Proceedings
World Geothermal Congress 2010

ISBN 9989-2315-2-4

- Table of Contents
- Authors List
- Search this CD

Convener:
International Geothermal Association (IGA)

Co-Convener:
Indonesian Geothermal Association (INAGA)

Endorsed by:
Ministry of Energy & Mineral Resources of the Republic of Indonesia

- Technical Programme Committee
- Editorial Teams

Sponsor Links:

energy

Chevron

PERTAMINA
GEOTHERMAL ENERGY

energy

ORMAT

ITOCHU

MEDCOENERGI

PT PLN (PERSERO)

HALLIBURTON

Proceedings
World Geothermal Congress 2010

ISBN 9989-2315-2-4

- Table of Contents
- Authors List
- Search this CD

Convener :
International
Geothermal Association (IGA)

Co - Convener :
Indonesian
Geothermal Association
(INAGA)

Endorsed by :
Ministry of Energy & Mineral Resources
of the Republic of Indonesia

- Technical Programme Committee
- Editorial Teams

Sponsor Links:

star energy
Chevron
PERTAMINA GEOTHERMAL ENERGY
energy
ORMAT
ITOCHU
MEDCOENERGI
PT. PLN (PERSERO)
HALLIBURTON

Proceedings World Geothermal Congress 2010
Bali, Indonesia, 25-29 April 2010

The Effects of Unique Powder to Stopped Mudflow on Porong Sidoarjo Underground Blowout

Suhascaryo, Nur

UPN "Veteran" , Ringroad Condongcatur Sleman Jogjakarta

suhascaryo@yahoo.com

Keywords: Materials powder unique, mudflow, term conditions

ABSTRACT

A unique, local powder additive was reactive to stopped mudflow underground blowout in Porong Sidoarjo and helped stabilize the borehole. The unique powder contains local lime, earth stability, API Oil Cement and obsidian glass (ceramic microsphere), so it can be used as a light weight additive for cement slurry. In geothermal fields, the reservoir temperature (up to 110°C)and steam caused the change of calcium silicate hydrate gel to alpha dicalcium silicate hydrate in the cement model composition, cement degradation and shrinkage, and borehole instability. The effects of HTHP conditions on the cement suspension were dehydration (partial liquid loss), fuggy channeling, shrinkage of the bulk volume, strength degradation, and an increase in the permeability of the cement. For the anticipated cement degradation to added by obsidian glass is 35% BWOS at term conditions. Research was carried out to model the composition of the unique powder slurry for mixing with mudflow in Porong Sidoarjo in order to anticpate strength degradation, volume shrinkage, low permeability, plugged zone fracture and isolated mudflow to the surface.

1. INTRODUCTION

The high temperature cementing of steam recovery wells, geothermal wells, and ultra deep wells presents problems. Reservoirs can experience a depletion of pressure and reservoir traps can often be found in faults or cracks. Cementing is performed to isolate the annulus between the casing and wellbore in order to prevent communication between the various formation layers. It is anticipated that the gradient pressure cement used has low density and high strength.

Cementing in drilling operations may have additional purposes:

1. Supporting the casing against the formation,
2. Protection of the casing against underground environmental effects like high pressure,
3. Prevention of gas or high-pressure formation fluid movement into the annulus between the casing and wellbore that may cause trouble at the surface,
4. Reduction of gas-oil, water-oil, and water-gas ratios,
5. Minimizing casing wear.

Successful cementing jobs require accurate data collection from the wellbore, good cementing technique, proper cement suspension characteristics, and high cement quality. The effects of the addition of an expansion additive obtained locally from Wonosari and Tuban on the performance of cement slurry, quality of cement hardener, and HTHP conditions are discussed in this paper.

Nearly all cement slurry characteristics affect the cement quality upon placement. Low cement slurry density results in low compressive strength, which may be caused by a high water-cement ratio (WCR) in the preparation of the cement slurry. Cementing at high temperature requires low cement density, impermeable and high cement strength by occurs formed mineralization, on first gel C-S-H, alpha diCa-S-H, Tobermorite etc. Thus, the cement slurry should have a high density to reduce it to the ceramic powder used. Meanwhile, in order to increase the cement strength at high temperature silica flour can be used as a special expansion additive to prevent shrinkage.

2. STATE OF THE ARTS

If the cement and additive are mixed with water, a cement hydration process occurs, followed by a cement setting process. The cement hydration process can be described as a chemical reaction between solids and liquids in which the mixture eventually sets. In the cement suspension, a hydration process occurs between clinker, calcium sulfate and water and causes the cement slurry to set.

The hydration of Portland cement is a sequence of overlapping chemical reactions between clinker components, calcium sulfate and water. This leads to continuous cement slurry thickening and hardening. Although the hydration of C_3S is often used as a model for the hydration of Portland cement, it must be kept in mind that many additional parameters are involved.

The hydration of Portland cement is a complex process of crushing/setting. Unlike in the pure single phase, the multi-component hydration reaction occurs at different rates. This has an influence between phases. For example, the C_3A hydration is modified by the presence of C_3S in which the formation of calcium hydroxide reduces the C_3A by gypsum. The clinker contains certain impurities, which depend on the composition of the raw materials that can contain different oxides.

As a consequence of the impurities, the hydration also becomes impure, and the C-S-H gel tends to bond with aluminate, iron oxide, and sulphur. Meanwhile, ettringite and monosulpho-aluminate contain silica. In this case, calcium hydroxide also contains a certain amount of other ions.

2.1 Hydration Processes

Hydration is a chemical reaction between solids and liquids, in which the mixture of both will eventually set into a solid. Tthe hydration taking place in the cement slurry used in the cementing job is between clinker, calcium sulfate, and water and results in a set cement at the end of the process.

Formation temperature is one of the main factors affecting the hydration process of Portland cement. High temperatures may accelerate the rate of hydration, but it can also affect the cement stability and change the cement component morphology. The hydration phenomenon of Portland cement can be classified into two categories based on temperature: low temperature and high temperature hydration.

In low temperature hydration, the components of Portland cement are anhydrous, which means that when they come into contact with water, the cement components break apart and hydrate, eventually setting into cement. Meanwhile, in high temperature hydration (above 110⁰C), the process begins with the formation of Alpha Dicalcium Silicate Hydrate (α-C_2SH), which changes the compositions of cement components that affect the cement strength. This is usually known as Strength Retrogression (introduced by Swayze 1954). Strength retrogression is overcome by the addition of silica flour as a special additive to the cement prior to mixing it with water. C-S-H gel is a material with excellent binding characteristics especially at temperatures 230⁰F (110⁰C). At higher temperature, C-S-H gel is subject to metamorphosis, which usually results in a decrease in compressive strength and an increase in permeability of the set cement. C-S-H gel is often converted into a phase known as alpha dicalcium silicate hydrate (α-C_2SH), which is highly crystalline and much denser than C-S-H gel. As a result, it affects the compressive strength and permeability of set cement at a temperature of 230⁰F (110⁰C).

Strength retrogression can be prevented by the addition of silica flour into the cement prior to mixing with water. The main purpose is to achieve a C/S ratio of approximately 1.0. It must be noted that commercial cement has a C/S ratio around 1.5; therefore, the amount of silica needed to reach the desired C/S ratio value is 35% (Menzd, Klousek, Carter and Smith).

Figure 1: Sampling of additive unique WNSR

2.2 Extender Additive

An extender is an additive used to reduce the density of cement and is therefore utilized in formations in danger of collapse. Microspheres are used as an extender and have a specific gravity of 0.4 to 0.6. As cementing technology has advanced, the use of microsphere has become more common. There are two types of microspheres: glass and ceramic microspheres. This research uses ceramic microspheres. The preparation of cement slurry using microspheres was developed in order to achieve certain values of cement slurry static pressure and density, which may influence the strength-density ratio of the cement. Microspheres have some advantages and disadvantages: although density tends to decrease as the composition of microspheres increase, t the compressive strength and shear bond strength decrease as well.

Figure 2: Sampling of unique powder TBN

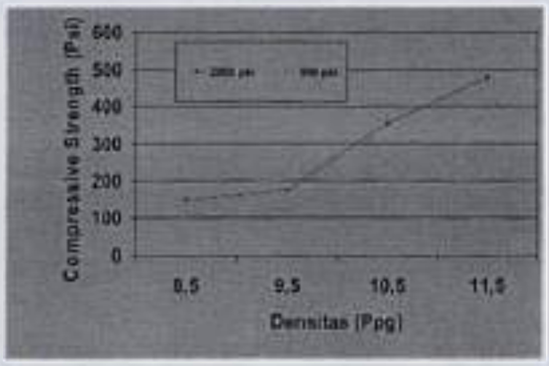


Figure3: The effects of ceramic microsphere density on compressive strength (Nelson 90).

2.3 Expanding Additives

Cement expansion is the expansion of cement relative volume due to cement bulk expansion (Danjuschewskij, 1983). It is caused by several factors:

1. Chemical contraction resulting in another hydrated product in the liquid phase (i.e. crystallization of dissolved salt at high temperatures).
2. The presence of expanding materials in cement slurry before hardening (i.e. lime, periclase, $CaSO_4$, etc.).
3. The presence of electrolytes around the cement bulk after hardening.

The second condition may increase the shear bond strength, and the expansion effect could be controlled by arranging the burning temperature and surface area of the expanding materials.

During the interim, a number of expansion additives have become available from the service industry. Most of these are patented and therefore are of unknown composition and efficacy.

Under borehole conditions, many of the known additives, such as powdered alumunium and ettringite-forming products, present problems with respect to effectiveness and control because of the expansion mechanism involved. Even under atmospheric conditions, several cements do not exhibit any expansion at all and merely experience a decrease in volumetric shrinkage.

In 1980, Danjuschewskij proposed lime and periclase as expansion additives to create expanding cement. His work resulted in expansion effects between 1 and 25% at specific cementing job is between clinker, calcium sulfate, and water and results in a set cement at the end of the process.

Formation temperature is one of the main factors affecting the hydration process of Portland cement. High temperatures may accelerate the rate of hydration, but it can also affect the cement stability and change the cement component morphology. The hydration phenomenon of Portland cement can be classified into two categories based on temperature: low temperature and high temperature hydration.

In low temperature hydration, the components of Portland cement are anhydrous, which means that when they come into contact with water, the cement components break apart and hydrate, eventually setting into cement. Meanwhile, in high temperature hydration (above 110^{0}C), the process begins with the formation of Alpha Dicalcium Silicate Hydrate (α-C_2SH), which changes the compositions of cement components that affect the cement strength. This is usually known as Strength Retrogression (introduced by Swayze 1954). Strength retrogression is overcome by the addition of silica flour as a special additive to the cement prior to mixing it with water. C-S-H gel is a material with excellent binding characteristics especially at temperatures 230^{0}F (110^{0}C). At higher temperature, C-S-H gel is subject to metamorphosis, which usually results in a decrease in compressive strength and an increase in permeability of the set cement. C-S-H gel is often converted into a phase known as alpha dicalcium silicate hydrate (α-C_2SH), which is highly crystalline and much denser than C-S-H gel. As a result, it affects the compressive strength and permeability of set cement at a temperature of 230^{0}F (110^{0}C).

Strength retrogression can be prevented by the addition of silica flour into the cement prior to mixing with water. The main purpose is to achieve a C/S ratio of approximately 1.0. It must be noted that commercial cement has a C/S ratio around 1.5; therefore, the amount of silica needed to reach the desired C/S ratio value is 35% (Menzd, Klousek, Carter and Smith).

Figure 1: Sampling of additive unique WNSR

2.2 Extender Additive

An extender is an additive used to reduce the density of cement and is therefore utilized in formations in danger of collapse. Microspheres are used as an extender and have a specific gravity of 0.4 to 0.6. As cementing technology has advanced, the use of microsphere has become more common. There are two types of microspheres: glass and ceramic microspheres. This research uses ceramic microspheres. The preparation of cement slurry using microspheres was developed in order to achieve certain values of cement slurry static pressure and density, which may influence the strength-density ratio of the cement. Microspheres have some advantages and disadvantages: although density tends to decrease as the composition of microspheres increase, t the compressive strength and shear bond strength decrease as well.

Figure 2: Sampling of unique powder TBN

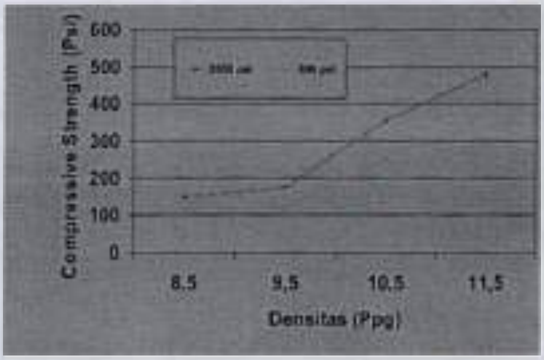


Figure3: The effects of ceramic microsphere density on compressive strength (Nelson 90).

2.3 Expanding Additives

Cement expansion is the expansion of cement relative volume due to cement bulk expansion (Danjuschewskij, 1983). It is caused by several factors:

1. Chemical contraction resulting in another hydrated product in the liquid phase (i.e. crystallization of dissolved salt at high temperatures).
2. The presence of expanding materials in cement slurry before hardening (i.e. lime, periclase, $CaSO_4$, etc.).
3. The presence of electrolytes around the cement bulk after hardening.

The second condition may increase the shear bond strength, and the expansion effect could be controlled by arranging the burning temperature and surface area of the expanding materials.

During the interim, a number of expansion additives have become available from the service industry. Most of these are patented and therefore are of unknown composition and efficacy.

Under borehole conditions, many of the known additives, such as powdered aluminium and ettringite-forming products, present problems with respect to effectiveness and control because of the expansion mechanism involved. Even under atmospheric conditions, several cements do not exhibit any expansion at all and merely experience a decrease in volumetric shrinkage.

In 1980, Danjuschewskij proposed lime and periclase as expansion additives to create expanding cement. His work resulted in expansion effects between 1 and 25% at specific conditions. Several investigations were also conducted on the effectiveness of expanding cements based on these calcium and magnesium oxide additives. Both materials are characterized by their capability to influence the reactivity, and thus the swelling behavior, by means of the manufacturing process.

Industrially, lime and periclase are usually manufactured by the calcining of calcium and magnesium carbonates (liberation of CO_2, deacidification). In contrast to other expanding additives, lime and periclase provide two possibilities to influence the reactivity (hydration activity) by means of the manufacturing process. Decreasing the reactivity by increasing the calcining temperature during the manufacture of the swelling additive, as well as increasing the reactivity by augmenting the specific surface area of fineness during grinding of the swelling additive.

3. DESIGN EXPERIMENTS

3.1 Design Simulator Curing Chamber.

A physical simulator model was designed as a modified pressure curing chamber that could be operated at 350°C and 3000 psi, as shown in Figure 4. The advantages of the simulator are its ability to handle a large amount of samples (30 samples) and its design that incorporated the use of formation water both from oil-gas fields and geothermal fields. It was also equipped with CO_2 and H_2S injection appliances.

The simulator was made up of the following parts:

1. Simulator tubes were equipped with a heater and a thermocouple.
2. The pressure source was a Maximator pump capable of supplying hydraulic pressures up to 6500 psi.
3. Safety valves and rupture disc.
4. Formation fluid injector.
5. Automatic thermo controller.
6. Gas injection flow meter.
7. Outlet exchanger and reservoir chamber.
8. Manometer and in/out simulator liquid gas regulator valves.

The test required 3 types of specimen molds for the cement slurry chamber to be treated during hardening. The Cubic type with dimensions 2" x 2" x 2" was used to determine the tensile and compressive strength of the cement. The cylindrical type with 1" diameter and 2" height was used to determine the shear bond strength between cement-casing and also to measure cement casing-permeability. This specimen mold needed chamber caps when placed into the simulator. Finally, the cylindrical type with 1" diameter and 2.5" height contained 6 cement chambers. The cement specimens were used to determine both cement permeability and the compressive strength. All specimen molds were designed to be run simultaneously in the simulator at given well conditions.

The compressive strength was calculated according to Equation 1:

$$CS = k.P.(A1/A2) \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

where

CS : compressive strength, psi

P : maximum load, psi

A1 : hydraulic mortar's bearing block cross section area, in^2

A2 : cement core's cross section area, in^2

k : correction constant, function of height (t) and diameter (d) ratio, see Table1.

Shear bond strength was calculated according to Equation 2:

$$SBS = P.(A1/\pi.D.h) \quad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

where

SBS: shear bond strength, psi ;

P : strain maximum load, psi;

A : cement core's cross section area, in^2;

H : cement core's height, in;

D : diameter core, in

Table 1. Relations of Constants and h/d

h/d	Konstanta (k)
2,00	1,00
1,75	0,98
1,50	0,96
1,25	0,93
1,00	0,87

3.2 Design Laboratories Works

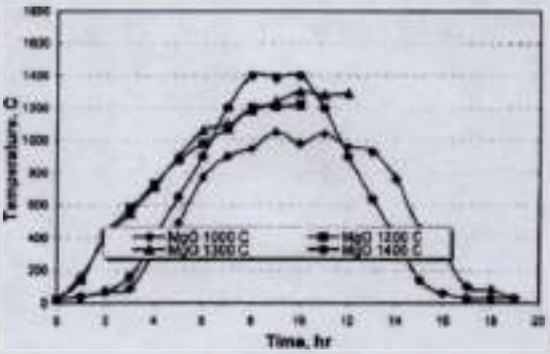


Figure 4: Conditioning unique raw materials

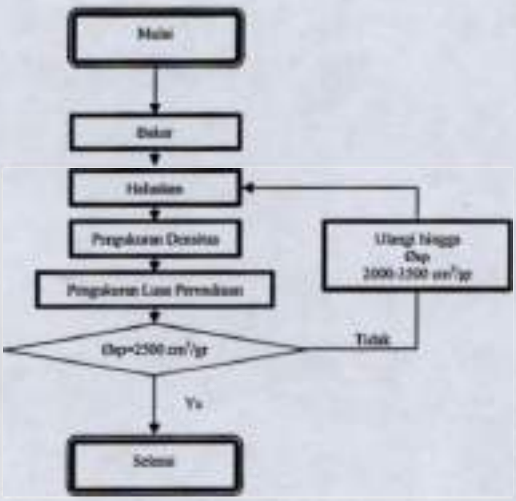


Figure 5: Activated unique raw material

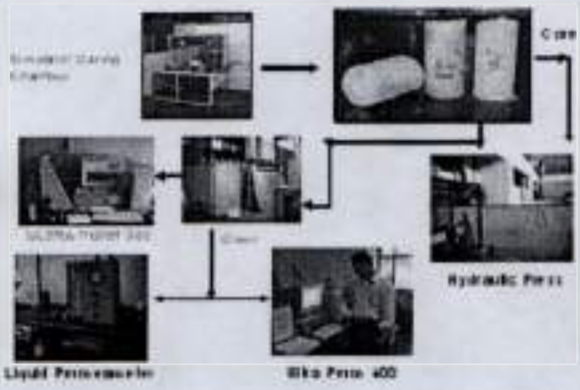


Figure 6: SOP laboratory measurement

4. RESULTS AND DISCUSSIONS

4.1 Results

Table 2. Composition Models

No.	Composition	Aquadest (mL)	CaO (gr)	MgO (gr)	Silica Flour (gr)	Cement (gr)	Microsphere (gr)
1.	Based Cement (BC)	250	-	-	-	566.18	-
2.	Silica Cement(SC)	250	-	-	196.86	369.32	-
3.	SC + CaO 3% BWOS	250	16.55	-	193.07	358.96	-
4.	SC + CaO 5% BWOS	250	27.06	-	189.39	351.73	-
5.	SC + MgO 3% BWOS	250	-	16.55	193.07	358.96	-
6.	SC + MgO 5% BWOS	250	-	27.06	189.39	351.73	-
7.	SCM + CaO 3% BWOS	250	16.65	-	193.97	193.07	165.49
8.	SCM+CaO 5% BWOS	250	27.06	-	189.39	189.39	162.34
9.	SCM+MgO 3% BWOS	250	-	16.55	193.07	193.07	165.49
10.	SCM+ MgO 5% BWOS	250	-	27.06	189.39	189.39	162.34

Table 3. Test of the Surface Area of the Unique Powder

Powder of Materials	Finenes (cm²/gr)
Based Cement	2517
Silica Flour	3150
Lime Local	3763
Periclase Local	2881

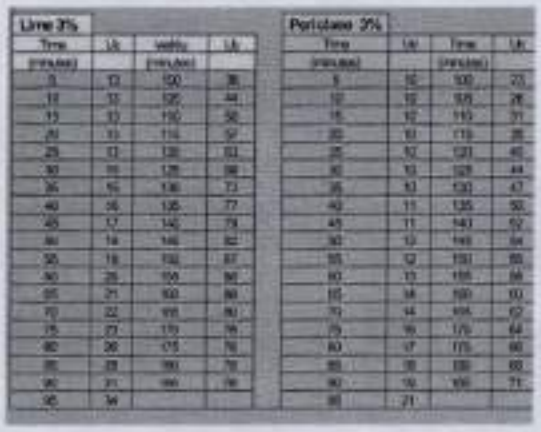
Table 4. Results of Density Measurements

No.	Composition Models	Density (ppg)
01.	Based Cement Powder	24.99
02.	Silica Flour Powder	22.24
03.	Lime Powder Local (CaO)	21.32
04.	Periclase Powder Local (MgO)	29.16
05.	Based of Cement Slurry (BC)	15.9
06.	Silica Cement Slurry (SC)	15.3
07.	SC + Periclase Local 3%	15.60
08.	SC + Periclase Local 5%	15.61
09.	SC + Lime Local 3%	15.55
10.	SC + Lime Local 5%	15.55
11.	SC Microsphere + Periclase Local 3%	11.75
12.	SC Microsphere + Periclase Local 5%	11.75
13.	SC Microsphere + Lime Local 3%	11.70
14.	SC Microsphere + Lime Local 5%	11.75

Table 5. The Results of Viscosity Measurements

Composition Models	Ф600 (dial)	Ф300 (dial)	Plastic Viscosity (cp)
Based Cement (BC)	166	134	32
Silica Cement (SC)	219	168	51
SC + Periclase 3% BWOC	130	90	40
SC + Periclase 5% BWOC	125	88	37
SC + Lime 3% BWOC	217	155	62
SC + Lime 5% BWOC	240	165	75
Microsphere Cement (MC)	300	200	100
MC + Periclase 3% BWOC	260	140	120
MC + Periclase 5% BWOC	300	205	95
MC + Lime 3% BWOC	300	185	115
MC + Lime 5% BWOC	300	175	125
SMC + Periclase 3% BWOC	300	157	143
SMC + Periclase 5% BWOC	300	163	137
SMC + Lime 3% BWOC	300	159	141
SMC + Lime 5% BWOC	300	155	145

Table 6. The Thickening Time Measurements for Model 1



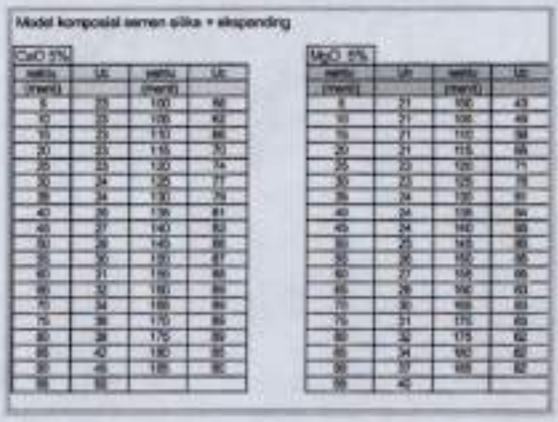
Lime 3%

Time (minutes)	Uc	waktu (minutes)	Uc
5	13	100	38
10	13	105	44
15	13	110	50
20	13	115	57
25	13	120	63
30	15	125	68
35	15	130	73
40	16	135	77
45	17	140	79
50	14	145	82
55	18	150	87
60	25	155	90
65	21	160	88
70	22	165	90
75	27	170	76
80	26	175	76
85	28	180	78
90	31	185	76
95	34		

Periclase 3%

Time (minutes)	Uc	Time (minutes)	Uc
5	10	100	23
10	10	105	28
15	10	110	31
20	10	115	35
25	10	120	40
30	10	125	44
35	10	130	47
40	11	135	50
45	11	140	52
50	12	145	54
55	12	150	55
60	13	155	58
65	14	160	60
70	14	165	62
75	16	170	64
80	17	175	66
85	18	180	68
90	19	185	71
95	21		

Table 7. The Thickening Time Measurements Model 2



Model komposisi semen silika + ekspanding

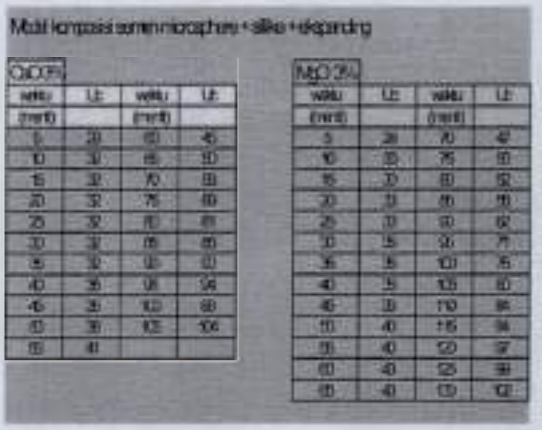
CaO 5%

waktu (menit)	Uc	waktu (menit)	Uc
5	23	100	60
10	23	105	62
15	23	110	66
20	23	115	70
25	23	120	74
30	24	125	77
35	24	130	79
40	26	135	81
45	27	140	82
50	28	145	86
55	30	150	87
60	31	155	88
65	32	160	89
70	34	165	89
75	36	170	89
80	38	175	89
85	42	180	92
90	46	185	92
95	50		

MgO 5%

waktu (menit)	Uc	waktu (menit)	Uc
5	21	100	43
10	21	105	49
15	21	110	58
20	21	115	66
25	23	120	71
30	23	125	76
35	24	130	81
40	24	135	84
45	24	140	88
50	25	145	90
55	26	150	95
60	27	155	96
65	28	160	83
70	30	165	83
75	31	170	83
80	32	175	82
85	34	180	82
90	37	185	82
95	40		

Table 8. The Thickening Time Model for Unique Powder 1



Model komposisi semen microsphere + silika + ekspanding

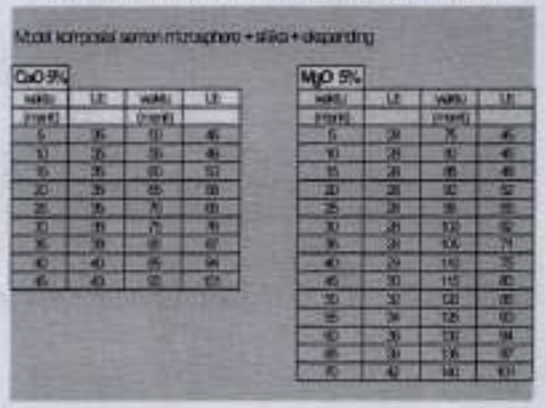
CaO 3%

waktu (menit)	Uc	waktu (menit)	Uc
5	30	60	45
10	31	65	50
15	32	70	53
20	32	75	60
25	32	80	71
30	32	85	80
35	32	90	83
40	35	95	94
45	35	100	98
50	36	105	104
55	41		

MgO 3%

waktu (menit)	Uc	waktu (menit)	Uc
5	28	70	47
10	30	75	50
15	30	80	52
20	31	85	55
25	33	90	62
30	35	95	71
35	35	100	75
40	35	105	80
45	38	110	86
50	40	115	94
55	40	120	97
60	40	125	98
65	40	130	102

Table 9. The Thickening Time for Unique Powder 2



Model komposisi semen microsphere + silika + ekspanding

CaO 5%

waktu (menit)	Uc	waktu (menit)	Uc
5	35	50	45
10	35	55	48
15	35	60	53
20	35	65	58
25	35	70	65
30	38	75	78
35	39	80	87
40	40	85	94
45	40	90	97

MgO 5%

waktu (menit)	Uc	waktu (menit)	Uc
5	28	75	45
10	28	80	46
15	28	85	48
20	28	90	52
25	28	95	55
30	28	100	62
35	28	105	71
40	29	110	75
45	30	115	80
50	32	120	85
55	34	125	90
60	36	130	94
65	38	135	97
70	42	140	101

Table 10. The Results of Model Compositions

Composition Models	Conditioning Time (hours)	*Compressative strength (psi)*	*Shearbond strength (psi)*
Silica Microsphere Cement (SMC) + Periclase 3% BWOS	24	2613	1087
	72	3050	1027
	168	3627	1294
Silica Microsphere Cement (SMC)+ Periclase 5% BWOS	24	2744	1179
	72	3020	992
	168	3506	1236
Silica Microsphere Cement (SMC) +Lime 3% BWOS	24	689	873
	72	891	427
	168	3796	1216
Silica Microsphere Cement SMC) + Lime 5% BWOS	24	3506	402
	72	3341	663
	168	3395	1030

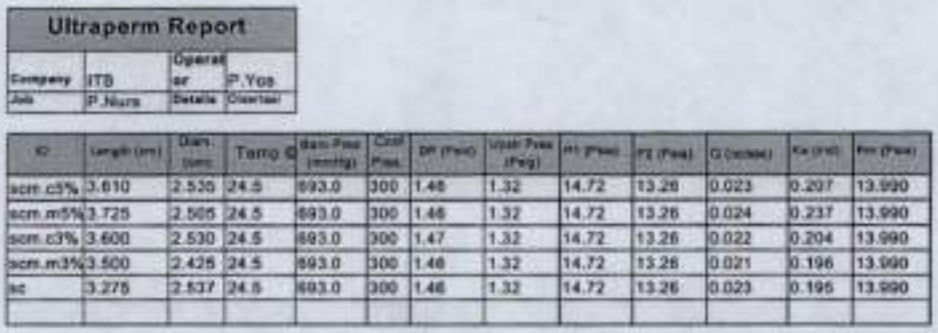
Table 11. The Ultra Pore Test of Unique Powder

Core Semen	Panjang (cm)	Diameter (cm)	Bulk Vol (cc)	Grain Vol (cc)	Pore Vol (cc)	Porositas (%)
SD	2.585	2.54	13.098	6.1981	6.899	52.2635
SC	2.86	2.502	14.061	9.4445	4.6165	32.832
SCM	3.875	2.54	19.635	8.8905	10.7445	54.721
SCM+CaO 3%	4.4	2.54	22.295	9.95405	12.341	55.353
SCM+CaO 5%	3.34	2.55	17.058	7.6768	9.381	54.996
SCM+MgO 3%	2.82	2.53	14.177	6.64696	7.5305	53.1175
SCM+MgO 5%	3.865	2.54	19.584	8.7324	10.852	55.4125

Table 12. The Liquid Permeability of Unique Powder

pengkondisian 72 jam (3 hari) 200oC										
core	d(inch)	davg(inch)	h(inch)	havg(inch)	A [illegible]	OP(psi)	FP(psi)	Time(sec)	Rate(mL)	k(md)
semen silica	2.31	2.33	3.26	3.2367	4.2666	300	200	11400	6.36	4.14 E-05
(SC)	2.33		3.23							
	2.35		3.26							
SC+CaO	2.42	2.4067	3.52	3.4633	4.5509	300	300	72000	0	0
3%BWOS	2.4		3.46							
	2.4		3.42							
SC+MgO	2.59	2.5933	3.2	3.2267	5.2641	300	300	18600	0	0
3% BWOS	2.59		3.24							
	2.6		3.24							
SC+MgO	2.56	2.4967	3.56	3.5633	4.8977	300	200	68400	2	3.15 E-08
5%BWOS	2.51		3.6							
	2.43		3.53							
SC+CaO	2.48	2.49	3.69	3.6967	4.8715	300	200	90000	28	2.31 E-05
5%BWOS	2.48		3.7							
	2.5		3.7							
SCM+MgO	2.6	2.5867	3.61	3.5833	5.1762	300	200	86400	0	0
3%BWOS	2.56		3.62							
	2.56		3.52							
SCM+CaO	2.5	2.53	3.96	3.9633	5.0250	400	200	13800	0	0
3%BWOS	2.53		3.97							
	2.56		3.96							
SCM+MgO	2.5	2.5033	3.48	3.48	4.9237	400	200	28100	0.4	7.96E-07
5%BWOS	2.5		3.42							
	2.51		3.54							
SCM+CaO	2.5	2.5133	1.98	1.9833	4.9631	400	200	5400	0	0
5%BWOS	2.52		1.99							
	2.52		1.98							

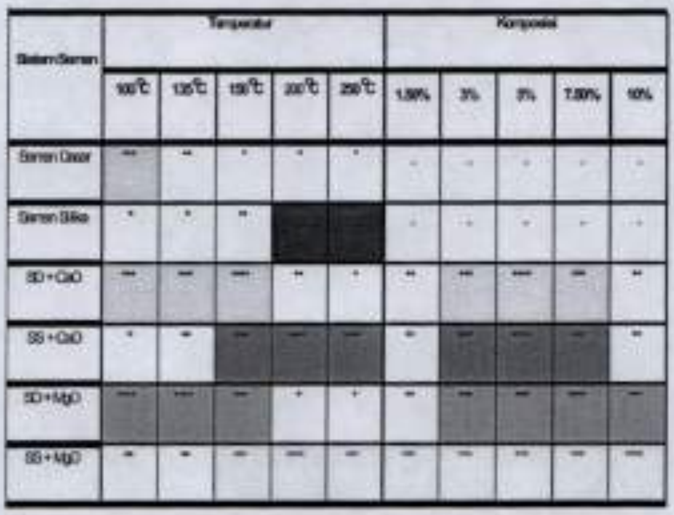
Table 13. The Ultra Perm of Unique Powder



Ultraperm Report			
Company	ITB	Operator	P.Yos
Job	P.Nurs	Details	[illegible]

ID	Length (cm)	Diam. (cm)	Temp C	Baro Pres (mmHg)	Conf Pres	DP (Psid)	Upstr Pres (Psig)	P1 (Psia)	P2 (Psia)	Q (cc/sec)	Ka (md)	Pm (Psia)
scm.c5%	3.610	2.535	24.5	693.0	300	1.46	1.32	14.72	13.26	0.023	0.207	13.990
scm.m5%	3.725	2.505	24.5	693.0	300	1.46	1.32	14.72	13.26	0.024	0.237	13.990
scm.c3%	3.600	2.530	24.5	693.0	300	1.47	1.32	14.72	13.26	0.022	0.204	13.990
scm.m3%	3.500	2.425	24.5	693.0	300	1.46	1.32	14.72	13.26	0.021	0.196	13.990
sc	3.275	2.537	24.5	693.0	300	1.46	1.32	14.72	13.26	0.023	0.195	13.990

Table 14. Composition Results for the Model



Sistem Semen	Temperatur					Komposisi				
	100°C	125°C	150°C	200°C	250°C	1.50%	3%	5%	7.50%	10%
Semen Dasar	+++	++	+	+	+	+	+	+	+	+
Semen Silika	+	+	++			+	+	+	+	+
SD + CaO	+++	+++	++++	++	+	++	++	+++	+++	++
SS + CaO	+	++	+++	+++	+++	++	+++	+++	+++	++
SD + MgO	+++	+++	+++	+	+	++	+++	+++	+++	+++
SS + MgO	++	++	+++	+++	+++	+++	+++	+++	+++	+++

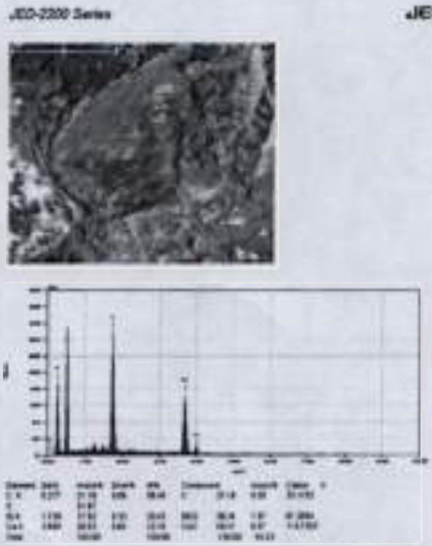


Figure 7: SEM of oil well Portland cement composition

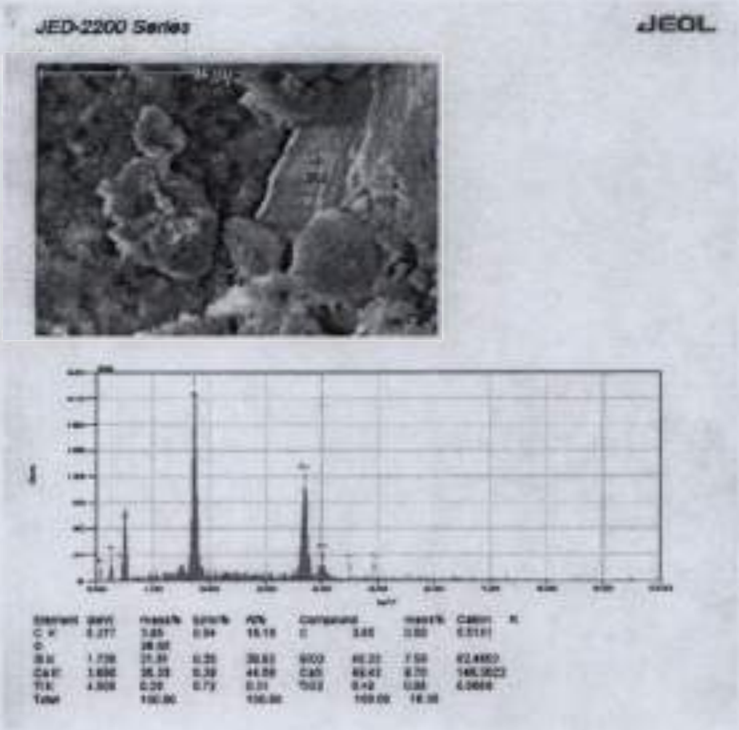


Figure 8: SEM of unique powder model 1

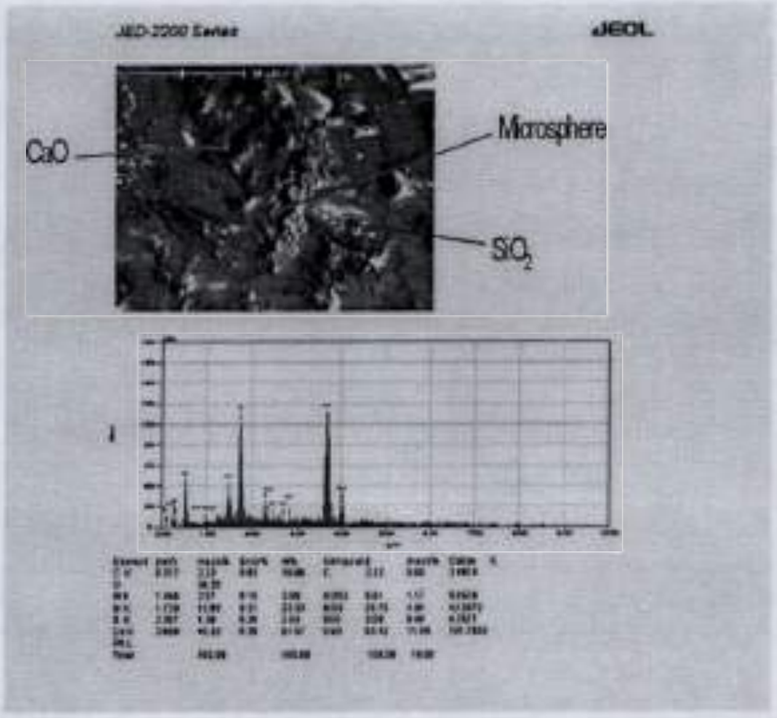


Figure 9: SEM of Unique powder model 2

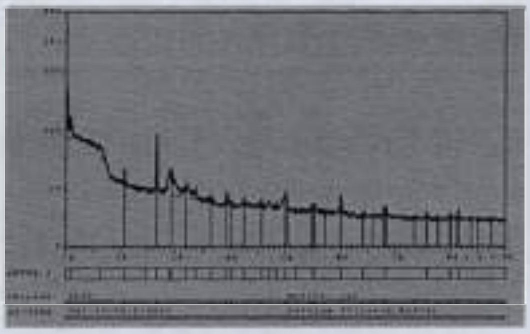


Figure 10: X-R-D of oil well Portland cement

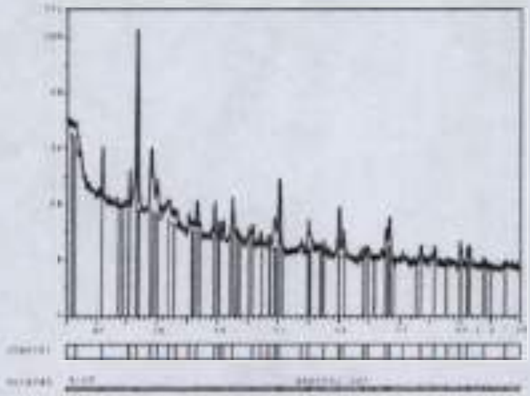


Figure 11: X-R-D of unique powder model 1

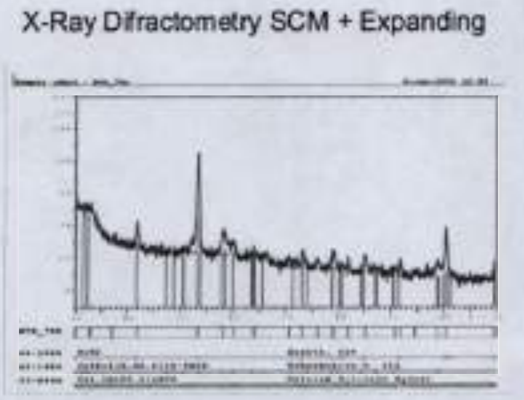


Figure 12: X-R-D of unique powder model 2

DISCUSSIONS

It can be seen in Table 3 that powder with finer particles are best for the cement slurry, because higher powder fineness leads to higher surface areas and stronger interactions between particles, such that the strength of the rock cement is better. API specifications of fineness range from 2000-3500 cm^2/gr. If testing with a Blain permeometer has a result lower than 2000 cm^2/gr, the fineness must be increased using grinding mill or a screen vibrator, as shown in Figure 5. As shown in Table 3, the fineness of lime must be higher than for other materials because it is a very weak and brittle hygroscopic material.

The rheology of cement is presented in Tables 4, 5, and 6. As can be seen in Table 4, the density of additive powder periclase is high (between powder cement and obsidian glass), because the molecular weight is different. The effect of the local expanding additive on the density of cement slurry is insignificant, but the obsidian rock extender additive is significantly similar to ceramic, because the specific gravity of ceramic is very low at about 0.4 - 0.6 (Nelson 93). Ceramic spheres are rounded and inset, and they contain a gas mixture of CO_2 and N_2, so the maximum bottom hole pressure is 4500 psi.

As shown in Table 5, the local expanding additive causes the plastic viscosity to increase that, because it is composed of inert reactive solids, and mixing lime or ceramic with water can cause suspension. The shear rate of cement suspension and expansion is lower than that of based cement. The water system is fixed at 44% BWOS, although some additives were used. The value of the plastic viscosity of the cement slurry after the addition of some additives is less than 200 cP (Based of API Spec.)

The thickening time of cement expansion after mixing is exact on based cement (120-150 minutes) on 70 Uc, as shown in Table 6. The composition models can be used to specify HTHP conditions of long setting times in between the casings and boreholes of ultradeep/offshore wells and geothermal wells. After the addition of ceramics, the thickening time decreased, because the shear rate is low for lightweight cement. A retardant additive must be used to increase the setting time, but perhaps ceramics should not be used in ultradeep wells.

The strength of composition models of cement expansion is highest at 3% BWOS and 5% BWOS concentrations at a temperature of 200°C and a pressure of 2000 psi, as shown in Table 10 (Nur S et al 2004). The use of ceramics in composition models of cement expansion caused cement strength cement and conditioning time to increase (24, 72, and 168 hours). However, the effect of concentration expanding on ceramic cement on strength is caused decrease value for 5% BWOS, see Table 12.

The local expansion additive had a larger effect on cement permeability at 3% BWOS concentration than at 5% BWOS, as shown in Tables 11 and 12. Strength accurs on mixing that is decreased after concentration mixing is increasing by ceramic extender fill it, see Table 13. The porosity of cement composition models after the addition of expansion and ceramic additives is high for silica cement and based cement, because the surface area of the suspension cement develops after ceramic mixing. (See Table 14.)

The changes of mineral C-S-H at a temperature of 110°C, is formed shape gel at high temperatures than it gel C-S-H change alpha di C-S-H with crystallization calcium hydroxide on based cement on C/S ratio nearest 2.0, see Figure 7 and 10. After silica flour and the local expansion additive were added to the C-S-H gel, the C-S-H changed to crystallized tobermorite (11°A) and lime formed as well. Thus, the cement strength increased at the C/S ratio nearest 1.0, as shown in Figures 8 and 11. The effect of the ceramic extender on composition models of expanding silica cement is the formation of the minerals tobermorite (11°A) and clino tobermorite at a C/S ratio of 0.72. (See Figures 9 and 12.) These minerals can cause an increase in the strength of silica cement (SC) and silica cement microsphere + local expansion additive composition models.

CONCLUSIONS

1. The optimal effects of the local expansion additive on HTHP conditions occurred at concentrations of 3% BWOS and 5% BWOS before ceramics are added and 3% BWOS after ceramics were added.
2. The mineralization of hard cement after mixing ceramics resulted in a new mineral (clino tobermorite), and the silica cement model is tobermorite (11 °A). However, this caused the porosity to be greater than before filling with ceramics.
3. The characteristics of cement and rock cement suspensions can be improved at 200°C and 2000 psi.
4. If ceramics are used in ultradeep wells or geothermal wells, a retardant additive must be added to increase the thickening time.

ACKNOWLEDGEMENTS

The authors wish to thank Prof. Dr. Ir. HP. Septoratno Siregar and the Ogrindo Research consortium of petroleum engineering FIKTM-ITB Bandung Indonesia.for their support in this research.