DENKA Σ1000

Additive for Super High-Strength Concrete

Description

DENKA Σ1000 is a revolutionary additive used in the production of super high-strength concrete products. Formation of ettringite and calcium silicate hydrate is enhanced when **DENKA Σ1000** is used, imparting super high-strength in concrete.

Features

- Enables manufacture of high-strength concrete in short periods (85N/mm^2 in 72 hours with steam curing)
- Enhances resistance to freezing/thawing, weathering
- Useable in slurry form
- Allows for rapid production of concrete products to increase delivery efficiency
- Chloride-free

Applications

- Concrete piles
- Spun pipes
- Box culverts

Packaging

- 25kg paper bags
- 1,000kg bulk bags

Shelf Life

- 8 months from production date
- Determine the production date by reference to the lot number. A lot number of “1AXXX” corresponds to production in Jan 2001; “2BXXX” to Feb 2002 and so on.

Technical Information

Chemical Composition

Ig-loss (%)	SiO_2 (%)	Al_2O_3 (%)	Fe_2O_3 (%)	CaO (%)	SO_3 (%)
≤5	12-22	≤8	≤3	30-40	30-48

Physical Properties

Density (g/cm^3)	Specific surface area (cm^2/g)
≤2.5	≥5000

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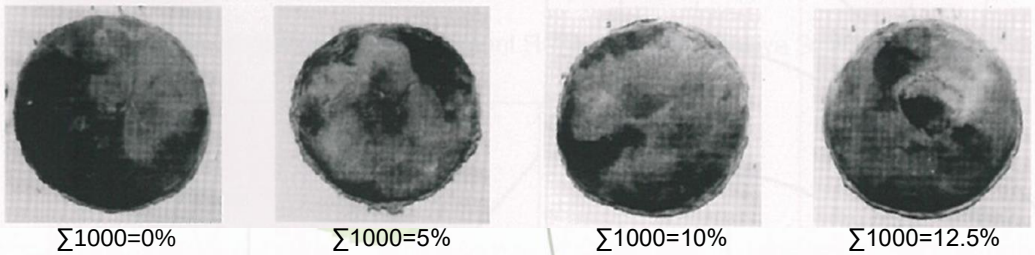
- Setting times

Dosage	0.0%	5.0%	7.5%	10.0%	12.5%
W/C	26.0%	25.6%	25.4%	25.0%	24.8%
Initial setting time	2h 28min	2h 26min	2h 25min	2h 23min	2h 22min
Final setting time	3h 33min	3h 35min	3h 40min	3h 54min	4h 00min

- Soundness properties



∑1000=0% ∑1000=5% ∑1000=10% ∑1000=12.5%

Soundness test (Pat test) done in accordance with JIS R-5201 boiling method.

Soundness shown to be good in both immersion and boiling tests done in accordance with JIS R-5201.

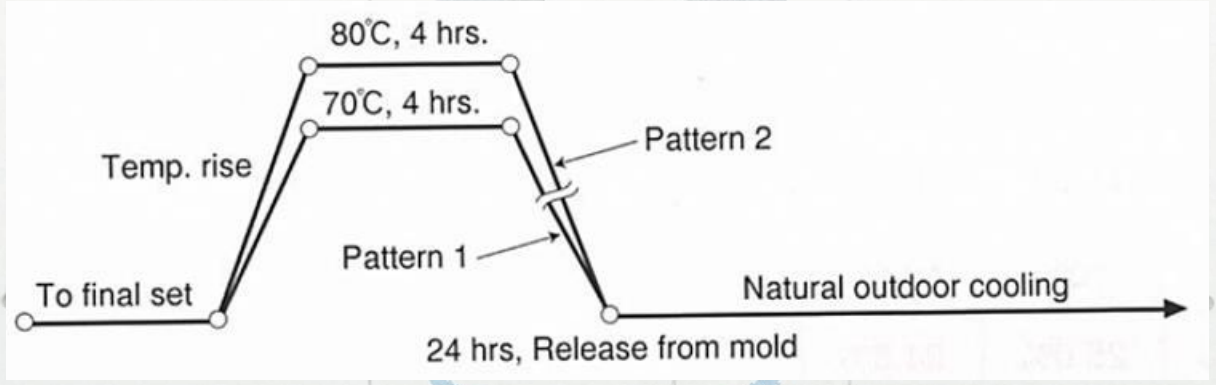
- Typical mix proportions

Gmax (mm)	Slump (cm)	s/a (%)	w/c (%)	OPC[1] (kg/m^3)	**∑1000**[2] (kg/m^3)	Water (kg/m^3)	Sand (kg/m^3)	Gravel (kg/m^3)	Superplasticizer (kg/m^3)
20	5	38	29	486	48.6	132	697	1154	7.2

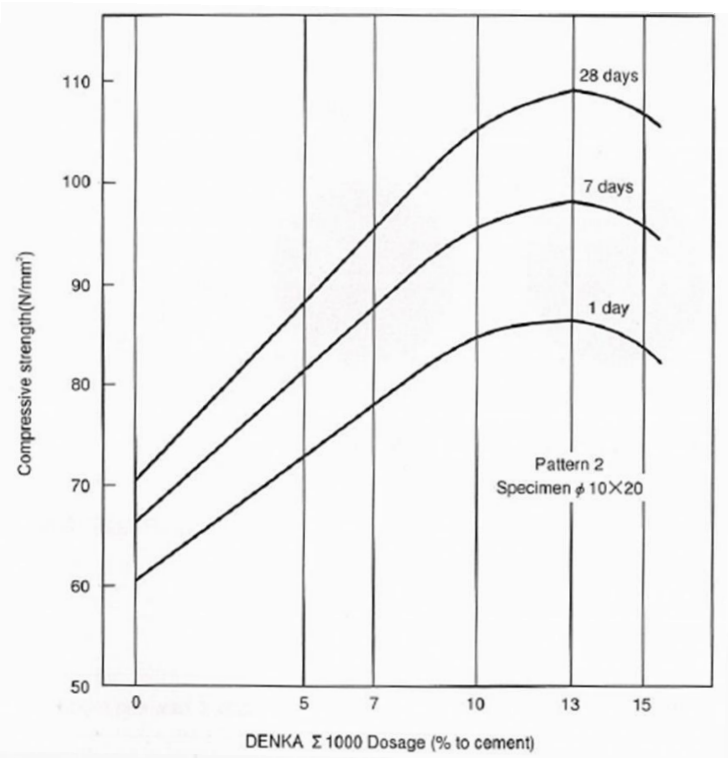
[1]DENKA cement

[2]Equivalent amount of sand replaced by **∑1000.** No slump difference observed.

- Curing method

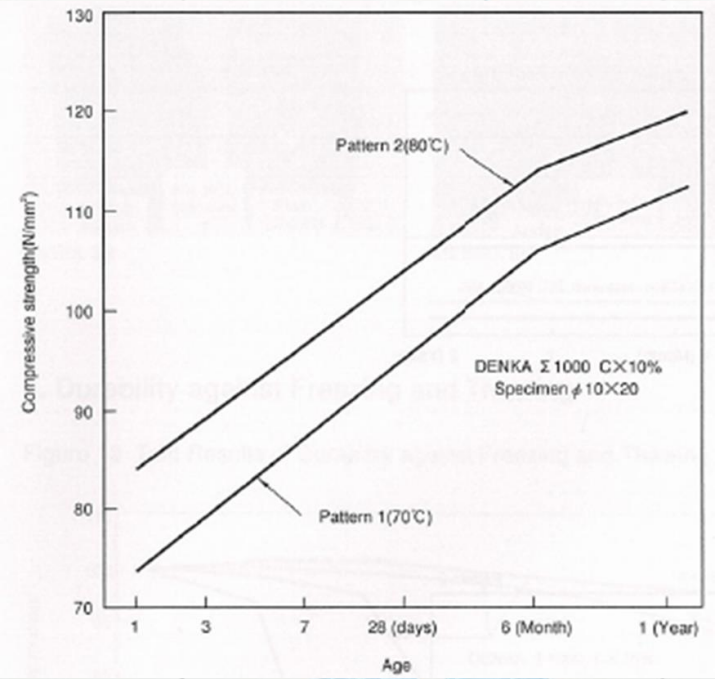


- Correlation between **DENKA Σ1000** dosage % and compressive strength



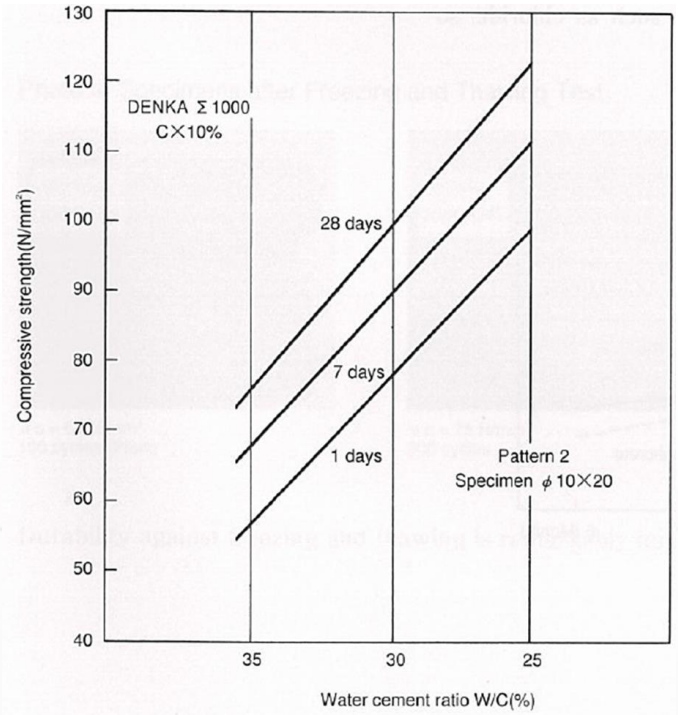
Optimum dosage of **DENKA Σ1000** is 7~10% by cement weight.

- Correlation between steam curing temperatures and compressive strength



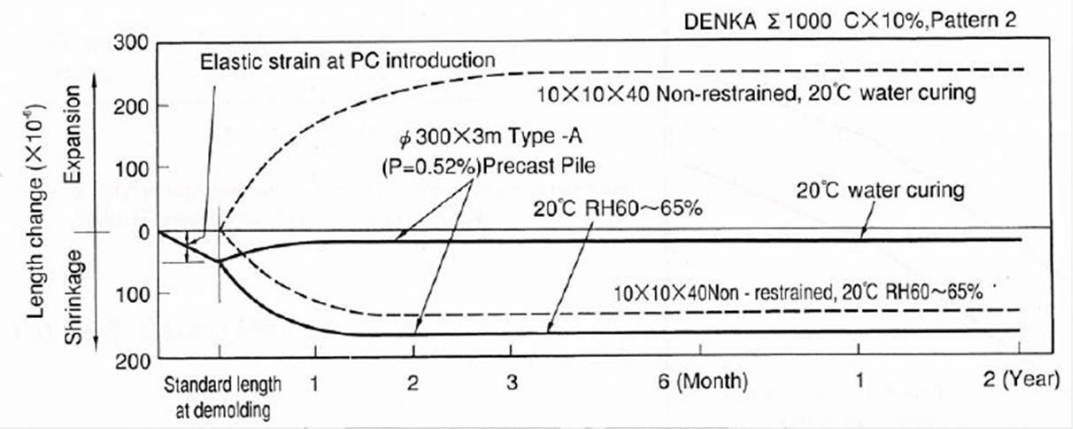
Temperatures of >70°C are recommended for curing concrete with **DENKA Σ1000**.

- Correlation between water cement ratio and compression strength

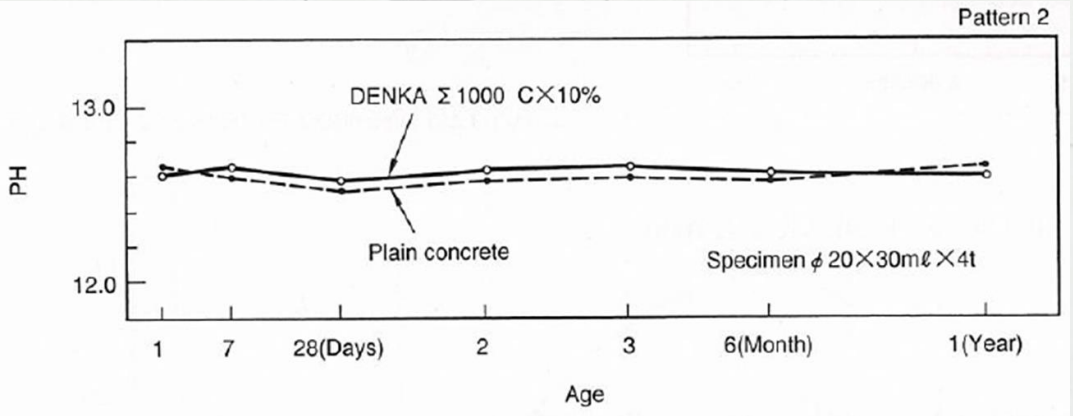


Compressive strength of cement containing **DENKA Σ1000** is shown to be inversely proportional to the water:cement ratio.

- Length change in concrete



- Concrete pH



Alkalinity of concrete is not affected by the use of chloride-free **DENKA Σ1000**. As such, rusting will be minimized in any reinforcing bars used in the concrete.

- Acid-resistance

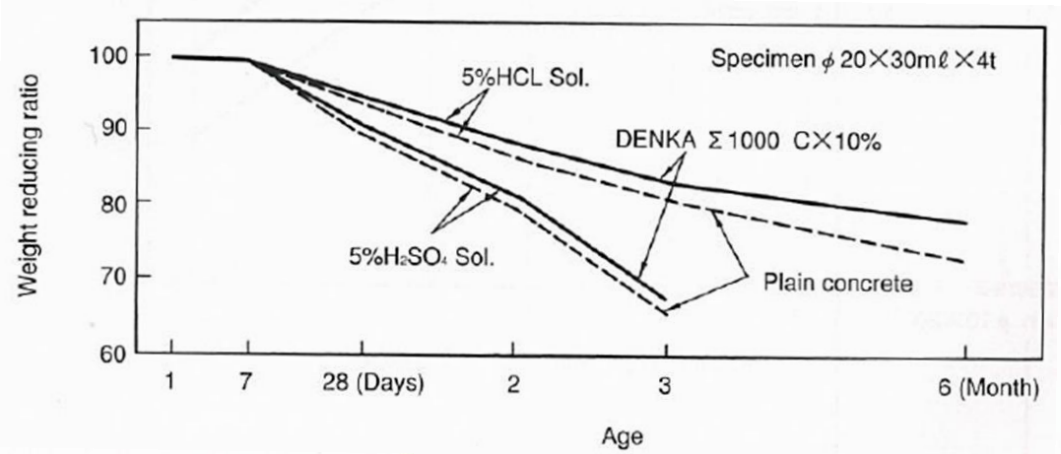
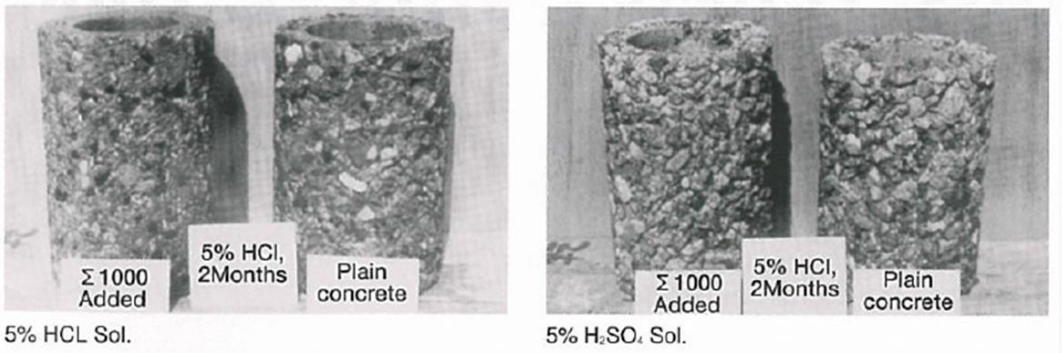


Figure showing cement ratio loss with time in 5% HCl solution and 5% H_2SO_4 solution.



Concrete specimens of the above test.

- Resistance to freezing/thawing (tests done in accordance with ASTM C-666)

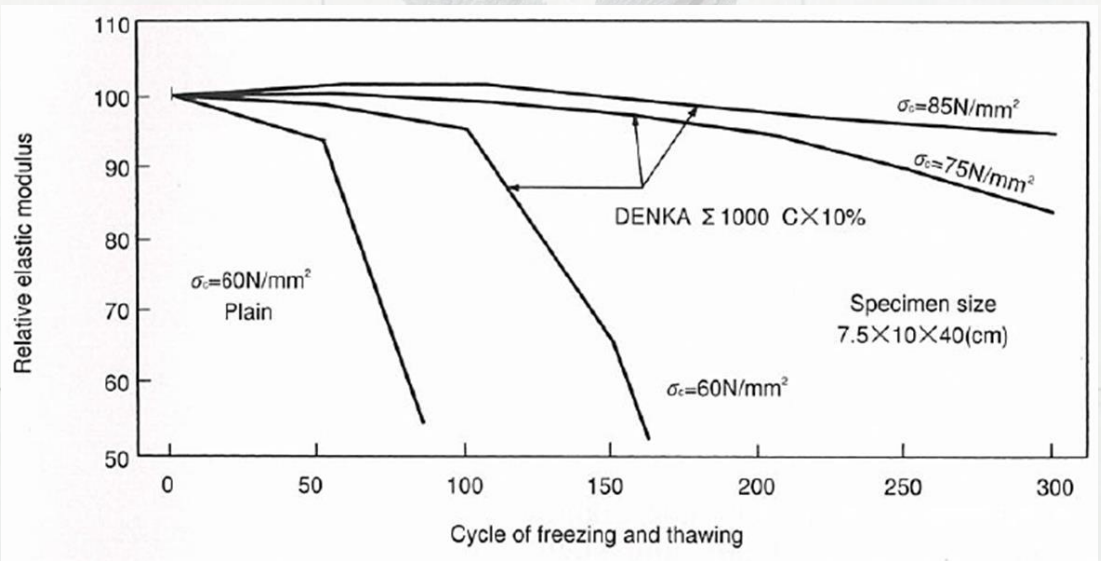
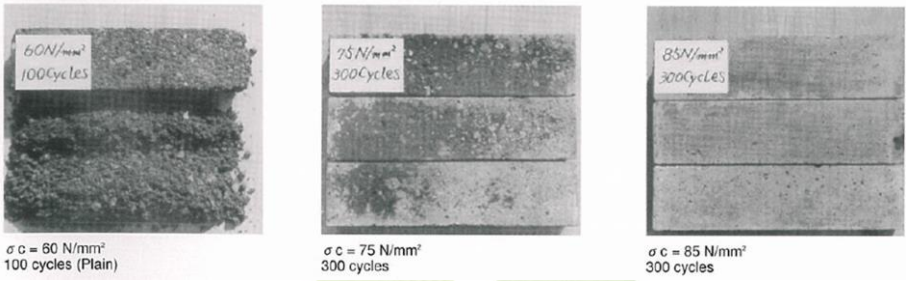


Figure showing relative elastic modulus of concrete samples with increasing exposure freezing/thawing exposure



σc = 60 N/mm² 100 cycles (Plain)　σc = 75 N/mm² 300 cycles　σc = 85 N/mm² 300 cycles

Above photos show concrete specimens after being treated to repeated cycles of freezing / thawing. With the addition of **DENKA Σ1000**, durability is greatly improved.

Application Examples

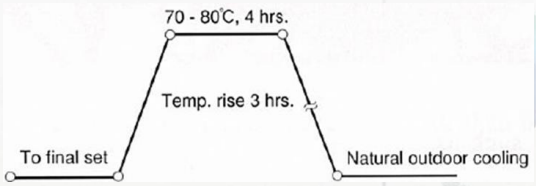
- Case Study 1: Prestressed Concrete Piles

Mix Proportions

Gmax (mm)	Slump (cm)	s/a (%)	w/c[3] (%)	OPC (kg/m³)	∑1000 (kg/m³)	Water (kg/m³)	Sand (kg/m³)	Gravel (kg/m³)	Superplasticizer (kg/m³)
20	5	38	29	486	48.6	132	697	1154	7.2

[3](Water + Water-reducing agent) / OPC

Curing method:



Test results:

	∑1000		Plain concrete	
Age	Day 1	Day 7	Day 1	Day 7
Compressive strength (N/mm²)	84	94	58	67
Young's modulus (N/mm²)	3.8 × 10⁴	4.5 × 10⁴	-	-
Flexural strength (N/mm²)	7.5	9.0	5.2	6.4
Tensile strength (N/mm²)	5.3	7.5	-	-

Pile performance:

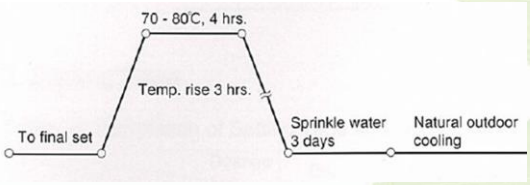
Pile Dimensions		Prestressed steel bars			Pile cross-sectional area (cm²)	Effective prestress		Flexural moment		Shear strength Qcr (t)	Bearing Capacity (t)
φ (mm)	Thickness (mm)	Type	φ (mm) X QTY	Cross-sectional area (cm²)		Standard	Design	Mcr (t-M)	Mu (t-m)		
400	70	A	8×10	4.00	765.8	40	43	6.7	8.4	17.9	129
		B	10×14	8.96		80	85	9.2	17.8	23.3	132
		D	14×12	15.00		120	125	11.9	27.2	28.0	132
		F	14×16	20.00		160	165	14.6	33.0	32.4	126
600	100	A	8×20	8.00	1570	40	42	22.1	34.8	36.2	264
		B	10×28	17.92		80	85	30.5	55.3	47.4	270
		D	12×32	28.80		120	125	38.8	84.5	56.8	269
		F	14×32	40.00		160	165	47.7	111.2	65.8	259

- Case Study 2: Box culverts

Mix Proportions

Gmax (mm)	Slump (cm)	s/a (%)	w/c[3] (%)	OPC (kg/m^3)	**∑1000** (kg/m^3)	Water (kg/m^3)	Sand (kg/m^3)	Gravel (kg/m^3)	Superplasticizer (kg/m^3)
25	12	38	32	460	36.8	141.7	658	1143	5.52

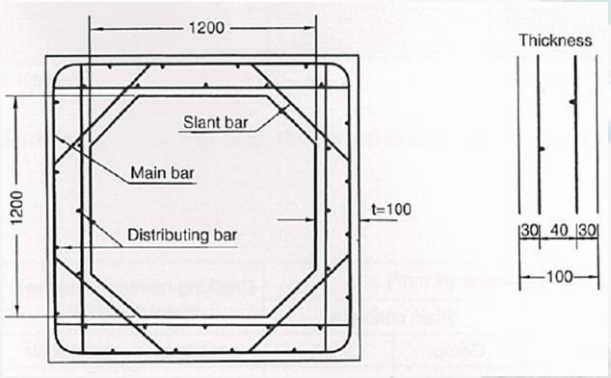
Curing method (with sheet):



Rebar specifications:

			Main bar														
			Pile cap				Base				Side wall				Distributing bar		Slant bar
			+		-		+		-		+		-				
H × W × L	t	Φ	QTY	φ	QTY	φ	QTY	φ	QTY	φ	QTY	φ	QTY	φ	QTY	φ	QTY
1200 × 1200 × 1500	100	D13	10	D10	10	D13	10	D10	10	D10	10	D10	10	D10	32	D10	40

Transverse section:



In the case of plain concrete, the specifications of the distributing bar are the same as above; the thickness of both the pile cap and the side wall is 16cm.

Test Results (Age: 7days):

Strength (N/mm^2)				Maximum load before cracking[4] (t)	
∑1000 added		Plain concrete			
Compressive	Flexural	Compressive	Flexural	Designed load	**∑1000** added
75	6.8	50.3	4.5	10.4	11.5

[4]Load tests were done by applying a 50 × 20cm square timber load at a point.

- Case Study 3: Box culverts

Mix Proportions

Gmax (mm)	Slump (cm)	s/a (%)	w/c[3] (%)	OPC (kg/m^3)	**∑1000** (kg/m^3)	Water (kg/m^3)	Sand (kg/m^3)	Gravel (kg/m^3)	Superplasticizer (kg/m^3)
25	2	40	31	460	36.8	137	700	1113	5.52

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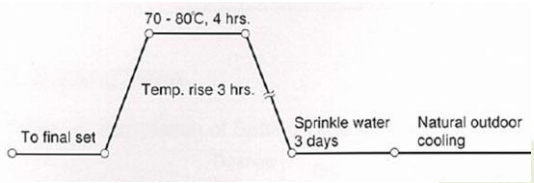
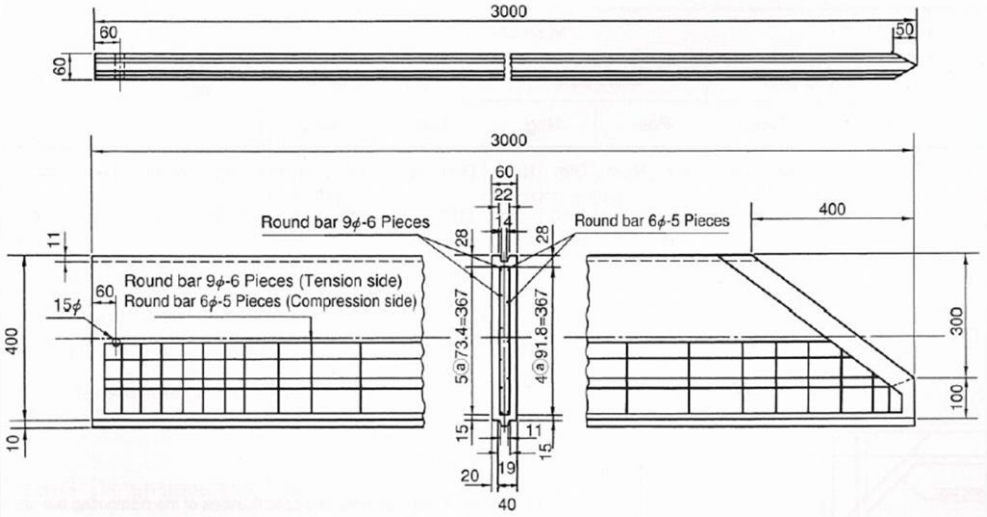
Curing method:



Transverse section:



Test Results (Age: 7days):

	Age (days)	Strength (N/mm²)				Maximum moment before cracking (t-m)	
		∑1000		Plain concrete			
		Compression	Flexural	Compression	Flexural	per sheet	per meter
∑1000	7	79.5	7.2	53.5	4.8	0.37	0.95
Standard	28	>40	-	-	-	0.32	0.82

Handling Precautions

- Refer to Safety Data Sheet (SDS) before use.
- Water-Cement (w/c) ratio control
  - Control the water cement ratio properly to ensure concrete strength. For super high-strength concrete, w/c ratio should be lowered as far as possible with the use of super-plasticizers.
- Steam-curing conditions
  - A minimum of 2 hours is required for pre-curing. Pre-curing is highly recommended before final setting of concrete is carried out.
  - If curing is carried out before the concrete is completely set, physical thermal expansion may occur that which lowers the compressive strength of the concrete.
  - Carry out steam curing at 70℃ for more than 4h. The greater the concrete maturity, the higher the strength achieved.
- Material selection
  - Concrete properties will differ depending on the characteristics of cement and aggregates. Conduct necessary trial tests and optimize concrete mix proportions.
  - Use of plasticizers will not affect the concrete strength so long as the w/c ratio is maintained.
- Wear protective gear (goggles, mask, gloves, and rubber boots) while handling the product. Do not dispose of the product in drains.
- Once opened, the product should be used up completely. Otherwise, reseal for storage.

- The product should be stored in a dry area, indoors, and out of direct sunlight.
- For further information, please contact DENKA.

Limitation of Liability

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