SaskPower International

Flyash Projects in Saskatchewan

Collaborative Seminar Series on " Responsible Use of Supplementary Cementing Materials (SCMs) in Performance Based Specifications" January 30,2006

Province of Saskatchewan

SaskPower Coal Fueled Generating Stations

- **Shand Power Station**
- **Poplar River Power Station**
- **Boundary Dam Power Station**

SaskPower Coal Fueled Generating Stations

Boundary Dam Power Station

- Began generating power in the 1950s
- Generating capability: 882 MW off 6 units
- Plant consumes 4.92 million tonnes of lignite coal annually
- Produces 365,000 tonnes of Class CI flyash annually
- Ash for sale is collected off 3 units
- SaskPower International exclusive marketer
- Supplies 80-85% of flyash used in Saskatchewan

Mill Test Results Boundary Dam

TECHNICAL REPORT
CSA STD CERTIFIED CONCRETE TESTING LABORATORY
IN ACCORDANCE WITH STD. A283

amec

FLY ASH ANALYSIS

TO: SASKPOWER INTERNATIONAL INC.
2025 VICTORIA AVENUE
REGINA, SK S4P 0S1

OFFICE: Calgary
PROJECT NO: CA16604
CLIENT PO#: FLY-01-2005
EMAIL: Saskpower – Wanda Perfect
Saskpower – Mickey Baran

ATTN: MR. GERRY EASU – MGR. FLY ASH
PROJECT: 2005 QUALITY ASSURANCE TESTING
SUBJECT: CHEMICAL AND PHYSICAL ANALYSIS OF FLY ASH

SAMPLE IDENTIFICATION: FLY ASH, UNITS 3 & 4
DATE SAMPLED: DECEMBER 2005
SAMPLED BY: CLIENT
SOURCE: BOUNDARY DAM GENERATING STATION
DATE RECEIVED: DEC 21, 2005
DATE REPORTED: JAN 24/06
TEST NO.: 05BD12

CHEMICAL ANALYSIS

TEST DESCRIPTION	TEST RESULTS	UNITS	SPECIFICATIONS				
			ASTM C618-03		CSA A3000-03		
			CLASS F	CLASS C	CLASS FA	CLASS CI	CLASS CH
• Silicon Dioxide (SiO_2)	51.40	%	-	-	-	-	-
• Aluminum Oxide (Al_2O_3)	21.00	%	-	-	-	-	-
• Iron Oxide (Fe_2O_3)	5.73	%	-	-	-	-	-
• Total (SiO_2)+(Al_2O_3)+(Fe_2O_3)	78.13	%	70 min.	50 min.	-	-	-
• Sulphur Trioxide (SO_3)	0.52	%	5 max.	5 max.	5 max.	5 max.	5 max.
• Calcium Oxide (CaO)	5.47	%	-	-	5	5-35	>35
• Moisture Content	0.12	%	3 max.	3 max.	3 max.	3 max.	3 max.
• Loss on Ignition	0.12	%	6 max.	6 max.	6 max.	6 max.	6 max.

PHYSICAL ANALYSIS

• Fineness in Retained on 45 µm (No. 325 Sieve)	17.3	%	34 max.	34 max.	34 max.	34 max.	34 max.
• Strength Activity Index with Cement - Percent of Control at 7 Days	82.7	%	75 min.	75 min.	-	-	-
• Percent of Control at 28 Days	82.4	%	75 min.	75 min.	75 min.	75 min.	75 min.
• Water Requirement, % of Control	94.2	%	105 max.	105 max.	-	-	-
• Soundness - Autoclave Expansion	0.08	%	0.8 max.	0.8 max.	0.8 max.	0.8 max.	0.8 max.
• Density	2.34	g/cc	-	-	-	-	-
• Increase of Drying Shrinkage @ 28 D	-	%	0.03 max.	0.03 max.	-	-	-
• Quantity of Air Entraining Agent	0.060	%	-	-	-	-	-
• Control of Alkali (NA) Agg. Reactivity Mortar Expansion at 14 Days	-	%	100 max.	100 max.	0.10 max.	0.10 max.	0.10 max.
• Sulphate Resistance @ 6 Months	-	%	Mod.Exp.<0.10 max. High Exp.<0.05 max.	Mod.Exp.<0.10 max. High Exp.<0.07 max.	100<0.10 max. 50<0.05 max.	100<0.10 max. 50<0.05 max.	100<0.10 max. 50<0.05 max.
UNIFORMITY REQUIREMENTS:							
• Density, Variation from Ave.	0.8	%	5 max.	5 max.	5 max.	5 max.	5 max.
• Fineness, 45 µm Sieve, Variation from Ave.	0.1	%	5 max.	5 max.	5 max.	5 max.	5 max.
• A.E.A., Variation from Ave.	NIL	%	+/- 20	+/- 20	+/- 20	+/- 20	+/- 20
• Multiple Factor	2.1	%	200 max.				

COMMENTS

SaskPower Coal Fueled Generating Stations

Shand Power Station

- Began generating power in the 1992
- Generating capability: 306 MW
- Plant consumes 1.83 million tonnes of lignite coal annually
- Produces 131,400 tonnes of Class CH flyash annually
- SaskPower International exclusive marketer

Mill Test Results Shand

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Kevin Guillemin
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ATTN: MR. GERRY EASU – MGR. FLY ASH

PROJECT: 2005 QUALITY ASSURANCE TESTING
SUBJECT: CHEMICAL AND PHYSICAL ANALYSIS OF FLY ASH

SAMPLE IDENTIFICATION: UNCLASSIFIED FLY ASH
DATE SAMPLED: DECEMBER 2005
SAMPLED BY: CLIENT
SOURCE:
DATE RECEIVED: DEC 7/05
SHAND GENERATING STATION
DATE REPORTED: JAN 18/06
TEST NO.: 05SH12

CHEMICAL ANALYSIS

TEST DESCRIPTION	TEST RESULTS	UNITS	SPECIFICATIONS				
			ASTM C618-03		CSA A3000-03		
			CLASS F	CLASS C	CLASS F	CLASS CI	CLASS CH
- Silicon Dioxide (SiO_2)	44.50	%	-	-	-	-	-
- Aluminum Oxide (Al_2O_3)	17.60	%	-	-	-	-	-
- Iron Oxide (Fe_2O_3)	3.93	%	-	-	-	-	-
- Total (SiO_2)+(Al_2O_3)+(Fe_2O_3)	66.03	%	70 min.	50 min.	-	-	-
- Sulphur Trioxide (SO_3)	1.00	%	5 max.	5 max.	5 max.	5 max.	5 max.
- Calcium Oxide (CaO)	20.20	%	-	-	< 8	8-20	>20
- Moisture Content	-	%	3 max.	3 max.	3 max.	3 max.	3 max.
- Loss on Ignition	-	%	6 max.	6 max.	6 max.	6 max.	6 max.

PHYSICAL ANALYSIS

- Fineness Retained on 45 µm (No. 325 Sieve)	17.8	%	34 max.	34 max.	34 max.	34 max.	34 max.
- Strength Activity Index with Cement Percent of Control at 7 Days	78.0	%	75 min.	75 min.	-	-	-
- Percent of Control at 28 Days	83.2	%	75 min.	75 min.	75 min.	75 min.	75 min.
- Water Requirement, % of Control	94.2	%	105 max.	105 max.	-	-	-
- Soundness, Autoclave Expansion	0.10	%	0.8 max.	0.8 max.	0.8 max.	0.8 max.	0.8 max.
- Density	2.41	g/cc	-	-	-	-	-
- Increase of Drying Shrinkage @ 28 D	-	%	0.03 max.	0.03 max.	-	-	-
- Quantity of Air Entraining Agent	-	%	-	-	-	-	-
- Control of Alkali (Na) Agg. Reactivity Mortar Expansion at 14 Days	-	%	100 max.	100 max.	0.10 max.	0.10 max.	0.10 max.
- Sulphate Resistance @ 6 Months	-	%	Mod Exp.=0.10 max High Exp.=0.05 max.	Mod Exp.=0.10 max High Exp.=0.05 max.	365=0.10 max 365=0.05 max.	365=0.10 max 365=0.05 max.	365=0.10 max 365=0.05 max.
UNIFORMITY REQUIREMENTS							
- Density, Variation from Ave.	+/-?	%	5 max.	5 max.	5 max.	5 max.	5 max.
- Fineness, 45 µm Sieve, Variation from Ave.	+/-3	%	5 max.	5 max.	5 max.	5 max.	5 max.
- A.E.A., Variation from Ave.	-	%	+/- 20	+/- 20	+/- 20	+/- 20	+/- 20
- Multiple Factor	-	%	200 max.	-	-	-	-

COMMENTS

Boundary vs. Shand

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- Aluminum Oxide (Al_2O_3)	21.00	%	-	-	-	-	-
- Iron Oxide (Fe_2O_3)	3.73	%	-	-	-	-	-
- Total (SiO_2)+(Al_2O_3)+(Fe_2O_3)	75.13	%	70 min.	50 min.	-	-	-
- Sulphur Trioxide (SO_3)	0.92	%	5 max.	5 max.	5 max.	5 max.	5 max.
- Calcium Oxide (CaO)	9.47	%	-	-	< 8	8-20	>20
- Moisture Content	0.12	%	3 max.	3 max.	3 max.	3 max.	3 max.
- Loss on Ignition	0.12	%	6 max.	6 max.	6 max.	6 max.	6 max.

SAMPLE IDENTIFICATION: UNCLASSIFIED FLY ASH
DATE SAMPLED: DECEMBER 2005
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DATE REPORTED: JAN 18/06
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CHEMICAL ANALYSIS

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			ASTM C618-03		CSA A3000-03		
			CLASS F	CLASS C	CLASS F	CLASS CI	CLASS CH
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- Aluminum Oxide (Al_2O_3)	17.60	%	-	-	-	-	-
- Iron Oxide (Fe_2O_3)	3.93	%	-	-	-	-	-
- Total (SiO_2)+(Al_2O_3)+(Fe_2O_3)	66.03	%	70 min.	50 min.	-	-	-
- Sulphur Trioxide (SO_3)	1.00	%	5 max.	5 max.	5 max.	5 max.	5 max.
- Calcium Oxide (CaO)	20.20	%	-	-	< 8	8-20	>20
- Moisture Content	-	%	3 max.	3 max.	3 max.	3 max.	3 max.
- Loss on Ignition	-	%	6 max.	6 max.	6 max.	6 max.	6 max.

Rules for Using Flyash In Concrete

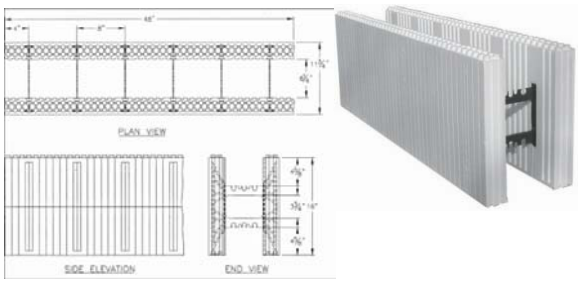
- Ensure flyash meets CSA Standard A-3000-03 specifications
- Most important to the Redi mix industry are fineness, LOI and consistency
- Regular testing according to CSA standards
- Maintain good quality control practices
- Monitor field air contents, strengths, etc.
- Monitor field results

Projects that have incorporated an unconventional us of Flyash

- ICF housing in Regina and Saskatoon
- SSWHR Hospital in Swift Current
- Centennial Wind Facility SW Saskatchewan

ICF Housing in Saskatoon and Regina

•Local Redi-Mix supplier
•Problem increase Flow of plastic concrete to facilitate better consolidation while maintaining competitive cost of product
•Solution increase percentage of Flyash Used in mix design



ICF Housing in Saskatoon and Regina

- Solution consisted of changing the basic wall mix presently in use to a 50 % Fly Ash and 50 % Type GU cement mix design, And a Reduction of maximum coarse aggregate size.
- Test results are consistently >30Mpa on a 25Mpa mix design
- Approximately 20 houses each year are constructed this way

SSWHR Hospital in Swift Current

- Problem:
  - undesirable soil conditions
  - Construction adjacent to existing hospital
  - Accelerated Construction schedule
- Traditional solution would be to use a driven piling system
- Solution Proposed and accepted by Southwest Saskatchewan Health authority: Continuous Flight Auger (CFA) Augercast Piles

Continuous Flight Auger (CFA) Augercast Piles

INTRODUCTION

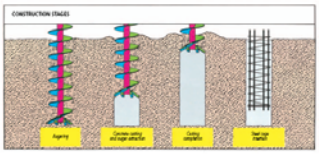
Auger Cast Piles are installed by rotating a continuously flighted hollow shaft auger into the soil to a specified depth – Without extraction of any soil. High strength cement grout is pumped under pressure through the hollow shaft of the auger as the auger is slowly withdrawn. The resulting grout column hardens and forms an auger cast pile. Reinforcing, when required, can be installed while the cement grout is still fluid. Augercast piles are available in a range of 400mm – 1000mm diameters with depths to 17m. Depths to 45m possible with special rigging.

Continuous Flight Auger (CFA) Augercast Piles

Auger Cast Piles can be used:
- As friction piles - the superstructure load is transferred to the soil through friction between the pile surface and the soil;
- As an end-bearing pile - the superstructure load is transferred through the pile tip into a hard stratum of soil or rock;
- As an anchor pile - hydrostatic or other uplift forces are resisted though a full length tendon embedded in the grout column;
- As a vertical component of a continuous curtain wall in temporary or permanent shoring systems and below grade walls; and
- As a temporary or permanent diagonal tie-back in auger cast curtain walls, beam and lagging walls, and sheet pile walls.

Continuous Flight Auger (CFA) Augercast Piles

The concrete is cast through the auger hollow stem by means of a proper concrete pump.
The pump is connected through a hose (4" to 6" diam.) to a feed swivel fitted on the rotary head. When the required depth is reached, concrete is pumped through the string stem and the auger is lifted; the concrete gradually fills the voids left by the auger which is then extracted without being rotated or just slowly in the same driving direction.
The integrity of the pile is assured by a constant control of the pressure on the concrete column by means of proper transducers fitted on the equipment.



Continuous Flight Auger

SOILMEC MODEL	AUGER	CENTRAL STEM	
	Diameter (mm)	Outer diam. (mm)	Inner passage (mm)
HD 4	350÷800	140	100
HD 5	450÷1000	168	125

The concrete used for the CFA pile is generally prepared with aggregates of fine round gravel (max size 15 mm) and sand ranging from 0.4 to 0.5 mm in size. The cement contents vary from 350 to 450 kg/m³ with water/cement ratio equal to 0.45 approximately. The slump should be maintained between 190 and 210 mm. Occasionally the use of fluidizing additives may be suggested.

Continuous Flight Auger (CFA) Augercast Piles

- **ADVANTAGES**

  Less noise - Auger cast piles are a drilled and pumped pile, not a driven pile. This eliminates the hammer impact noise created by driving piles.

  No objectionable vibration - The elimination of a pile-driving hammer allows the installation of auger cast piles adjacent to existing structures without the danger of settlement or damage to existing footings, walls, other structural components, or nearby equipment.

  No casing required - During the installation of an auger cast pile, the earth filled auger maintains the shape of the pile hole during the drilling phase. The pressures produced by the grout pump during the withdrawal and grouting phase exceed the lateral pressures exerted by the soil, and while the gout is still fluid, the lateral pressures per foot of depth of the grout exceed those pressures per foot of depth of the soil.

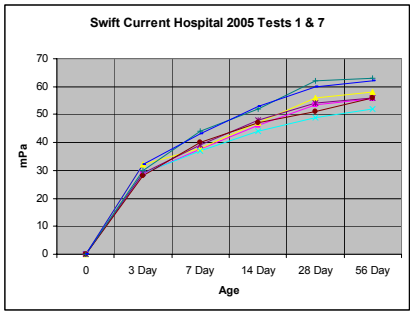
  Soil at each pile hole can be inspected - The grout that is pumped into the pile displaces the existing soil for the entire length of the pile. This displacing action allows the soil along the length of the extracted auger to be available for visual inspection and testing.

Continuous Flight Auger (CFA) Augercast Piles

Concrete Spec:
- Compressive Strength- 32 MPa
- Air 4-7%
- Slump-200+/- 20mm
- W/C Ratio- 0.32

Mix Design: per cubic meter:
- 14mm Rock-675kg
- Fine aggregate- 530 kg
- Type HS Cement- 310 kg
- FlyAsh- 310 kg
- Water-200 litre
- High Range water reducer-1.8 litre
- Water Reducer- 1200 ml
- Air entraining agent- 240 ml

Continuous Flight Auger (CFA) Augercast Piles



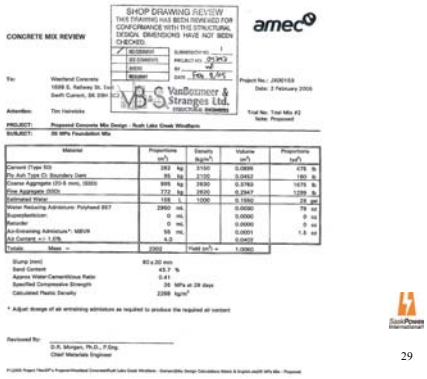
Centennial Wind Power Facility

- Project: 83 turbines, capable of putting out a total of 150 megawatts—enough to power 64,000 homes.
- The final structure, from ground to the top of the rotor when a blade is pointing straight up, is 107 metres tall: roughly the height of a 30-story building.

Centennial Wind Power Facility

- 2 TYPES OF FOUNDATIONS
- 1) Spread footings
- Total = 57
- See attached mix design
- Base dimensions = approx. 14m(46') x 14m(46')
- Depth = approx. 1.9m(6.3') to 2.3m(7.5')
- Concrete Volumes:
  - -Mud slab = 25 yd3
  - -Main foundation = 190 yd3
  - -Pedestal = 10 yd3
  - -TOTAL = 225 yd3
- 2) P&H Foundations (Patrick & Henderson)
- Total = 26
- See attached mix design
- Depth = 9.75m (32')
- CMP=Corrugated Metal Pipe
- Outter CMP Diameter = 4.0m(13')
- Inner CMP Diameter = 3.2m(10.6')
- Void on outside of outter CMP ranges from 6" to 3'
- Slurry is poured in thirds up the foundation on outside of outter CMP(waiting 6-8 hrs between pours to prevent collapse of CMP).
- Amount of slurry ranges between 80 to 300 yd3
- Concrete, anchor bolts, and rebar placed between inner and outter CMP (2.5' thick).
- Concrete volume: approx. 65 yd3
- Inside of inner CMP backfilled with loose uncompacted native backfill.

Centennial Wind Power Facility



CONCRETE MIX REVIEW

SHOP DRAWING REVIEW
THIS DRAWING HAS BEEN REVIEWED FOR CONFORMANCE WITH THE STRUCTURAL DESIGN. DIMENSIONS HAVE NOT BEEN CHECKED.

amec

B+S VanBommer & Stranges Ltd.

Material	Proportions (m³)		Density kg/m³	Volume (m³)	Proportions (yd³)
Cement (Type 50)	283	kg	3150	0.0899	476 lb
Fly Ash Type D: Boundary Dam	85	kg	3150	0.0452	180 lb
Coarse Aggregate (20-5 mm), ISSSS	895	kg	2630	0.3783	1675 lb
Fine Aggregate (SSD)	772	kg	2630	0.2947	1299 lb
Estimated Water	155	L	1000	0.1550	29 gal
Water Reducing Admixture: Polyheed 997	2960	mL		0.0030	79 oz
Superplasticizer:	0	mL		0.0000	0 oz
Retarder:	0	mL		0.0000	0 oz
Air-Entraining Admixture*: MBVR	55	mL		0.0001	1.8 oz
Air Content +/- 1.5%	4.5			0.0450	
Totals: Mass →	2955		Yield (m³) =	1.0060	

Slump (mm)	80 ± 20 mm
Sand Content	43.7 %
Approx Water-Cementitious Ratio	0.41
Specified Compressive Strength	35 MPa at 28 days
Calculated Plastic Density	2288 kg/m³

* Adjust dosage of air entraining admixture as required to produce the required air content

Reviewed By:
D.R. Morgan, Ph.D., P.Eng.
Chief Materials Engineer

Centennial Wind Power Facility

GE GROUND ENGINEERING LTD.
CIVIL & GEOTECHNICAL ENGINEERS

CONCRETE TEST REPORT
(CSA A23.1-00 & A23.2-00)

CYLINDER NUMBER	FIELD SENT	DATE CAST	DATE RECEIVED	DATE TESTED	COMPRESSIVE STRENGTH (MPa) 7 DAYS	28 DAYS	TYPE OF FRACTURE
19		16-Feb-05	14-Feb-05	23-Feb-05	38.6		2
20		16-Feb-05	14-Feb-05	16-Mar-05		50.6	2
21		16-Feb-05	14-Feb-05	16-Mar-05		52.7	2
22		16-Feb-05	14-Feb-05	HOLD			
23	F/C	16-Feb-05	18-Feb-05	18-Feb-05	2 DAY = 23.1 MPa		2
24	F/C	16-Feb-05	19-Feb-05	19-Feb-05	3 DAY = 31.7 MPa		2
25	F/C	16-Feb-05	20-Feb-05	20-Feb-05	4 DAY = 38.7 MPa		2

TYPE OF FRACTURE : 1 FRACTURED AGGREGATE (NORMAL CONICAL BREAK); 2 FRACTURED AGGREGATE OR DEGREE BREAK); 3 FRACTURED AGGREGATE AT DEGREE BREAK); 4 NO FRACTURED AGGREGATES (CONICAL BREAK); 5 OTHER

THE CYLINDERS WERE CURED ACCORDING TO CSA A23.2-3C OR 4C AND A23.2-9C UNLESS SPECIFIED : CYLINDERS 23, 24, AND 25 WERE FIELD CURED ON SITE UNTIL SUBMITTED

LOCATION OF CONCRETE ON TEST STRUCTURE : 5C) 23 MASS FOOTING, STAGE 1 (BOTTOM), SAMPLED 1.2m BELOW THE FINISHED TOP OF CONCRETE FOR THE STAGE 1 FOOTING

CYLINDERS CAST IN FIELD	X	CYLINDERS CAST IN LABORATORY	X
UNIT WEIGHT OF FRESH CONCRETE :	kg/m³	UNIT WEIGHT OF HARDENED CONCRETE : 2318	kg/m³
TYPE OF CEMENT :	1 50 SULPHATE RESISTANT	TEMPERATURE OF CONCRETE (Celsius) : 16	°C
REQUIRED SLUMP :	150 after super p	TEMPERATURE OF ATMOSPHERE (Celsius) : -8	°C
SPECIFIED SLUMP :	80 TO 100 mm	CONCRETE TRUCK NUMBER : 6	
REQUIRED AIR :	5.5 %	TICKET NUMBER : 6691	
SPECIFIED AIR :	4 TO 6 %	MIX DESIGN NUMBER :	
ADMIXTURES :	AIR, WATER REDUCER, SUPER P	TIME LOAD LEFT PLANT : 1:50 PM	
MAXIMUM AGGREGATE SIZE :	20 mm	TIME CONCRETE SAMPLED : 2:40 PM	
WATER ADDED ON THE JOB :	Liters	TIME CYLINDERS CAST : 3:05 PM	
AT REQUEST OF :		TYPE OF MOLD USED : PLASTIC	

Centennial Wind Power Facility

CONSTRUCTION METHODOLOGY

-Excavate hole with track hoe.

-Place mud slab on unfrozen ground.

-Provide heat and hoarding to area to prevent freezing of mud slab and undisturbed soil below it.

-The undisturbed soil below the mud slab will not be allowed to freeze.

-Heating and hoarding removed and replaced to allow for placement of rebar.

-During placement of concrete, heating and hoarding will ensure rebar temperature meets CSA A23.1 requirements.

-Concrete will be cured for 3 days at a minimum of 10C OR the time necessary to achieve 40% of 28 day compressive strength. Field cured concrete cylinders will be taken and tested to verify curing period.

-Once curing period has elapsed heaters will be removed and tarps will be left on to prevent thermal shock of the concrete.

-Foundations will be backfilled with unfrozen native material and compacted to specified standard proctor densities.

- 83 Foundations were installed between January and July, 2005.

Centennial Wind Power Facility

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Centennial Wind Power Facility

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Centennial Wind Power Facility

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Questions?