,2	12,0	19,9	24,2	17,8	25,9	20,9	24,4	19,5
2,0 µm		12,8	21,8	30,4	15,3	26,0	30,2	23,1	33,4	27,2	31,1	24,9
2,5 µm		15,1	26,0	36,0	18,4	31,0	35,9	27,9	40,2	32,9	37,2	29,8
3,0 µm		17,1	29,7	40,8	21,0	35,1	41,0	32,1	45,9	37,6	42,5	34,1
6,0 µm		25,5	45,3	59,8	31,7	50,3	60,2	48,2	65,1	54,4	62,6	51,5
12 µm		37,0	66,5	81,5	44,8	65,7	79,9	67,7	82,9	72,0	82,0	70,1
32 µm		68,0	98,6	99,9	72,8	89,2	99,2	97,5	99,7	97,9	99,3	96,0
63 µm		93,3	100	100	91,3	99,8	100	100	100	100	100	100
90 µm		99,4	100	100	97,8	100	100	100	100	100	100	100
125 µm		100	100	100	99,9	100	100	100	100	100	100	100
200 µm		100	100	100	100	100	100	100	100	100	100	100
Blaine	g/cm2	2660	5200	7050	2900	5580	6680	5580	8320	7100	7040	5830
x'	µm	25,2	9,7	6,3	21,3	10,6	6,6	9,5	5,9	8,2	6,3	8,9
n	-	0,83	0,92	0,90	0,79	0,84	0,81	0,91	0,90	0,90	0,90	0,87
P	vol.-%	48,4	54,1	58,4	44,6	48,7	57,4	52,2	57,1	52,3	54,2	52,1
Density	g/cm3	3,13	3,11	3,11	3,16	3,00	2,95	2,95	2,94	2,95	2,95	2,96
Strength development acc. to EN 197-1												
2d	MPa	21.8	51.1	58.2	23,9	22,1	36.9	32.1	40.2	35.5	35.5	33.4
7d		42.6	64.1	68.0	39,4	32,2	47.2	39.5	48.2	43.6	45.1	39.8
28d		57.7	75.3	77.7	51,2	39,7	53.8	47.0	54.3	52.5	40.3	46.6
90d		67,0	78,9	79,0	59,2	n. d.	54,0	46,9	53,5	54,7	48,2	49,5

RefC = Reference Cement – 100 % K (2700 g/cm^2) + sulphate	
CEM 1-0 = 65 % K (3500 g/cm^2) + 35 % LL1 + sulphate	
CEM 1-1 = 65 % PC3+ 35 % LL1	CEM 1-2= 65 % PC2+ 35 % LL1
CEM 2-1 = 65 % PC3+ 35 % LL2	CEM 2-2= 65 % PC2+ 35 % LL2
CEM 3-1 = 65 % PC3+ 35 % LL3	CEM 3-2= 65 % PC2+ 35 % LL3
R.f. = Results following	n. d. = not determined

Table 19: Particle size distribution, specific surface area (Blaine), density, position parameter x', slope n, void content P and strength development of cements

Parameter	Unit	CEM 11-1	CEM 11-2	CEM 12-1	CEM 12-2	CEM 13-1	CEM 13-2	CEM 4-2	CEM 6	CEM 7	CEM 8-3	CEM 9-3	CEM 5b
1	2	3	4	5	6	7	8	9	10	11	12	13	14
Particle size distribution (% Passing)													
0,1 µm	mass.-%	0,91	0,76	0,86	0,70	1,00	0,82	1,28	1,10	0,65	0,80	0,78	1,03
0,3 µm		4,30	3,53	3,66	2,91	4,17	3,44	4,07	3,44	3,07	3,45	3,21	4,65
0,5 µm		7,54	6,00	6,10	4,68	6,88	5,73	6,61	5,75	5,38	2,80	5,18	8,01
0,7 µm		10,6	8,42	8,26	6,32	9,20	7,67	9,46	8,11	7,55	7,86	6,97	11,0
1,0 µm		14,8	12,2	11,2	8,80	12,2	10,2	14,4	11,9	10,7	10,6	9,51	15,1
1,5 µm		21,8	18,2	16,0	12,8	17,3	14,4	21,7	18,0	16,0	15,1	13,5	21,8
2,0 µm		28,4	23,8	20,7	16,6	22,3	18,6	27,6	23,7	21,1	19,3	17,3	28,0
2,5 µm		34,3	28,7	25,0	20,0	26,8	22,5	32,5	28,7	25,7	23,2	20,6	33,6
3,0 µm		39,3	33,0	28,8	23,0	30,8	26,0	36,5	32,8	29,8	26,6	23,5	38,2
6,0 µm		57,6	49,0	35,0	34,7	37,3	40,8	51,2	47,2	44,5	39,3	35,1	53,4
12 µm		77,1	67,8	62,4	48,1	63,5	57,5	66,6	62,1	59,4	53,4	48,9	66,2
32 µm		98,1	96,0	91,4	76,0	87,5	85,2	90,0	89,1	86,8	80,9	77,3	89,0
63 µm		100	100	100	96,2	99,1	98,4	99,9	99,9	99,5	98,4	97,3	99,8
90 µm		100	100	100	100	100	100	100	100	100	100	100	100
125 µm		100	100	100	100	100	100	100	100	100	100	100	100
200 µm		100	100	100	100	100	100	100	100	100	100	100	100
Blaine	g/cm2	6700	5660	4725	3475	4840	4290	5450	5310	4830	4220	3630	7130
x'	µm	7,5	9,5	11,4	18,5	11,7	13,9	10,1	11,4	12,6	15,3	17,8	10,1
n	-	0,91	0,91	0,88	0,81	0,81	0,84	0,81	0,84	0,84	0,80	0,81	0,77
P	vol.-%	56,3	52,6	51,0	47,6	51,6	51,6	54,8	51,1	51,9	n. d.	n. d.	n. d.
Density	g/cm3	2,92	2,93	2,97	2,97	2,92	2,92	3,03	3,00	3,00	3,00	3,05	2,97
Strength development acc. to EN 197-1													
2d	MPa	28,2	25,7	22,1	8,8*	9,2*	9,6*	24,1	23,3	21,7	20,9	18,6	25,0
7d		35,1	33,7	37,1	21,5	24,5	25,0	32,8	36,6	36,7	35,2	35,1	36,9
28d		40,1	38,3	50,9	34,3	43,6	37,0	42,8	46,5	47,0	47,4	53,7	44,4
90d		40,7	37,4	56,7	45,3	53,6	47,3	n. d.	51,4	56,0	49,1	62,6	47,3

CEM 11-1 =	55 % PC3+ 45 % LL1	CEM 11-2=	55 % PC2+ 45 % LL1
CEM 12-1 =	50 % PC2+ 20 % LL1 + 30 % S1	CEM 12-2 =	50 % PC1+ 20 % LL1 + 30% S1
CEM 13-1 =	30 % PC3+ 20 % LL1 + 50 % S1	CEM 13-2=	30 % PC2+ 20 % LL1 + 50% S1
CEM 4-2 =	65 % K + 30 % LL1 + sulphate	CEM 7 =	65% K + 25% LL1 + 10% S1 + sulph.
CEM 5b =	65 % K + 35 % LL2 + sulphate	CEM 8-3 =	65% K + 20% LL1 + 15% S1 + sulph.
CEM 6 =	65 % K + 30 % LL1 + 5 % S1 + sulph.	CEM 9-3 =	65 % K + 35 % S1 + sulph.
R.f. =	Results following	* =	to be repeated

8.1.11 References

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8.2 Partner 2: CTG

8.2.1 General

The cements that are under assessment by CTG are described in table 20.

Table 20: Cements under assessment by CTG

No	Cement	Notation	Constituents				
			Clinker K	Blast furnace slag S	Limestone LL	Glass G	Brick B
1	2	3	4	5	6	7	8
1	Blastfurnace cement	CEM III/A	50	50			
2	Limestone cement	CEM 45LL	55		45		
3	Limestone-slag cement	CEM 40S-20LL	40	40	20		
4	Recycled pozzolanic cement	CEM 30G-15B	55			30	15
5	Reference cement	CEM Ref	100				

As can be noticed by the analysis of table 20, one cement is a standard cement according to EN 197-1, while the remaining three are cements having a composition beyond the EN 197-1. In particular two constituents of cement No. 4 (glass and brick) are not taken into account by EN 197-1 among the possible main constituents of standard cements.

The reason for the choice of the cements No. 1- 4 is briefly described in the following.

- CEM III/A — Standard cement potentially characterised by excellent performances. As a function of the production process, the focus can be shifted on different aspects such as, for example, high long term strengths or high durability.
- CEM 45LL — The standard limestone cements contain 35% of limestone as a maximum value. Their good performances after several years of use in many different environments suggest to test the described composition.
- CEM 40S-20LL — The ternary composition based on clinker, slag and limestone could allow to define a blending cement characterised by excellent properties both at the fresh and hardened state.
- CEM 30G-15B — The ground brick has been successfully used as pozzolanic material. Nevertheless mortars and concretes in which the cement has been partially substituted by ground brick showed high water demand and low durability. The use of a third recycled pozzolanic material will be investigated in order to reduce the aforesaid problems.

8.2.2 Starting materials

The chemical compositions, with the exception of glass, are shown in Table 21. For the clinker the potentail mineralogical composition is reported too.

Table 21: Chemical composition of the starting materials and potential mineralogical composition of clinker

Parameter	Unit	Clinker	Slag	Limestone	Brick
1	2	3	4	5	6
Source	% by mass	Rezzato (BS)	Taranto	Rezzato (BS)	Impruneta (FI)
SiO2		21.54	34.27	1.28	50.89
Al2O3		5.25	9.98	0.30	18.74
Fe2O3		2.36	2.80	0.15	7.68
CaO		67.17	41.05	54.15	10.35
MgO		1.63	7.53	0.39	3.07
SO3		<0.16	1.76	<0.06	0.72
Na2O		0.29	0.34	<0.08	0.62
K2O		0.28	0.15	0.05	3.43
SrO		<0.07	0.09	<0.03	<0.3
Mn2O3		0.08	0.37	<0.04	0.12
P2O5		0.51	<0.03	<0.03	0.14
TiO2		0.27	1.35	0.02	0.82
l.o.i.		0.37	2.16	43.43	- - -
C3S (Bogue)		68.13	- - -	- - -	- - -
C2S (Bogue)		10.72	- - -	- - -	- - -
C3A (Bogue)		9.92	- - -	- - -	- - -
C4AF (Bogue)		7.17	- - -	- - -	- - -
Cl-		- - -	0.211	- - -	- - -
Insoluble residue		- - -	0.81	- - -	- - -

8.2.3 Production of cements

The clinker, the slag and the limestone for the preparation of the cements have been ground, in 30 kg batches, by a laboratory mill. The granulometric properties of the ground materials are shown in Table 22. Two clinkers having different fineness have been ground: the coarser to prepare the reference cement (Clinker Re) while the finer to prepare the blending cements (Clinker Bl). Main granulometric properties of glass and brick are compiles as well.

Table 22: Granulometric properties of ground materials

Parameter	Unit	Clinker Bl	Slag	Limestone	Glass	Brick	Clinker Re
1	2	3	4	5	6	7	8
0.9	% by mass	6.0	4.1	12.2	-	-	5.2
1.1		7.2	5.1	14.4	-	-	6.3
1.3		8.4	6.3	16.5	-	-	7.3
1.5		9.7	7.6	18.5	-	-	8.2
1.8		11.4	9.5	21.4	-	-	9.7
2.2		13.5	12.1	24.9	-	-	11.5
3.7		21.3	22.5	36.4	-	-	17.8
5.0		27.4	31.4	44.5	-	-	22.7
7.5		37.5	47.0	56.9	-	-	31.2
10.5		47.8	62.8	67.8	-	-	39.8
15.0		60.0	79.2	78.8	-	-	50.5
21.0		71.8	91.0	87.6	-	-	61.5
25.0		77.6	95.3	91.2	-	-	67.3
30.0		83.2	97.9	94.2	-	-	73.3
43.0		92.0	99.8	98.0	-	-	83.9
51.0		94.9	99.9	98.9	-	-	88.2
61.0		97.0	100.0	99.5	-	-	91.9
73.0		98.5	100.0	99.8	-	-	94.8
87.0		99.3	100.0	99.9	-	-	96.9
103.0		99.7	100.0	100.0	-	-	98.2
123.0		100.0	100.0	100.0	-	-	99.1
147.0		100.0	100.0	100.0	-	-	100.0
x'	µm	16.4	10.6	9.1	22.6	16.6	22.1
n	-	0.96	1.30	0.88	0.80	0.82	0.91
Blaine	g/cm²	3500	4200	5050	3950	3950	2950

8.2.4 Cement properties

In table 23 the standard properties of cements 1 to 5 are presented. The correct test results for cement N. 2 (55% Clinker and 45% Limestone) are those reported in Table 3 of these report; a mistake was made when inserting the data for this cement in the previous report. The tests have been carried out according to EN 196-1 and EN 196-3.

Table 23: Standard properties of cements

Parameter	Unit	CEM III/A N. 1	CEM 45LL N. 2	CEM 40S-20LL N. 3	CEM 30G-15B N. 4	CEM Ref N. 5
1	2	3	4	5	6	7
Initial setting time	h:min	3:37	2:50	2:49	3:36	2:07
Final setting time		4:17	3:48	4:06	5:06	2:41
Soundness	mm	0	0	0	0	0
Strength development						
1d	MPa	7.8	5.3	5.5	6.1	18.2
2d		15.5	10.6	11.8	10.3	26.7
7d		37.3	20.2	32.7	18.5	40.9
28d		57.6	27.1	44.6	31.7	50.3

8.2.5 Cement classification

In figure 1 the values of mechanical strength reported in table 3 are plotted. On the same plot the threshold limits for three strength classes according to EN 197-1 (32.5 N – 32.5 R – 42.5 N) have been superimposed.

From the analysis of table 3 and figure 1 it can be observed that, with respect to the requirements of EN 197-1:

- cement N. 1 (CEM III/A) well satisfies the requirements for strength class 42.5 N;
- cement N. 2 (CEM 45LL) is quite far from the minimum threshold limits for strength class 32.5;
- cement N. 3 (CEM 40S-20LL) can be included in the classes 32.5 N, 32.5 R and 42.5 N, even if the class that better fits its strength development is 32.5 N;
- cement N. 4 (CEM 30G-15B) exhibits a compressive strength at 28 days that is slightly lower than the required value for class 32.5; the two day and the seven days requirements are satisfied;
- cement N. 5 (CEM Ref) well satisfies the requirements for strength class 42.5 R.

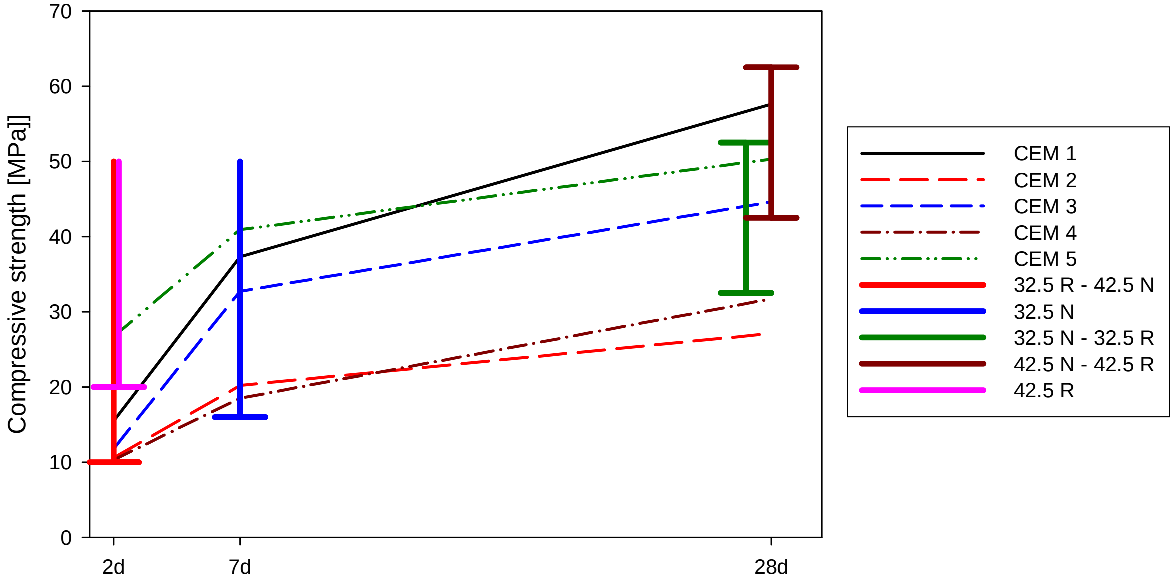

Figure 9: Mechanical strengths of tested cements and strength classes threshold limits

The possible classification of the laboratory cements is summarised in table 24.

Table 24: Possible classification of cements under assessment by CTG

No	Cement	Notation	Maximum strength class according to EN 197-1
1	2	3	4
1	Blastfurnace cement	CEM III/A	42.5 N
2	Limestone cement	CEM 45LL	none
3	Limestone-slag cement	CEM 40S-20LL	42.5 N
4	Recycled pozzolanic cement	CEM 30G-15B	none
5	Reference cement	CEM Ref	42.5 R

From the analysis of table 24 can be observed that two cements cannot be classified according to EN 197-1. Cement N. 4 needs just a slight refinement of its formulation, while for cement N. 2 an extensive experimental work needs to be carried out.

8.2.6 Results on concrete

Starting from the cements described in the previous clauses, three concrete mixes have been prepared. The concrete compositions, the volumic mass and the slump classes, according to EN 206-1, are given in table 25.

Table 25: Concrete composition and fresh concrete properties

MIX	3	4	5
1	2	3	4
CEM content [kg/m³]	300		
Cement No	3	4	5
Aggregate (fluvial) [kg/m³]	1900 (Füller grading curve - $\varnothing_{max}$ = 20 mm)		
Water reducing admixture (Naphtalene sulphonate) [l/m³]	2.9	2.2	4.7
w/c ratio	0.55		
Volumic mass [kg/m³]	2410	2370	2400
Slump class	S4	S4	S3

For each mixes the following quantities will be measured:

- compressive strength development (cubic specimens – 10 cm – conforming to EN 12390-1 and test procedure conforming to EN 12390-3)
- drying shrinkage development (beam specimens – 10 x 10 x 40 cm – conforming to EN 1290-1 and internal test procedure)
- freeze/thaw resistance (beam specimens – 10 x 10 x 40 cm – conforming to EN 1290-1 and test procedure conforming to UNI 7087).

In table 26 are reported the available data.

Table 26: Strength and drying shrinkage development

Parameter	Unit	MIX 3	MIX 4	MIX 5
1	2	3	4	5
Strength development				
3d	MPa	15.5	11.0	24.0
7d		25.5	16.5	32.5
Drying shrinkage development				
2d	[με]	86	99	86
7d		134	147	125

The available data are not enough to asses the behaviour in concrete of the tested cements at this stage of the project, nevertheless it can be noticed, at least at 7 days, a good correlation between compressive strength of standard mortars and compressive strength of concretes.

8.3 Partner 3: NORCEM

8.3.1 General

Norcem's work with blended cements in cluster 2 comprises cement types included in and beyond the limits of EN 197-1. Some of the cements according to EN 197-1 would, however, be new in the Norwegian market, containing a new constituent (limestone), or greater quantities of substitutes (more fly ash), or mixes of additional constituents (fly ash and limestone).

These new cement types have so far not been approved in the Norwegian application documents and therefore would need further documentation of durability for certain applications.

The work at Norcem R&D has proceeded according to the work plan as outlined in the previous periodic report.

8.3.2 Work plan

Norcems work plan for cements and concretes to be produced and tested is given in this section: It was decided following cluster meetings 1 and 2 held in Düsseldorf Sept. 5, 2003 and Oct. 18, 2003 and internal project work meetings.

Proposed concrete mix design to be applied for trial mixes by the laboratory at Norcem R&D is given in tables 27 to 29.

Table 27: Cement & concrete mix design for housing (8 mixes)

Cement	FA	LL	Class	C[1]	Freeze-thaw (water)[2]	Cl[3]	S[4]	V/C 0,60	V/C 0,50
Ref. Std.FA	20	0	42,5 R	X	-	-	-	X	-
CEM II/A-V	20	0	42,5	X	X	-	-	X	X
CEM II/ B-M	20	10	.	X	-	-	-	X	-
,,	30	20	.	X	X	-	-	X	X
CEM II/ A-LL	0	20	32,5	X	X	-	-	X	-
Reference mix (80% Ind, 20% Anl) CEM I	0	0	42,5 R	X	X	-	-	X	-

1 Carbonation (w/c 0,60)
2 Freeze-thaw resistance (water) w/c 0,60 and 0,50
3 Penetration of chlorides.
4 Sulphate resistance.
X NMR analysis.

The cement CEM II/B-"M" is made of Standard clinker with fly ash (FA) and lime filler (LL).

Table 28: Cement & Concrete mix design for heavy structures (8 mixes)

Cement	FA	LL	C[1]	Freeze-thaw (water)[2]	Cl[3]	S[4]	V/C 0,50	V/C 0,40
CEM I 42,5	*0*	-	X	X	X	X	*X*	X
CEM II A-V	20	-	X	X	X	X	X	-
CEM II B-V	35	-	X	X	X	X	X	X
CEM II "B"-V	*50*	-	X	X	X	X	*X*	X
CEM I (Ref 80%Ind, 20% Anl)	*0*	0	X	X	X	X	-	X

1 Carbonatisation (w/c 0,60)
2 Freeze-thaw resistance (water) w/c 0,60 and 0,50
3 Penetration of chlorides.
4 Sulphate resistance.
0/50 NMR analysis (w/c 0.50 or 0,40??)

Table 29: Overview of the 15 mixtures of the concrete for housing (No. 1-8) and construction (No. 3 + 9-15)

No.	Cement	FA	LL	w/c 0,60	w/c 0,50	w/c 0,40
1	Ref. Std.FA	20	0	X		
2	CEM II A-V	20	0	X		
3	‘’	20	0		X	
4	CEM II B-“M”	20	10	X		
5	‘’	30	20	X		
6	‘’	30	20		X	
7	CEM II A-LL	0	20	X		
8	CEM I (Ref. 80% Ind, 20% Anl)	0	0	X		
9	CEM I 42,5	0	0		X	
10	‘’	0	0			X
3	CEM II A-V	20	0		X	
11	CEM II B-V	35	0		X	
12	‘’	35	0			X
13	CEM II ”B”-V	50	0		X	
14	‘’	50	0			X
15	CEM I (Ref. 80% Ind, 20% Anl)	0	0			X

- The project was started 1 October 2003. The laboratory tests have to be finished within two years.
- The laboratory made cements are tested in accordance with EN 196.
- If NMR of the construction mixes is done, we have to decide the w/c to be tested.

8.3.3 Production of new cement types

The cements for testing in concrete are six cements made/mixed with laboratory equipment (several hundred kilos of each cement) and two factory produced cements, which are presently marketed (No 1 and No 6), to be used for reference purposes.

In order to get cements with particle size distributions as close to factory produced as possible (cements ground in large scale mills with high efficiency separators), the new cements were made by mixing appropriate quantities of factory produced cements with ground fly ash and ground limestone meal.

The cements used for this purpose was a low alkali cement with Blaine 390 m^2/kg (Norcem Anleggsement CEM I 52,5 LA) and a rapid hardening cement with Blaine 539 m^2/kg (Norcem Industri CEM I 42,5 R). This method gives cements with more normal water demand (less) than obtained with laboratory cements. The mix of these two was kept 80 % Industri and 20 % Anlegg in all the blended cements. An extra reference cement (No 9) had also this mix ratio.

8.3.4 Constituents

Table 30 displays the main chemical and physical parameters for the blending constituents: ground fly ash, limestone meal, Industri cement and Anlegg cement. The fly as is according to EN 450 and is imported from power plants in Denmark.

The limestone is high grade limestone from the Dalen mine in Brevik. This is ground separately and is used in some cement as minor additional constituent (less than 5 %) and is also sold for use as filler etc. More data can be given if required.

8.3.5 Data for produced cements and reference cements

All cements have so far been tested according to EN 196. Table 31 gives an overview of some of the chemical and physical data for the nine cements. Some data are still to be completed.

8.3.6 Further work

The production of trial mixes was originally planned for May/June 2004. Due to capacity problems and internal restructuring of work tasks, as well as other strategic issues, led to a re-scheduling of the laboratory programme. The concrete mixes are now planned for november/december 2004.

Table 30: Main chemical and physical parameters for the blending constituents

Constituents	Blaine	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Na_2O	K_2O	SO_3	Total organic Carbon	Clay
	m^2/kg	m.-%									
Fly ash	416	55,92	20,89	6,14	5,06	2,16	1,20	2,22	0,51	3,56	n. d.
Limestone	343	6,28	1,94	1,58	50,23	1,34	0,22	0,45	0,53	0,09	0,023
Industry cement	539	19,68	5,12	3,35	61,50	2,47	0,48	1,20	3,77	n. d.	n. d.
Anlegg cement	390	21,05	4,35	3,63	63,53	1,64	0,21	0,53	2,81	n. d.	n. d.

Table 31: Norcem Cement Types and ~ Characteristics to be included in the Programme.

Cement			L.O.I.	Blaine	SO_3	Water soluble Chloride	Fly ash	Standard Consistency	Sound-ness	Setting time	Compressive Strength			
											MPa			
			m.-%	m^2/kg	m.-%				mm	min	1 d	2 d	7 d	28 d
No:1	AI2	Norcem Brevik Standard FA cement Ref	1,08	452	3,06	0,03	17,3	30,1	0,5	115	24,3	32,7	43,7	55,2
No:2	PP1	20% FA	2,12	496	3,01	0,03	19,0	30,1	0,0	116	24,5	32,7	42,7	r. f.
No:3	PP2	20% FA +10% Limestone	5,51	463	2,80	0,02	20,0	29,7	0,0	128	20,0	29,4	40,5	r. f.
No:4	PP3	30% FA +20% Limestone	9,46	454	2,06	0,02	30,3	28,5	0,0	141	10,5	17,7	24,8	r. f.
No:5	PP4	20% Limestone	8,61	479	3,04	0,03	-	29,8	0,5	114	23,3	34,2	43,5	r. f.
No:6	BP2	Norcem Brevik Standard cement Ref	2,20	352	3,07	0,02	-	27,8	1,0	140	19,8	32,2	42,5	50,9
No:7	PP5	35% FA	2,48	473	2,61	0,02	34,4	30,6	0,0	154	17,5	25,7	33,0	r. f.
No:8	PP6	50% FA	2,93	438	2,50	0,02	47,0	30,0	0,0	198	10,1	16,3	22,2	r. f.
No:9	PP7	80% IND + 20% ANL Ref	1,53	513	3,59	0,03	-	30,5	0,3	102	32,2	41,5	50,8	r. f.

8.4 Partner 5: TITAN

8.4.1 General

The aim of this investigation is to produce two categories of cement, one according to EN 197-1 and the other with even greater levels of additions. The raw materials that have been chosen as additives in this project included four fly ashes (from different power plants – three in the North and one in the South part of Greece), limestone from the area near Athens and natural pozzolana from Milos island (Milos earth). Prior to their implementation, all of these materials were chemically and mineralogically characterized. In the framework of this project, the properties of these blended cements and of concrete produced with them, are being investigated.

Natural pozzolanas of volcanic origin, mainly composed of volcanic glass, are deposited as pyroclastic rocks in sedimentary basins or on land. In general, the youngest pyroclastic rocks are more reactive than the old ones because of their high, unaltered glass content. Rock types of the first category occur in the South Aegean volcanic arc (Milos, Kimolos, Kos, Santorini, Nisiros) and also in the East and N.E Aegean Sea islands (Mitilini, Samos).

The limestone used in this project had a rather high calcite and low alkali content and was obtained from the Xirorema quarry, close to the Kamari Plant.

Burning of lignite in the power plants of Greece produces 2,5 million tons of Fly Ash, yearly. The high CaO content of these fly ashes (> 10%) renders them unsuitable for the manufacturing of concrete, according to the EN 450. Currently, they are being used for the production of cement but their implementation requires some precaution because they exhibit problems regarding:

- Inhomogenity

Being a byproduct of the specific process – that is burning of lignite – they are characterised by some inhomogenuity not only with respect to their chemical but also to their mineralogical composition. As a result, the properties of the structural materials containing them might vary, following the instability of the fly ashes. This instability originates from the quality of lignite, the burning conditions and various other production parameters. After burning, some of the total CaO not bound to any other oxide in the fly ash still remains as free CaO. The latter is considered to be an important factor with respect to the suitability of the fly ash, due to its expansive nature and considerable temperature increase during hydration.

- High SO_3 values

The sometimes high SO_3 content of the fly ashes is directly related to the lignite type and also to the burning conditions. Burning affects the binding of SO_3 to CaO and depending on the conditions more or less $CaSO_4$ is formed.

Nowadays, fly ash is added in cement in ~10% resulting into a yearly consumption of less than 1 million tons.

8.4.2 Characterization of the raw materials

8.4.2.1 Chemistry and mineralogy of raw materials

The chemical and mineralogical analyses of the raw materials are summarized in the following tables 32 and 33.

Table 32: Chemical analyses

-	F. ASHES				-	-
-	KARDIA	PTOLEMAIDA	MEGALOPOLIS	AGIOS DEMETRIOS	LIMESTONE	MILOS EARTH
SiO_2	30,62	35,24	51,26	24,90	2,77	60,96
Al_2O_3	13,15	16,82	19,39	11,81	1,39	15,10
Fe_2O_3	5,25	5,91	8,44	5,42	0,64	3,36
CaO	37,11	28,83	11,82	40,46	50,6	6,10
MgO	3,67	2,83	2,27	4,25	0,71	1,28
K_2O	1,08	1,35	1,81	0,78	0,14	2,13
Na_2O	0,50	0,72	0,53	0,40	-	0,62
SO_3	5,22	5,30	2,91	6,08	-	1,49
f.CaO	12,80	7,60	8,80	N/D	-	-
LOI	3,32	3,00	1,67	3,44	40,50	8,93

- The fly ashes form N. Greece namely Kardia, Ptolemaida, and Agios Demetrios were clearly of the calcareous type, whereas, that from Megalopolis was marginally calcareous.
- The higher %SO_3 measured at the Kardia, Ptolemaida and Agios Demetrios fly ashes were due to their greater $CaSO_4$ content.
- Free lime was detected in all fly ash samples, with the Kardia fly ash being the one with the highest f.CaO content. Part of the f.CaO existing in the ashes was hydrated forming $Ca(OH)_2$.
- The LOI of all ashes was relatively low and below the 5% (max) limit required by the EN 197-1, for use in the cement.

- The fly ash and Milos Earth reactivity –as pozzolanic additives- greatly depend on their glass content. That is because only the amorphous SiO_2 of the glass is reactive and contributes to the formation of C-S-H. This forms during the pozzolanic reaction and it is mainly responsible for the development of strength. All fly ashes contained both crystalline constituents and amorphous ones, with most of the latter being in the form of glassy spheres. Quartz, hematite, feldspars (albite, sanidine, anorthite), anhydrite, lime and $Ca(OH)_2$ were the main minerals of these ashes. The Milos Earth was also composed of glass and a number of minerals, with feldspars being present in abundance.
- Calcite was the major constituent of the limestone. Some dolomite and very little quartz were also present.

Table 33: Mineralogical analyses

-	-	F. ASHES				LIMESTONE	MILOS EARTH
-	-	KARDIA	PTOL.	MEGAL.	AGIOS DEMETRIOS		
Quartz	SiO_2	+	+	+	+		+
Gehlenite	$(Ca,Al,Si.Mg,Fe)SiO_2$	+			+		
Hematite	Fe_2O_3	+	+	+	+		+
Lime	CaO	+	+	+	+		
Calcite	$CaCO_3$	+	+	+	+	+	+
Anorthite	$CaAl_2(SiO_4)2/CaO\cdot Al_2O_3\cdot 2SiO_2$	+			+		
Brownmillerite	$4CaO.Al_2O_3.Fe_2O_3$	+			+		
Illite	$KAl_2Si_3AlO_{10}(OH)_2$	+	+				+
Chrysotile	$Mg_3(Si_2\text{-}O_5)(OH)_{4\text{-}4x}$		+				
Albite	$NaAlSi_3O_8$	+	+	+	+		+
Periclase	MgO	+			+		
Portlandite	$Ca(OH)_2$	+	+	+	+		
Anhydrite	$CaSO_4$	+	+	+	+		
Dolomite	$Ca(Mg,Fe)(CO_3)_2$					+	+
Sanidine	$(K,Na)AlSi_3O_8$		+	+			
Coesite	SiO_2		+	+			
Montmorillonite	$NaMgAlSiO_2(OH)H_2O$			+			+
Akermanite	$MgAlSi1.5O_6$		+	+			

The mineralogical composition of the raw materials is shown in the following XRD figures.

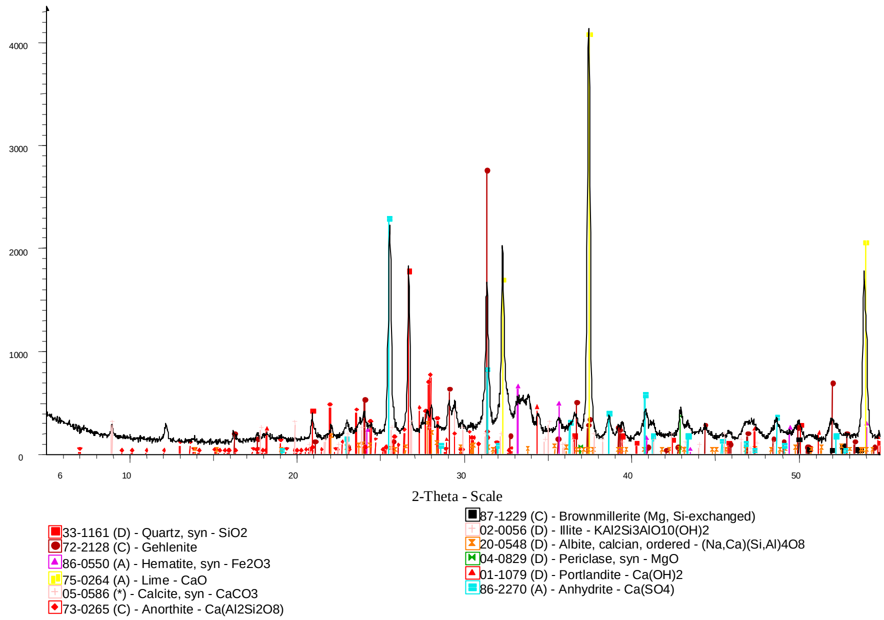

Figure 10: XRD of Fly Ash from Kardia

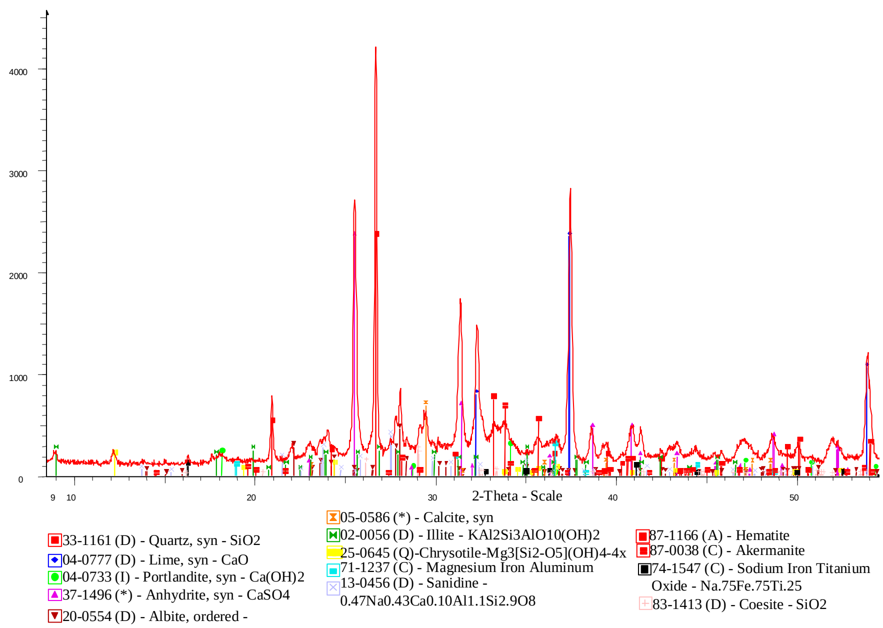

Figure 11: XRD of Fly Ash from Ptolemaida

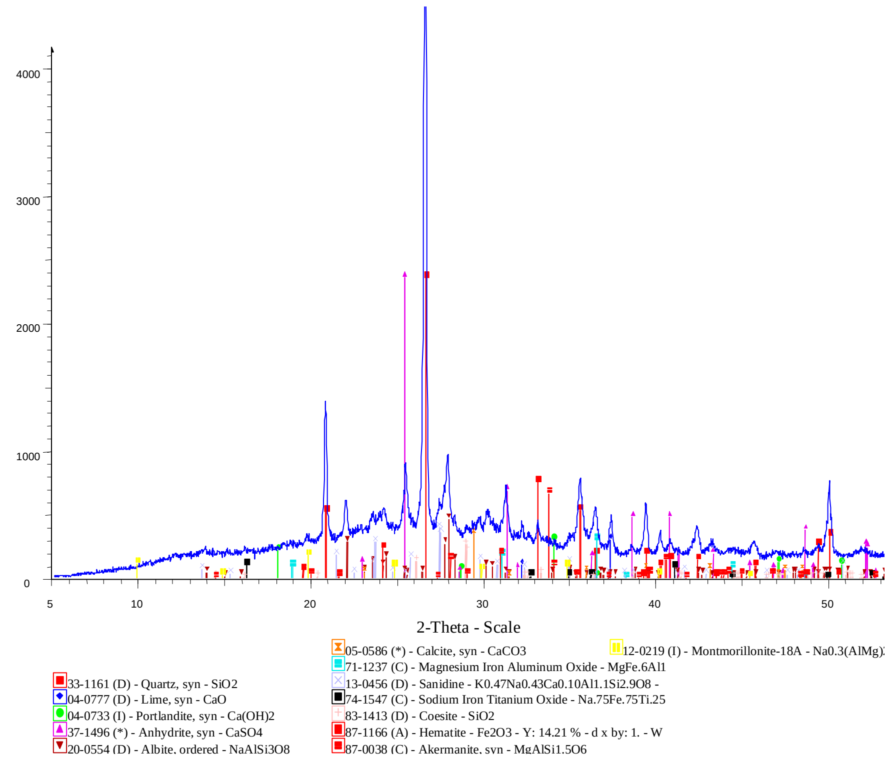

Figure 12: XRD of Fly Ash from Megalopolis

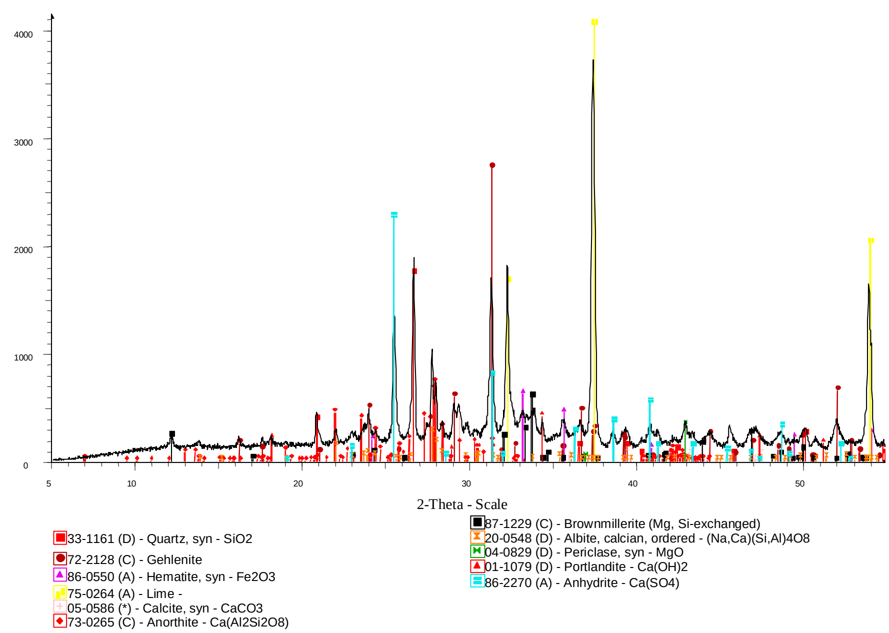

Figure 13: XRD of Fly Ash from Agios Demetrios

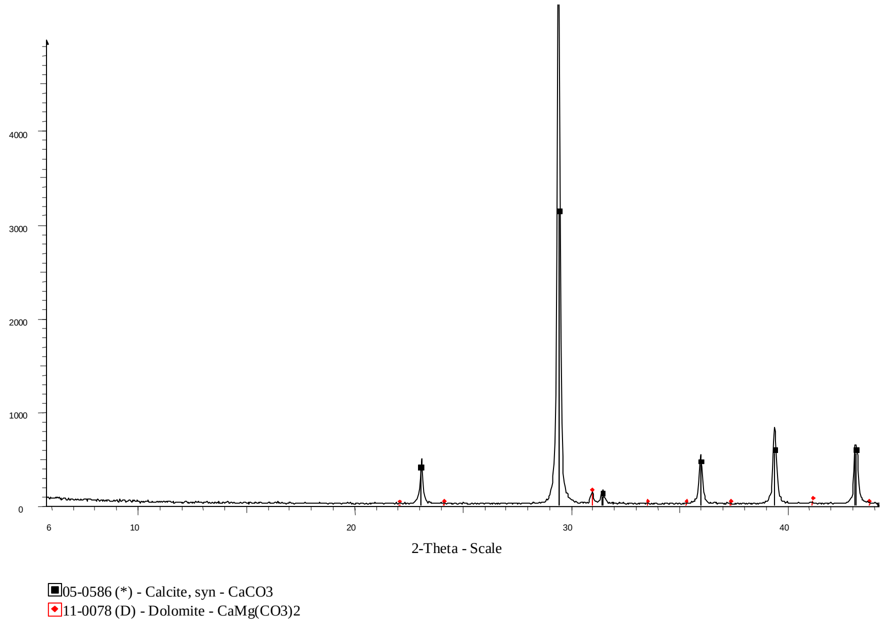

Figure 14: XRD of Limestone

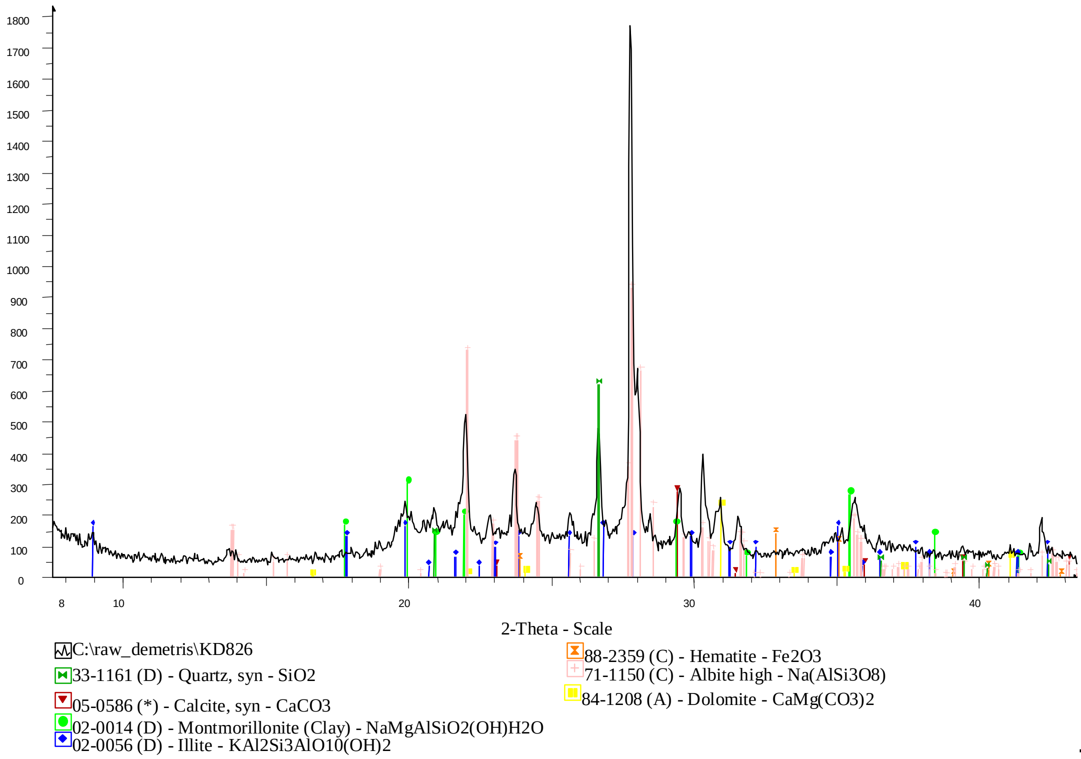

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Figure 15: XRD of Milos Earth

8.4.3 Cement Production - Mixing Of Constituents

There were two stages in cement production. The first one included the preparation of the raw materials and the second the production of composite cements by mixing the raw materials with CEM I 42,5 cement. The initial particle size distribution of the F.As used is shown in table 3. Preparation included grinding of the fly ashes to various fineness. The water demand and compressive strength of these laboratory produced composite cements were determined.

Table 34: Grain size distribution of Fly Ashes (% passing)

µm	KARDIA	PTOLEMAIDA	MEGALOPOLIS	AGIOS DEMETRIOS
1	2,7	2,3	1,0	2,4
2	3,3	2,7	1,2	2,9
2	5,0	4,1	2,0	4,3
3	7,5	6,2	2,8	6,6
4	10,2	8,6	3,8	9,3
6	13,4	11,4	4,9	12,7
8	18,6	16,0	6,9	17,8
12	25,3	22,5	9,5	24,8
16	34,1	31,4	13,3	33,7
24	44,2	42,8	18,5	45,2
32	56,0	56,3	27,1	58,0
48	73,4	76,0	45,9	76,9
64	79,6	82,0	56,5	82,6
96	93,3	94,9	81,4	94,5
128	98,3	98,7	95,3	98,6
192	100,0	100,0	100,0	100,0

Table 35: Different type of fly ashes in certain fineness

F.ASH	FINENESS	%H2O
MEGALOPOLIS	RAW, +45=65,2%	117,77
	+45=18%	112,44
	+45=11,2%	111,11
PTOLEMAIDA	RAW, +45=34,5%	115,55
	+45=20,3%	110,22
	+45=10,5%	107,55
AGIOS DEMETRIOS	RAW,+45=37,4%	111,11
	+45=21%	110,22
	+45=10,8%	106,67
KARDIA	RAW, +45=34,6%	111,11
	+45=21%	109,33
	+45=9,5%	107,55

As a preliminary evaluation of the fly ash addition, a series of test with the above mentioned fly ashes were performed. CEM I 42,5 was chosen as the reference cement. The tests included water demand and strength of cement blended with different type of fly ashes in certain fineness, as shown in the table 35. The water demand of the fly ash was determined according to flow table method. In this test the control mortar (proportion of constituents and water demand as described in EN 196-1, CEM: 450 g, Sand: 1350 g, w/c: 0,5), is tested for consistency according to flow table method (EN1015-4). Fly ash was tested by substituting 30 % of the cement (CEM: 315 g, F.A.: 135 g, Sand: 1350 g, w/c as much needed for the same consistency) in the control mortar and comparing to the reference sample. In all fly ash samples lower fineness at 45 μm sieve resulted in lower water demand. The water demand for all fly ashes was also higher than the control mortar (Figure 16).

The reduction in water demand by the grinding was probably a result of the finer fly ash particles becoming absorbed on the surface of cement particles. If enough fine fly ash particles are present to cover the surface of the cement particles, which become deflocculated, the water demand for a given workability is reduced (Neville, 2000).

The behavior of cement - fly ash mixes is also governed by fly ash fineness as strength increasing with fly ash fineness. For this test, mixes of CEM I 42,5 - fly ash (75/25) are compared against the reference sample CEM I 42,5. Fly ash is added as received and in three different fineness as well. The activity index (ratio of strength of cement-fly ash blend to cement) is higher than 1 in 3 months for fly ash fineness below R(45μm) = 15 %. In all cases of grinded fly ash, the activity index is higher than 75 % at 28 days and 85 % at 90 days as stated at PrEN 450-1. An increase in fly ash fineness results in the physical effect of packing of the fly ash particles at the interface of coarse aggregate particles. One beneficial effect of packing on strength is a reduction of the mortar air content but the main contribution lies in the reduction of large capillary pores.

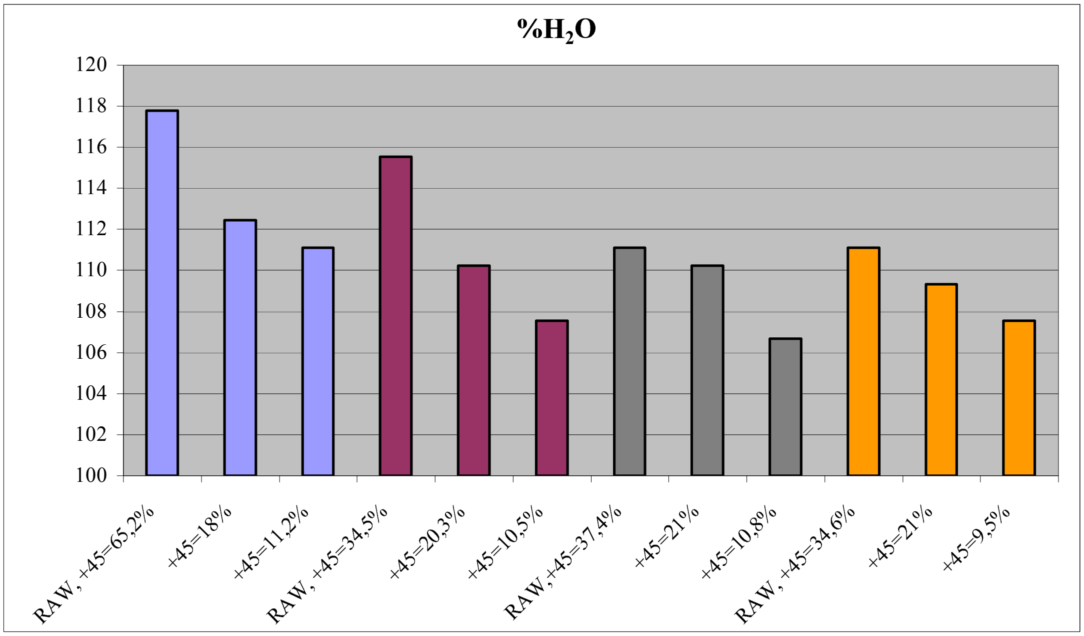

Figure 16: Water demand of mortars with fly ashes in certain fineness

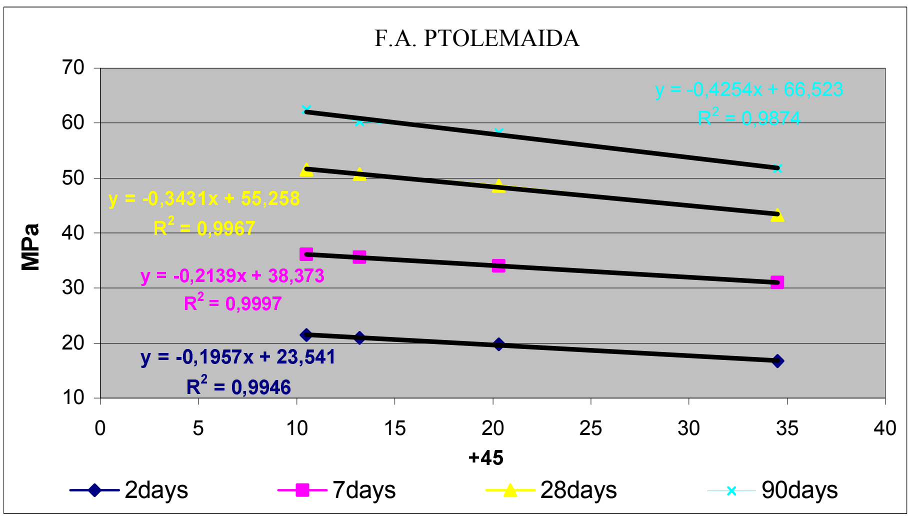

Figure 17: Compressive strength of mortars dependend on the amount of fly ash from Ptolemaida

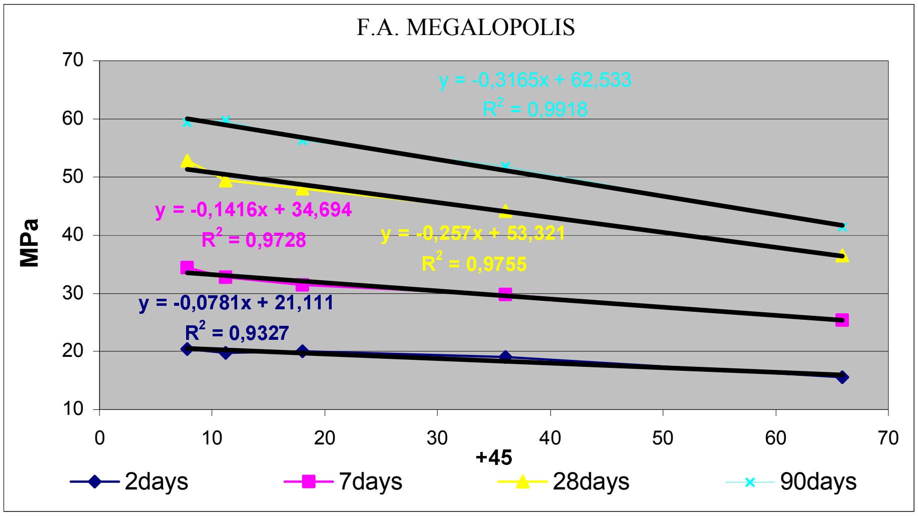

Figure 18: Compressive strength of mortars dependend on the amount of fly ash from Megalopolis

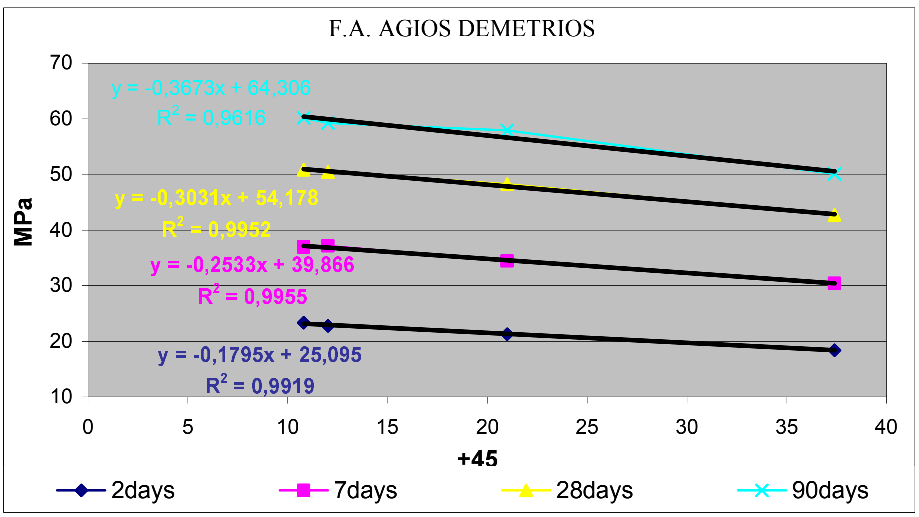

Figure 19: Compressive strength of mortars dependend on the amount of fly ash from Agios Demetrios

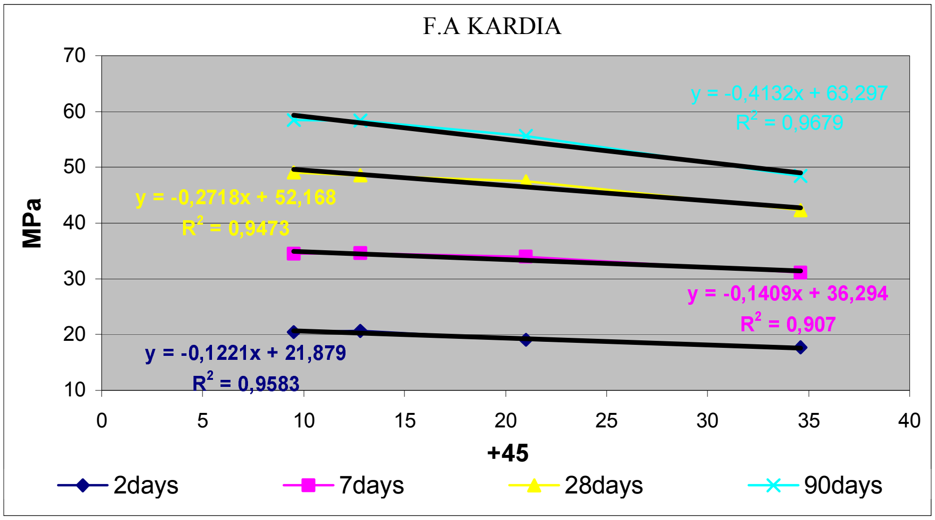

Figure 20: Compressive strength of mortars dependend on the amount of fly ash from Kardia

As the preliminary results showed, the role of particle size distribution of the additive in the performance of the cement is crucial. Thus, it was decided for all six additives (4 F.As, 1 limestone, 1 pozzolana) to explore mixtures with two levels of addition (35 % and 45 %) and different PSDs. In this case the reference cement is OPC (clinker and gypsum) I 52,5. The results so far are summarized in table 37.

- The water demand was higher at the higher addition level (45%) comparing mixtures with fly ash of the same fineness.
- The water demand is decreasing with decreasing fineness for both addition levels.
- The initial setting time was longer for the higher addition level (45%) but it was getting shorter for finer fly ash.
- The strength development correlates well to the 3-32µ fraction for all mixtures. The 3-32 µm fraction is increasing with increasing fineness because the >32µ fraction is decreasing at a higher rate than the < 3µm fraction is increasing.
- The CILAS Granulometry 715 was used for the determination of PSDs for all materials used. It was found that the agglomeration of grinded limestone was considerable, as it is shown by the PSD results with and without the use of ultrasounds.

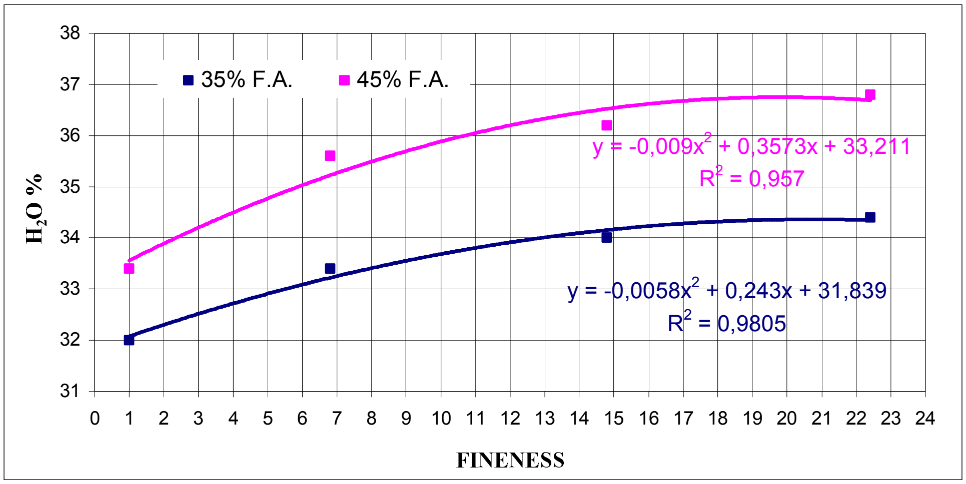

Figure 21: Water demand dependend on the fineness

In general, at the end of the reporting period all blended cements with one additive have been prepared and tested according to schedule. As a matter of fact, more blended cements with one additive have been prepared than those we were committed to investigate because it is appropriate to test each component alone before mixing them in three additives mixtures.

8.4.4 Fly Ash In Concrete

8.4.4.1 General

In the framework of Eco–Serve four types of Greek fly ashes (F.A.), from Megalopolis, Kardia, Ptolemaida and Agios Dimitrios were used in concrete in order to examine the effect of addition on the fresh and the hardened concrete properties. In order to eliminate the effect of the different particle distribution, of the above mentioned fly ashes they were all grinded to similar fineness (retained fraction at 45 μm) i. e. 18 % for Megalopolis' F.A., 21 % for Kardia's F.A., 20,3 % for Ptolemaida' s F.A. and 21 % for Agios Demetrios' F.A..

The experiments in the laboratory were realized as described below:

Four exposure classes were chosen according to the European regulation EN 206-1, XC1 (max w/c = 0,65), XC2 (max w/c = 0,60), XC3 (max w/c = 0,55) and XC4 (max w/c = 0,50). The ratio w/c was calculated considering the k – value of fly ash equal to 0,4 in the case concrete contains cement type CEM I 42,5 or higher. The maximum amount of fly ash that was taken into account for the k – value concept met the requirement fly ash/cement □0,33 by mass.

Four reference concrete mix designs were produced without fly ash (for more details see table 36, mix design 1). The other mix designs also described in table 6, were produced considering the following requirements:

- The minimum cement content required for the relevant exposure class was allowed to be reduced by a maximum amount of the additive, the later given by the following equation: k · (minimum cement content – 200) kg /m^3.

- The amount of cement+fly ash should not be less than the minimum cement content required by EN 206-1 (see table 36).

The measured characteristics were: slump flow and compressive strength at the ages of 3, 7 and 28 days. The aim in the mix designs related to XC1 exposure class was to examine the variation of slump flow once different amounts of fly ash were added in the concrete mixture. The purpose of the mix designs connected to XC2, XC3 and XC4 exposure classes was to achieve the same slump flow (80-100 mm) with, if needed, the use of an admixture with plasticizing properties.

- Slump flow decreased when a small amount (24kg/m^3) of fly ash was added for the mixtures with w/c = 0,65 (XC1), from initially 9cm to 4cm. When the F.A. amount increased the difference in the measured slump flow was smaller (1 or 2 cm).

- The effect of fly ash on the slump flow loss was more distinct for the mixtures with lower w/c ratios (0,60, 0,55, 0,50), since the admixtures needed in order to keep the concrete's workability at the same level as for the reference concrete was increased.

- The highest amount of admixture was required for the mixtures Agios Demetrios' fly ash. It is important to underline that according to the admixture supplier the maximum amount of the plasticizer is 2 %. In Agios Demetrios' mixtures case the amounts of the admixture were up to 7,8 kg/m^3 (3 % of the cement weight). On the other hand the mixtures with Megalopolis' F.A. demanded double the amount of admixture for almost double amount of fly ash added.

- All of the mixtures reached compressive strengths that satisfied the minimum strength classes that EN 206-1 requires.

Table 36: Concrete mix designs

		Carbonation-induced corrosion			
	Exposure classes	XC1	XC2	XC3	XC4
	Maximum w/c	0,65	0,60	0,55	0,50
	Minimum strength class	C20/25	C25/30	C30/37	C30/37
	Minimum cement content (Kg/m³)	260	280	280	300
	Minimum air content (%)	---	---	---	---
	Fly Ash	KARDIA	PTOLEMAIDA	MEGALOPOLIS	AG. DEMETRIOS
MIX DESIGN					
1	Cement I42,5	260	280	280	300
	F.Ash	0	0	0	0
	Water	169	168	154	150
	Admixture	0	0	1,12	2,40
	w/c	0,65	0,60	0,55	0,50
	Slump Flow	9	8	10	9
	C.Strength 3days	19,4	21,9	24,2	31
	C.Strength 7days	24,2	29,5	30,7	37,4
	C.Strength 28days	33	37,7	37,8	44,6
2	Cement I42,5	236	248	248	260
	F.Ash	24	32	32	40
	Water	159,6	156,5	143,5	138
	Total Admixture	0,00	1,12	3,50	7,20
	w/c	0,65	0,60	0,55	0,50
	% F.Ash	9,2	11,4	11,4	13,3
	Slump Flow	4	9	10	10
	C.Strength 3days	20,9	20,73	25	31,3
	C.Strength 7days	26,7	28,6	35,9	40,8
	C.Strength 28days	35,7	37,7	47	50,8
3	Cement I42,5	236	248	248	260
	F.Ash	50,94	56,92	56,92	62,9
	Water	166,7	162,5	149	142,6
	Total Admixture	0,00	1,22	4,00	7,30
	w/c	0,65	0,60	0,55	0,50
	% F.Ash	17,75	18,67	18,67	19,48
	Slump Flow	8	8	10	9
	C.Strength 3days	20,8	19,5	26	31,1
	C.Strength 7days	26,6	29,2	34,4	40,4
	C.Strength 28days	36	41	45,2	50,5
4	Cement I42,5	236	248	248	260
	F.Ash	77,88	81,84	81,84	85,8
	Water	173,7	168,4	154,5	147,2
	Total Admixture	0,00	1,55	5,80	7,80
	w/c	---	0,60	0,55	0,50
	% F.Ash	24,81	24,81	24,81	24,81
	Slump Flow	7	8	10	9
	C.Strength 3days	21,1	18,8	26,9	32,3
	C.Strength 7days	27,7	27,4	37	40,4
	C.Strength 28days	38,9	40,4	51,6	50,7

8.4.4.2 Mixtures of opc with fly ash

This report is focusing on the investigation of composite cements by mixing OPC I-52,5 with Fly Ashes. The chemical and mineralogical analyses of four Fly Ashes from Greece (shown in the previous report) revealed their differences in free lime and sulphur content and confirmed that those from N. Greece, namely Kardia, Ptolemaida and Agios Demetrios are clearly of the calcareous type, whereas the one from Megalopolis is marginally calcareous.

Table 38 summarises the properties of blended cements by mixing OPC and two Fly Ashes from Megalopolis and Ptolemaida, each one in two ratios according to the final workplan (i.e. 35 & 45% F.A.). For each ratio both Fly Ashes were grinded at 4 different finenesses (from 1,0 up to 23,4% residues at 45 µm sieve).

The following conclusions can be drawn out of the results of table 38 and out of the comparison to table 37:

- The water demand is higher at higher addition level for both Fly Ashes.
- The water demand is decreasing with decreasing fineness for both addition levels of both Fly Ashes.
- The setting time is increased with increasing addition level, but it is getting considerably shorter for finer Fly Ashes.
- Despite the fact that Megalopolis Fly Ash contains less sulphur (SO_3) and its mineralogical analysis revealed less anhydrite, the retardation of setting time is higher compared to the one caused by Ptolemaida Fly Ash.
- As expected, the higher addition level, the lower the final compressive strength, but the effect is almost diminished as the Fly Ashes are getting finer.

- Although the set target was to accomplice the same four levels of finenesses for both Fly Ashes and that was realized to a great extent, the PSDs (by CILAS Granulometre 715) exposed that for the same fineness level the –3 μm fraction of Ptolemaida Fly Ash is quite higher. The starting size and nature of the particles are essential for the above finding. The ESEM and EDAX images, as those following, will help us to be more detailed.

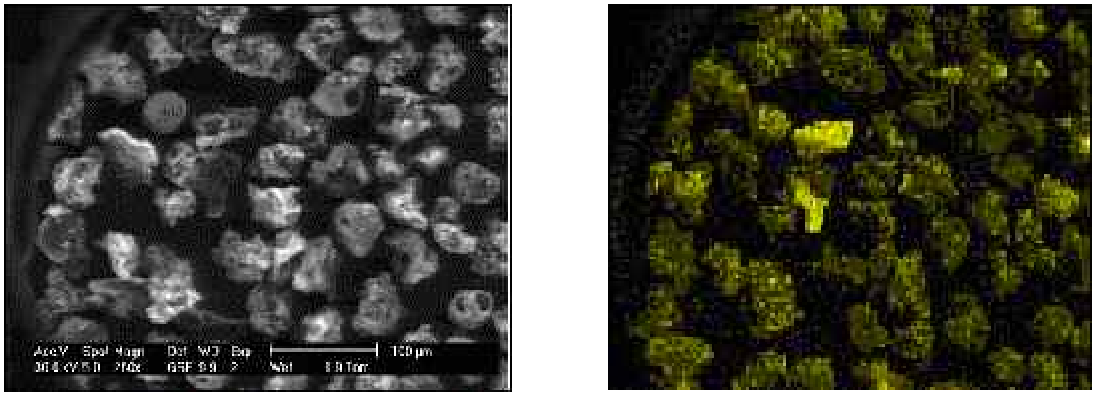

Figure 22: ESEM and EDAX (SiO_2) images of Megalopolis F.A. as received.

- Comparing mixtures with pozzolana (table 37) and those with Fly Ash (table 38) it is easy to conclude that pozzolana has no effect on water demand and on setting time, while the fineness of the addition has a minor effect on compressive strength.

All the above point out to the crucial role of PSDs along with the necessity for further investigation, in particular of more complicated systems.

Table 37: Mixtures of OPC and additives

	OPC	LIMESTONE				ADMIXTURE WITH 35% LIMESTONE	ADMIXTURES WITH 35% MILOS EARTH			ADMIXTURES WITH 45% MILOS EARTH		
+45µm:		as it is	ultrasound	as it is	ultrasound	*13,5*	*5,8*	*13,6*	*24,4*	*5,8*	*13,6*	*24,4*
1µm	8,5	3,2	9,2	2,4	11,8	9,1	5,4	5,2	4,9	4,9	4,8	4,4
1,5µm	10,7	3,7	11,9	2,7	16,0	11,9	7,3	6,8	6,3	6,7	6,4	5,9
2µm	15,7	4,7	18,3	3,3	24,4	18,2	12,5	11,1	10,3	11,5	11,4	10,0
3µm	21,3	5,4	24,3	3,9	33,4	25,1	19,1	16,8	15,7	18,2	17,5	15,2
4µm	26,4	6,9	29,7	5,0	38,6	30,3	24,5	22,0	20,8	23,4	22,8	20,0
6µm	32,0	9,3	33,5	6,6	44,8	36,1	31,0	29,0	26,8	30,5	28,9	25,6
8µm	40,3	15,2	41,3	9,8	51,5	43,7	39,5	37,7	34,8	38,3	37,2	33,4
12µm	50,3	25,2	46,9	15,7	59,2	52,8	50,2	48,8	44,6	49,3	47,0	42,4
16µm	61,1	35,3	54,6	22,9	64,3	61,6	60,3	59,3	55,0	58,9	58,1	53,0
24µm	75,7	46,0	59,3	34,1	69,9	73,9	74,6	73,4	67,4	73,8	71,3	65,3
32µm	88,3	55,6	68,5	44,9	75,5	83,7	86,5	85,5	80,2	84,3	84,5	77,8
48µm	100,0	67,7	78,7	61,0	86,5	95,3	98,7	99,4	94,4	97,7	98,2	92,3
64µm	100,0	72,8	82,9	69,2	87,7	95,8	98,7	99,4	95,6	97,7	99,2	94,6
96µm	100,0	86,0	95,1	81,8	98,7	100,0	98,7	99,9	98,3	97,7	100,0	99,1
128µm	100,0	96,5	98,7	95,4	100,0	100,0	99,6	99,9	99,5	99,4	100,0	99,7
192µm	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0
< 3	21,30					25,10	19,10	16,80	15,70	18,20	17,50	15,20
>32	11,70					16,30	13,50	14,50	19,80	15,70	15,50	22,20
3 - 32	67,00					58,60	67,40	68,70	64,50	66,10	67,00	62,60
n=	0,94					0,82	0,98	1,03	0,98	0,98	1,00	0,97
d=	15,79					15,84	16,46	17,08	19,81	17,17	17,70	21,12
%H_2O	25,4					25,2	34,0	34,2	34,2	36,0	36,0	36,6
I.Set	95					80	120	120	130	120	120	140
F.Set	145					120	180	170	180	180	180	180
Le Chat.	0,1					0,1						
1day	18,5					10,4	12,8	13,1	12,5	10,7	9,9	10,0
2days	29,8					17,5	19,3	20,7	18,6	15,8	15,7	15,3
7days	44,0					27,9	31,1	30,4	28,9	26,4	24,6	24,5
28days	66,0					37,5	43,0	42,8	41,2	39,2	37,2	35,3

Table 38: Mixtures of OPC and additives

	OPC	F.ASH MEGALOPOLIS				ADMIXTURES WITH 35% F.A. MEGALOPOLIS				ADMIXTURES WITH 45% F.A. MEGALOPOLIS				OPC	F. ASH PTOLEMAIDAS				ADMIXTURES WITH 35% F.A. PTOLEMAIDAS				ADMIXTURES WITH 45% F.A. PTOLEMAIDAS			
+45μm:		*1,0*	*6,8*	*14,8*	*22,4*	*1,0*	*6,8*	*14,8*	*22,4*	*1,0*	*6,8*	*14,8*	*22,4*		2,0	6,5	16,0	19,8	2,0	6,5	16,0	19,8	2,0	6,5	16,0	19,8
1μm	8,5	7,2	5,2	3,9	3,1	6,8	7,1	6,6	6,5	7,0	6,7	6,3	6,0	8,0	13,6	9,7	5,0	4,1	10,6	8,9	7,1	6,7	10,9	8,3	6,7	6,4
1,5μm	10,7	10,0	7,1	5,2	4,1	8,7	9,2	8,6	8,2	9,1	8,8	8,1	7,6	9,9	17,8	13,0	6,3	5,2	13,4	11,3	8,9	8,4	13,8	10,4	8,5	7,9
2μm	15,7	16,9	12,1	8,8	6,9	14,1	14,0	13,2	12,6	15,3	13,6	12,4	11,6	14,8	26,8	20,0	10,0	8,2	20,1	17,0	13,2	12,5	20,6	15,4	12,6	11,8
3μm	21,3	26,5	18,2	13,4	10,4	21,1	20,3	19,0	17,5	22,6	19,8	17,8	16,5	19,6	38,3	28,7	14,6	11,7	26,9	23,0	18,1	17,0	28,2	21,5	17,5	16,2
4μm	26,4	33,1	23,4	17,5	14,0	27,8	25,1	23,6	22,3	29,5	24,8	22,4	20,8	24,6	46,8	34,4	19,2	15,3	33,2	28,5	22,7	21,5	35,1	27,4	22,0	20,6
6μm	32,0	42,7	30,0	22,7	18,1	34,5	31,6	29,4	27,1	35,7	31,3	28,2	25,9	29,3	56,2	41,9	24,3	19,1	38,8	34,0	27,7	26,1	41,7	34,4	27,1	25,2
8μm	40,3	52,4	38,5	29,8	24,4	44,2	39,6	36,9	34,8	46,0	39,2	35,7	33,0	37,8	66,1	50,0	31,8	25,6	48,0	42,5	35,2	33,6	51,1	44,0	34,6	32,5
12μm	50,3	65,6	49,9	39,3	32,5	54,4	50,3	47,0	43,3	56,3	50,0	45,5	42,1	47,0	75,6	60,8	40,2	33,7	57,0	52,0	44,4	42,3	60,1	54,0	44,0	41,3
16μm	61,1	75,6	61,3	48,8	42,0	67,0	60,3	56,6	53,8	68,9	60,1	55,2	51,9	59,4	83,0	69,2	49,6	43,5	68,1	63,2	55,1	53,1	70,5	64,9	54,6	52,0
24μm	75,7	89,2	76,4	62,2	53,4	80,0	75,8	71,7	66,9	80,7	75,6	69,3	65,1	75,4	90,5	81,4	60,9	55,3	80,4	77,5	70,0	67,5	82,2	78,2	69,2	65,9
32μm	88,3	95,1	88,5	75,4	67,3	92,4	87,3	83,8	80,7	93,8	87,0	81,7	77,9	90,1	96,5	89,5	73,8	69,0	92,2	89,8	83,2	81,1	92,9	90,2	82,2	79,4
48μm	100,0	100,0	100,0	93,5	86,9	100,0	100,0	100,0	95,2	99,5	100,0	97,6	94,4	100,0	100,0	100,0	89,7	86,1	100,0	100,0	97,2	95,0	100,0	100,0	96,5	93,7
64μm	100,0	100,0	100,0	94,3	91,4	100,0	100,0	100,0	96,3	100,0	100,0	98,6	96,4	100,0	100,0	100,0	93,2	91,4	100,0	100,0	100,0	96,0	100,0	100,0	96,5	95,4
96μm	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	98,2	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0
128μm	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	99,5	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0
192μm	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0
< 3	21,30					21,10	20,30	19,00	17,50	22,60	19,80	17,80	16,50	19,6					26,90	23,00	18,10	17,00	28,20	21,47	17,50	16,20
>32	11,70					7,60	12,70	16,20	19,30	6,20	13,00	18,30	22,10	9,9					7,80	10,20	16,80	18,90	7,10	9,80	17,80	20,60
3 - 32	67,00					71,30	67,00	64,80	63,20	71,20	67,20	63,90	61,40	70,5					65,30	66,8	65,10	64,10	64,70	68,70	64,70	63,20
n=	0,94					0,99	0,97	0,98	0,95	0,97	0,98	0,97	0,97	1,00					0,86	0,92	0,98	0,97	0,85	0,95	0,97	0,97
d=	15,79					14,05	16,07	17,64	19,84	13,41	16,21	18,72	20,88	16,42					12,95	14,89	18,59	20,00	12,00	14,52	19,15	20,86
% H_2O	25,4					32,0	33,4	34,0	34,4	33,4	35,6	36,2	36,8	27,6					29,6	30,4	36,0	34,6	31	31,6	35,6	37,2
I.Set	95					175	220	230	240	195	240	260	280	150					140	160	180	190	150	190	200	210
F.Set	145					265	290	300	310	285	320	340	350	200					180	210	230	240	200	250	250	260
Le Chat.	0,1					0,0	0,1	0,1	0,1	0,0	0,0	0,1	0,1													
1day	18,5					12,3	11,8	10,5	10,0	10,0	9,2	8,5	7,6	18,4					16,9	16,3	14,4	11,8	15,6	15,1	12,3	10,5
2days	29,8					21,7	21,0	18,5	18,2	19,0	18,0	16,2	15,0	29,6					27,4	29,0	24,2	22,2	25,5	26,0	22,1	19,8
7days	44,0					37,8	34,1	30,4	29,0	35,4	31,0	28,6	26,2	47,3					41,0	42,2	37,8	35,3	40,2	40,6	35,0	30,8
28days	66,0					63,5	58,1	52,5	52,2	62,0	56,0	51,2	48,0	64,6					60,8	58,2	52,8	50,1	59,6	59,0	52,0	47,6

8.4.5 Preliminary results of the concrete tests

Several concrete mixtures were prepared in order to examine their mechanical properties and durability by using blended cements with Fly Ash from Ptolemaida. The characteristics of the used blended cements are presented in table 38.

The preliminary results of the concrete compressive strength were in accordance to the cement compressive strength.

The laboratory tests have shown that:

- Higher compressive strengths are obtained by using blended cement with lower ratio of the additive (35 % FA) than blended cement with the higher ratio of FA (45 %) in the concrete mixtures.
- The compressive strength of the concrete mixtures decreases with the increase of the additive's fineness.

The results are presented in table 39.

Table 39: Compressive strengths, 2 and 7 days, for 8 concrete mixtures

CEMENT TYPE	1	2	3	4	5	6	7	8
Fineness (%)	6,5	16,0	19,8	6,5	16,0	19,8	2,0	2,0
FA ratio (%)	35	35	35	45	45	45	35	45
2 days in MPa	28,3	27,6	27,9	25,8	24,9	24,0	28,8	25,6
7 days in MPa	41,8	40,7	38,6	39,6	36,8	33,7	43,0	42,2

Concrete tests and their evaluation will be the main body of the next progress report according to workplan.

9 Annex B: Minutes of the meetings

9.1 1. Meeting

Date: 05 September 2003 at 11 a.m.
Place: Research Institute of the Cement Industry, Düsseldorf, Germany

Present were:

1	Manolis Haniotakis	(MH)	Titan Cement Company S.A.
2	Christoph Müller	(CM)	Verein Deutscher Zementwerke e.V.
3	Eberhard Siebel	(ES)	Verein Deutscher Zementwerke e.V.
4	Erik Stoltenberg-Hansson	(ESH)	NORCEM
5	Paolo Ursella	(PU)	CTG SpA

Minutes taken by CM.

Agenda

1 Opening of the meeting
2 Formalities (Contract etc.)
3 Essential arrangements on the performance of tasks R1-R3 of the work plan:
   - Composition of the cements produced in task R1
   - Investigations (R2/R3)
   - Deliverables
   - Milestones
   - Schedule
4 Any other business

Opening of the meeting

ES welcomed all participants to the 1. meeting of research activities in cluster 2 of the ECO-Serve Network. He then asked for comments to the proposed agenda.

The proposed agenda was adopted.

Formalities

All signed contracts will be send to VDZ latest within one week after this meeting. VDZ will then send the contracts to the commission (completed 11.09.2003).

Due to the fact, that the contract shall enter into force following its signature by all the contracting parties (principal contractors and the Community) and because the duration of the project shall be 24 months from the first day of the month after the last signature of the contracting parties, the starting date will be estimated 01.10.2003.

This starting date is 7 month before the date scheduled in Annex I („Description of work“) of the contract no. G1RD-CT-2002-00782. The accelerated start was enforced by the commission.

The revised and adjusted timetable for start in October 2003 was given to all partners with the documents ECO-Serve-C2-R-0002 and ECO-Serve-C2-R-0003. All partners agreed on the new timetable and the consequences for milestones and deliverables. Objections can be send to VDZ within two weeks after this meeting.

Essential arrangements on the performance of tasks R1-R3 of the work plan

CM presented, which cements VDZ is going to investigate. After his presentation, ES asked the other partners to present their proposals for cements to be investigated. Table A1 gives an overview of the cements, that will be investigated by the partners.

Table A1: Overview of the cements, that will be investigated by the partners in cluster 2

Partner		Cements
Cements with maximum amounts of main constituents besides clinker acc. to EN 197-1		
Verein Deutscher Zementwerke e.V.	-	CEM II-W and CEM II-M (S-W)
		2 Fly ashes (W):
		1 x Lausitz Area (Jänschwalde) 1 x Mitteldeutsches Revier = Halle/Leipzig Area (Schkopau)
		1 Clinker, 1 GBFS and 10, 20 or 30 % Fly ash
	-	CEM II-LL
		3 Limestone: Devon, Cretaceous, Jura
		65 % clinker, 35 % limestone
NORCEM	-	CEM II-M (V-LL)
		2 cements with up to 30 % Limestone
	-	selective use of GBFS
Titan Cement Company S.A.	-	CEM II/B-V with 35 V
	-	CEM II/B-W with 35 W
	-	CEM II/B-LL with 35 LL
	-	CEM IV A/B with LL
CTG SpA	-	CEM III with 50 % GBFS

Table A1: Continuation

Cements with a composition beyond the limits of EN 197-1		
Verein Deutscher Zementwerke e.V.	-	CEM with LL
		Limestone: Devon
		55 % clinker, 45 % limestone
	-	CEM V
		Limestone / GBFS
		- 30 % GBFS, 20 % limestone
		- 50 % GBFS, 20 % limestone
NORCEM	-	2 cements with 35-40 % Fly ash (V)
Titan Cement Company S.A.	-	CEM with 45 % V
	-	CEM with 45 % W
	-	CEM with 45 LL
CTG SpA	-	CEM with 35-45 LL
	-	CEM V with 40 % GBFS and 20 % LL
	-	CEM with pozzolana (mixture of glass/brick with natural pozzolana acc. to EN 197-1)

The Partners decided not to use silica-fume because no benefit is expected within the ECO-Serve scope. The planned strength for all cements is 45 - 50 MPa acc. to EN 197-1. Every partner uses a typically used cement of his region for comparative tests.

CM will develop a sheet, in which every partner can enlist the cement composition in detail (ECO-Serve-C2-R-0006).

For the comparability and the reproducibility of the investigations and their results, it is essential, that the partners agree on some mortar- and concrete compositions as well as the test methods. As a basis for further discussions document ECO-Serve-C2-R-0004 “Test methods” was delivered to the partners. The results of the discussion are summarised in Table A2.

Table A2: Overview of test methods

Task	Subject	Test method / Concrete composition
2.1	Physical and chemical properties of components and cements	Particle size distribution, Blaine, EN 196
2.2	Interaction between the main constituents	No Test method required
2.3	Microstructure	Standard: Water uptake under atmospheric pressure and 15 MPa. REMARK: Pore size distribution with Hg-Intrusion is optional.

Table A2: Continuation

3.1	Basic concrete properties	Fresh concrete: EN 12350 Hardened concrete: EN 12390 Compressive strength 2d, 7d, 28d, 90d	c = 280 kg/m^3 w/c = 0,60 c = 320 kg/m^3 w/c = 0,50
3.2	Carbonation	Beams 100 x 100 x 400 mm^3 *1d moulded, 6d water storage, (20±2) °C / (65±5) % r. H.* Evaporation in the climate chamber: (45±15) g/(m^2·h)	c = 280 kg/m^3 w/c = 0,60
3.3	Penetration of chlorides	Rapid chloride migration method (RCM) - comp. Brite EuRam III project DuraCrete	c = 320 kg/m^3 w/c = 0,50
3.4	Freeze-thaw resistance	Beam test	c = 320 kg/m^3 w/c = 0,50
	Freeze-thaw resistance with de-icing salt	Slab test	c = 320 kg/m^3 w/c = 0,50, AE
3.5	Sulphate resistance	There is no Europeanwide accepted test method for the determination of the sulphate resistance of mortar or concrete. Partners will use the test methods, which are commonly used in their countries.	

Any other business

CM reminded all partners to send their bank accounts by email and to proceed with their mapping activities (ECO-Serve-C2-N-0009) as well as the data collection (ECO-Serve-C2-N-0010) and the compilation of application rules (ECO-Serve-C2-N-0011).

Because of the temporal closeness to the planned meeting of the network activities in cluster 2 on 15.10.2003, research partners assigned VDZ to ask the other network partners of cluster 2 to postpone the meeting to one of the following dates: 18., 19., 21. or 24.11.2003.

The meeting closed at 16:00 p.m.

signed
Dr.-Ing. E. Siebel

signed
i. V. Dr.-Ing. C. Müller

9.2 2. Meeting

Date: 18 November 2003 at 11 a.m.
Place: Research Institute of the Cement Industry, Düsseldorf, Germany

Present were:

1	Manolis Haniotakis	(MH)	Titan Cement Company S.A.
2	Hendrik Möller	(HM)	SCHWENK
3	Christoph Müller	(CM)	Verein Deutscher Zementwerke e.V.
4	Terje Rønning	(TR)	NORCEM
5	Rico van Selst	(RS)	INTRON
6	Eberhard Siebel	(ES)	Verein Deutscher Zementwerke e.V.
7	Paolo Ursella	(PU)	CTG SpA

Absent were:

Thorsten Reschke	(TR)	BAW

Minutes taken by CM.

Agenda

Network

N5 Opening of the meeting
N6 Minutes of the 1. meeting
N7 Formalities (Cost statements etc.)
N8 Discussion of the draft of the 2. periodic report and adoption
N9 Continuation of mapping and data collection - further procedure
N10 Any other business

Research

R1 Minutes of the 1. meeting
R2 Fixing the final workplan
R3 Any other business

Network

N1 Opening of the meeting

ES welcomed all participants to the 2. meeting of cluster 2 in the ECO-Serve Network. He then asked for comments to the proposed agenda. The proposed agenda was adopted without changes.

ES especially welcomed RS as a member of the management group. ES asked RS to give an overview of the management activities, the status quo of the network activities and the Warsaw meeting under agenda item N3.

N2 Minutes of the 1. meeting

The minutes of the first meeting were adopted without comments or changes.

N3 Formalities (Cost statements etc.)

Report of RS about management activities, status quo of the network activities and the Warsaw meeting.: In the following some essential aspects are summarised.

- ECO-Serve is one of the biggest networks in Europe at the moment.
- The course of the network was not optimal in all cases up to now.
- Cluster 2 is in good progress.
- The ECO-Serve web-site has to become more attractive.
- Web-site: The Management will send a format to report about the progress of the clusters for the presentation on the web-site until 2003-11-20.
- The development of a power-point-presentation for ECO-Serve is in progress. It will present the network in an interactive way. It will lead the user to the clusters with detailed information.
- A first yearly workshop is planned for May/June 2004.
- Indicators for the environmental assessment: Task 2 will development an excel-sheet.

Cost statements:

- Principal contractors send the statements directly to Dansk Beton Teknik (DBT) and a copy to VDZ.
- Members are sending cost statements to the contract holders who sign them and forward these to DBT.
- DBT will check that the costs comply with the contract and forward the cost statements to the Commission.
- DBT should receive the statements until ***5th December*** so they can be submitted before ***15th December***. 15th December was fixed because this date is one month after the end of the first year.
- RS: Costs can be claimed. It is possible for example to change man hour into travel to some extend.
- Cost statements have to consider the principles laid down in the network manual compiled by the coordinator

N4 Discussion of the draft of the 2. periodic report and adoption

Chapter	Remarks
1	Adopted without changes.
2	Adopted without changes.
3	Figures 1-7 have to be significantly signed as a first draft. Adopted with this complement.
4	Figure 10 will be added with Cement types in the CEMBUREAU countries 2001; Source: CEMBUREAU statistics with values referring to all strength classes. Adopted with this complement.
5	Adopted without changes.
6	Adopted without changes.

N5 Continuation of mapping and data collection - further procedure

- TR: Data for Finland will be available presumably in December.
- Besides the enquiry using the questionnaires, all partners will intensify their search using other sources (e. g. data-bases, internet → web-sites of cement producers, official statistics (e. g. Federal Statistical Office Germany) etc.)
- VDZ and RS will contact CEMBUREAU to request to what extent CEMBUREAU statistics can be used for the evaluation in the project.
- Use of questionnaires: Partners will compile a list, to whom they have send the questionnaires and who did not answer.
- While sending the questionnaire, partners will ask for a short comment when the respondent is not able to answer to give a short explanation: „Why not“.
- Application rules: For the next meeting all partners will contribute to this chapter.
- To encourage the co-operation with cluster 3, sometime during the duration of the network a common workshop of cluster 2 and cluster 3 might be helpful. As a first step, all partners are invited to join the first workshop of cluster 3 (ECO-Serve-C2-N-0018).
- Second end user: TR will have a meeting with the National road work administration. Possibly he can win them over to join the network.
- ES: The network in no way is a platform for political discussions. All partners agreed.

- Data collection must consider the market situation respectively „historical“ evolutions: e. g. „How was Sweden able to have a significant change on cement types within a few years ?“; e. g. England: No blended cements but use of granulated blast furnace slag as a concrete addition.

N6 Any other business

none

Research

R1 Minutes of the 1. meeting

TOP 3: “The planned strength for all cements is 45 - 50 MPa acc. to EN 197-1. Every partner uses a typically used cement of his region for comparative tests.”
Remark of MH: Strength 45 - 50 MPa will maybe not be reached with 40 % of fly ash.

> ***Decision: If the strength of the tested cement is significantly lower than 45 - 50 MPa, partners use a reference cement with a reduced strength.***

The minutes of the first meeting were adopted with this complement.

R2 Fixing the final workplan

Partners agreed on the concrete compositions and test methods compiled in the minutes of the first meeting. The cement compositions were fixed acc. to ECO-Serve-C2-R-0006.

R3 Any other business

none

No date was fixed for the next meeting. The next meeting should take place later on in 2004. VDZ will arrange a date during the summer 2004.

The meeting closed at 15:30 p.m.

9.3 3. Meeting

Date: 01 February 2005 at 10 a.m.
Place: Research Institute of the Cement Industry, Düsseldorf, Germany

Present were:

… to be completed