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CITEPH-64-2012

Wave propagation in ice-covered seas

Basin Tests Specification

Project: C11.2.053

Date: 18/09/2012

Revision: 2

	REVISION					REVISION			
Sheet N°	**0**	**1**	**2**	**3**	**Sheet N°**	**0**	**1**	**2**	**3**
1	X				44				
2	X				45				
3	X				46				
4	X				47				
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IDENTIFICATION SHEET

DOCUMENT REFERENCES			
Type of document		☐ Study ☐ Tests	☐ Publication X Specification ☐ Report ☐ Proposal
	Number	**Title**	
Reference	**C11.2.053**	**CITEPH-64-2012 : Wave propagation in ice-covered seas Basin tests specification**	
Revision	**Rev 2**		
External References			
Client		**CITEPH**	

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DISTRIBUTION		
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Full document	**Internal**	**External**
	Filing	NERSC, DORIS, SAIPEM, TOTAL

KEY WORDS

TABLE OF CONTENTS

1. INTRODUCTION

This document presents the specification for the model tests campaign to be performed within the CITEPH-64-2012 project, untitled “Wave propagation in ice-covered seas”, in BGO FIRST basin. This project aims at improving physical, mathematical and numerical models of wave propagation in areas partly and fully covered with sea ice.

The objective of the present campaign is to perform 3D model tests at medium scale to provide the WIFAR (Waves-in-Ice Forecasting for Arctic Operators) partners with experimental data in order to validate and improve their numerical models.

A Marginal Ice Zone (MIZ) will be formed in the basin by installing a large number of rigid synthetic floes of a given shape. This MIZ will be then submitted to wave and wave+wind.

The tests will have two main objectives:

1. Investigate the evolution of ocean waves in the MIZ by measuring incoming, reflected and transmitted waves
2. Investigate the MIZ rheology by measuring the displacement of floes with respect to each other and the frequency of floes collisions under combined wind and wave action

2. DOCUMENTS OF REFERENCE

Ref. 1 CITEPH-64-2012 – Convention rev.0 – 27.02.2012

Ref. 2 CITEPH-64-2011 – Minutes of kick-off meeting (24.02.2012)

3. DESCRIPTION OF TESTS FACILITY

OCEANIDE wave tank named BGO FIRST is an oceanic basin which allows the simultaneous generation of waves, current and wind.

Its main characteristics are as follows:

- length : 40 m (adjustable floor 24 m),
- width : 16 m,
- depth : adjustable from 0 to 4.8 m,
- pit : 5 m diameter and 10 m depth,
- wave period : from 0.6s to 4s model scale,
- wave height : up to 0,8 m model scale,
- regular and irregular wave,
- current velocity : up to 0,4 m/s for 3 m depth and up to 1.2 m/s for 1.0 m depth, velocity can also be increased by the use of a convergent
- carriage platform longitudinal speed : up to 1.2 m/s,
- carriage platform transversal speed : up to 0.8 m/s,
- constant, squalls or wind spectrum generation: up to 5 m/s.

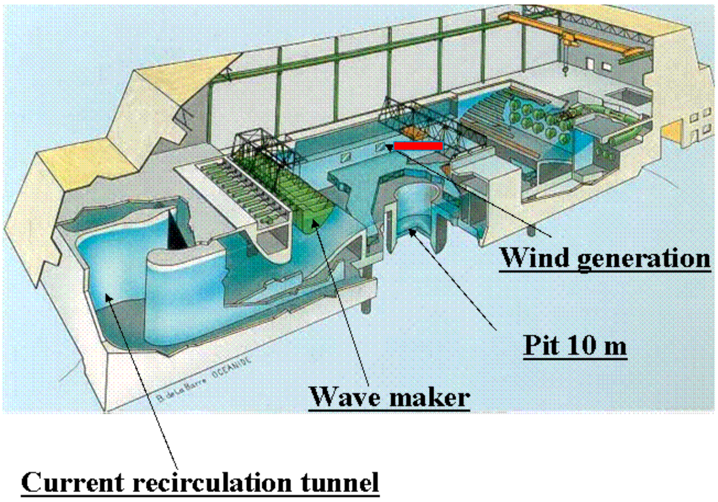


Figure 3-1 – BGO FIRST

4. EXPERIMENTAL SET-UP

Basin tests set-up is illustrated in Appendix 1 for two different floes concentration: 79% and 39%.

4.1. Scale

The selected model scale is 1/100 and will be applied based on the Froude similarity law. All data in this report are expressed in full scale, unless otherwise when indicated.

4.2. Test tank configuration

Tank depth will be set at 300m which allows simulating deepwater conditions.

The MIZ will be implemented at basin centre on the full basin width: i.e. 1600m. The MIZ length is limited by the cameras field of view (50deg field angle) and is equal to 500 m.

In order to avoid floes drifting away, two types of devices will be implemented:

- Vertical net on each side of the MIZ, for 79% floes-concentration and rheology tests only
- Mooring system, composed of a vertical cable and springs, implemented on each floe (see section 4.4 for details) for all other tests

4.3. Model

The Marginal Ice Zone will be composed of a maximum of 80 floes, modelled by circular plates of 1m diameter model scale and made of 33mm model scale thickness wood.

Wood has been selected to increase the floes freeboard with respect to full scale ice floes and in order to avoid greenwater, as greenwater would make the comparison with numerical models difficult.

Particular attention will be brought on model coating to avoid density variation during the tests. All tops of floes will be painted in white to ease video post-treatment. As an option it is proposed to add a number, painted on top, to identify each flow.

All floes will have a draft of 1.8m and the same diameter of 100m. Different floes concentration will be tested during this campaign. Each concentration will be obtained by adding or removing some floes. The required number of floes is presented in Table 4-1 for five different floe-concentrations: 79%, 70%, 50% and 39%.

No floes (-)	Covered Area (m^2)	Concentration
80	62.8	79%
71	55.8	70%
51	40.1	50%
40	31.4	39%

Table 4-1: Floes number and concentration

4.4. Mooring system

Two types of tests will be performed during this campaign:

- Attenuation tests in order to measure the waves transmitted and reflected by the MIZ
- Rheology tests in order to measure floes motion and collisions induced by waves and wind

During attenuation tests, two concentrations will be tested: 79% and 39%.

For the last concentration (39%) it is proposed to moor each floe using a vertical cable + springs system, in order to keep the same MIZ initial configuration from one test to another.

This mooring system will be soft enough to ensure that it has a negligible impact on the floes wave frequency behaviour. The mooring system has been designed and is presented in Appendix 2.

For the 79%-concentration vertical nets will be used to avoid floes drifting away.

4.5. Environmental conditions

4.5.1. Wave

Regular and irregular waves will be generated during this campaign along the basin main direction. For irregular waves, a JONSWAP spectrum with a shape factor (γ) of 3.3 will be used.

Main waves characteristics will be the followings:

- Height (or significant Height for irregular waves): from 2 to 10m
- Period (or peak period for irregular waves): from 6.5 to 20s
- Steepness lower than 5%

Waves will be calibrated prior to the model set-up in the basin.

4.5.2. Wind

Wind will be generated along the longitudinal basin axis by a system made of 8 in-line propellers on 6m width model scale.

Picture 4-1: Wind generation system

Four of the propellers, on a side of the wind generation system, will be inverted in order to generate a shear wind regime, as illustrated in Figure 4-1. Wind velocity will be set at 30m/s at profile extremities.

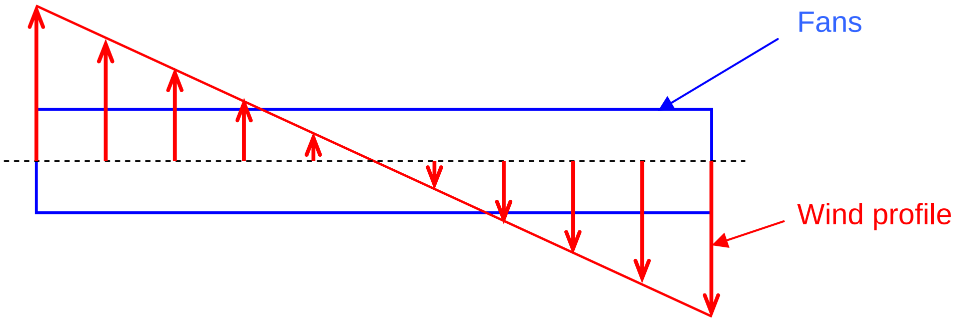


Figure 4-1: Shear wind profile (top view)

Spatial distribution of the shear wind will be measured prior to the tests.

In addition, two constant wind velocities will be calibrated for ''free-floating drifting tests'' (see section 7.3): 15m/s and 30m/s

4.5.3. Current

During rheology tests, a current opposite to waves might be generated to limit floes drift and accumulation along nets.

5. INSTRUMENTATION

During this campaign the following instrumentation will be used:

- A set of 18 wave probes (9 on beach side and 9 on wave maker side): to measure incoming, transmitted and reflected waves
- Video cameras: four standard 25 Hz model scale cameras for collision and ISMER high resolution cameras (typ. 1Hz model scale)

- A set of 10 1D vertical cargo accelerometers to quantify as far as possible, the number of collisions and the heave motions of 10 floes

6. TESTS PROCEDURE

6.1. Calibration of environmental conditions

Calibration of environmental conditions will be performed without the MIZ in the basin.

6.2. Wave and wave+wind tests

Test procedure will be as follows:

- T0=0s, measurements start
- T1=200s, start of environmental conditions (wave or wave+wind)
- T2, end of test. The test end-time will be selected as follows:
    - For regular waves: to allow a minimum of 8 established waves to travel along the basin length
    - For irregular waves: to generate a 1-hour sea-state

7. TESTS LIST

7.1. Calibration of environmental conditions

The list of wave to be calibrated is presented in Table 7-1 and Table 7-2.

Test nb	T	H1	H2
[-]	s	m	m
1	6.5	2.0	-
2	8.0	2.0	4.0
3	9.5	3.0	-
4	11.0	4.0	-
5	12.5	4.0	-
6	14.0	4.0	8.0
7	15.5	4.0	-
8	17.0	4.0	-
9	18.5	4.0	-
10	20.0	4.0	10.0

Table 7-1: Regular wave to be calibrated

Test nb	Tp	Hs1	Hs2
[-]	s	m	m
1	8.0	2.0	-
2	14.0	4.0	8.0
3	20.0	4.0	-

Table 7-2: Irregular wave to be calibrated

The list of wind to be calibrated is presented in Table 7-3.

Test nb	Wind pattern	Velocity
[-]	[-]	m/s
1	Shear	+/- 30
2	Constant	30
3	Constant	15

Table 7-3: Wind to be calibrated

7.2. Wave attenuation tests

Objective of these tests is to measure the waves transmitted and reflected by the MIZ.

A total of 26 wave attenuation tests will be performed, for 2 different concentrations (79% and 39%) and including regular and irregular waves.

Note that for each concentration, one test is repeated three times to check tests repeatability.

Test nb [-]	Model concentration [%]	Wave type [-]	Wave characteristics T or Tp [s]	H or Hs [m]
1	39	Regular	6.5	2.0
2		Regular	9.5	3.0
3, 3a, 3b		Regular	12.5	4.0
4		Regular	15.5	4.0
5		Regular	18.5	4.0
6	79	Regular	6.5	2.0
7		Regular	8.0	2.0
8		Regular	8.0	4.0
9		Regular	9.5	3.0
10		Regular	11.0	4.0
11, 11a, 11b		Regular	12.5	4.0
12		Regular	14.0	4.0
13		Regular	14.0	8.0
14		Regular	15.5	4.0
15		Regular	17.0	4.0
16		Regular	18.5	4.0
17		Regular	20.0	4.0
18		Regular	20.0	10.0
19	79	Irregular	8.0	2.0
20		Irregular	14.0	4.0
21		Irregular	14.0	8.0
22		Irregular	20.0	4.0

Table 7-4: wave attenuation tests

7.3. Rheology tests

A total of 12 experiments are foreseen, with different floes concentration and external forcings. Each experiment must be started from rest and reach a steady state of motion.

Waves will be either turned on or off in order to make the floes collide with each other, or to increase the number of collisions. The wind will be turned on in order to induce a collective circulation of the floes within the test area.

One day of basin will be dedicated to preliminary tests with the lower concentration (39%) to select two waves and one optimal wind patterns that will be kept the same for all experiments.

Table 7-5 describes the rheology tests to be performed.

Test nb	External forcing		*Floe*
	Wave	Wind	*Concentration*
1	1	1	39%
2	2	1	39%
3	-	1	39%
4	1	1	50%
5	2	1	50%
6	-	1	50%
7	1	1	70%
8	2	1	70%
9	-	1	70%
10	1	1	79%
11	2	1	79%
12	-	1	79%

Table 7-5: Rheology tests

In addition free floating drifting tests will be performed with single floes of different diameters.

The floe average drift velocity induced by wave or wind will be measured thanks to the video cameras.

Results will be used in order to calibrate numerical model.

Table 7-6 describes the rheology tests to be performed.

Test nb	Floe diameter [m]	Wave	Wind velocity
1	1.0	1	
2	1.0	2	
3	1.0		1
4	1.0		2
5	0.5	1	
6	0.5	2	
7	0.5		1
8	0.5		2
9	1.5	1	
10	1.5	2	
11	1.5		1
12	1.5		2

Table 7-6: Drag tests

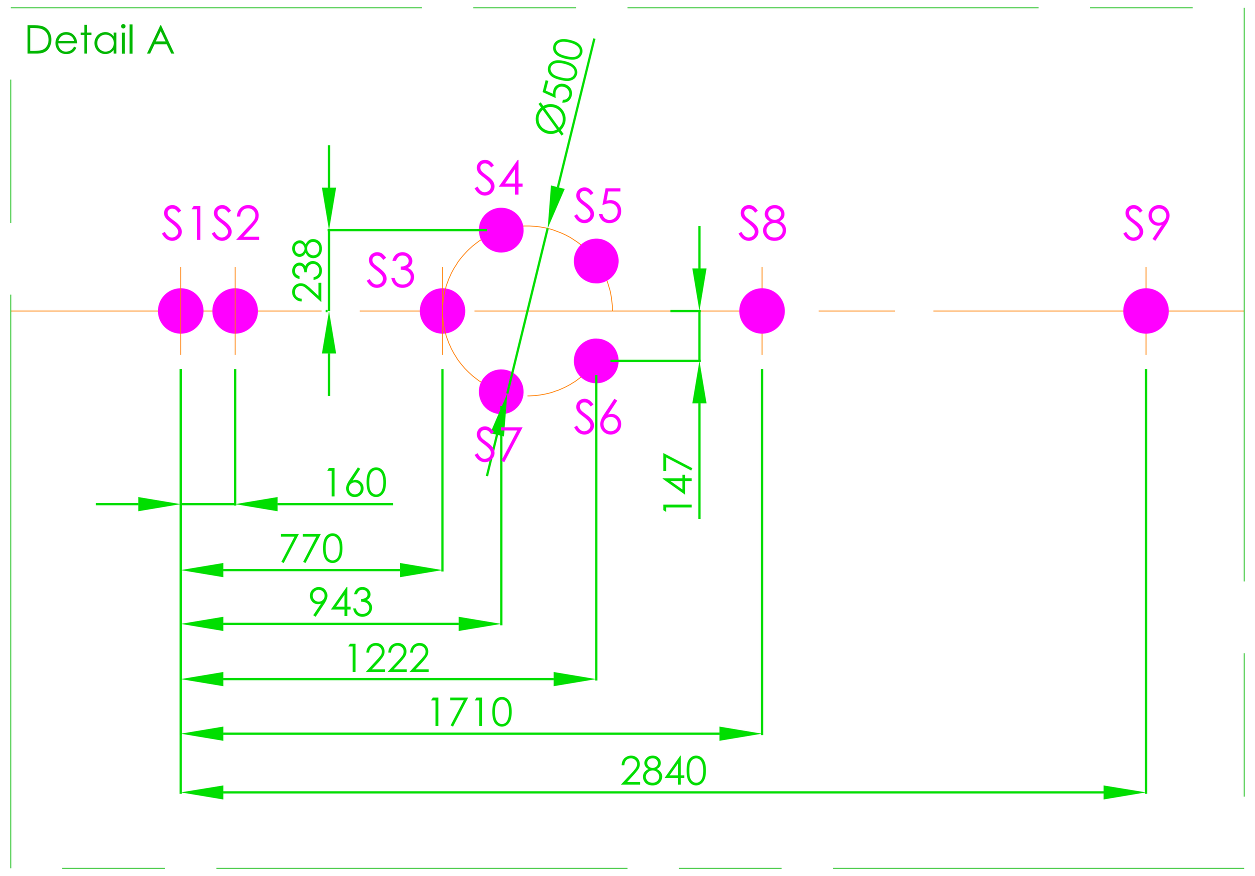
8. TESTS REPORT

The test report will include:

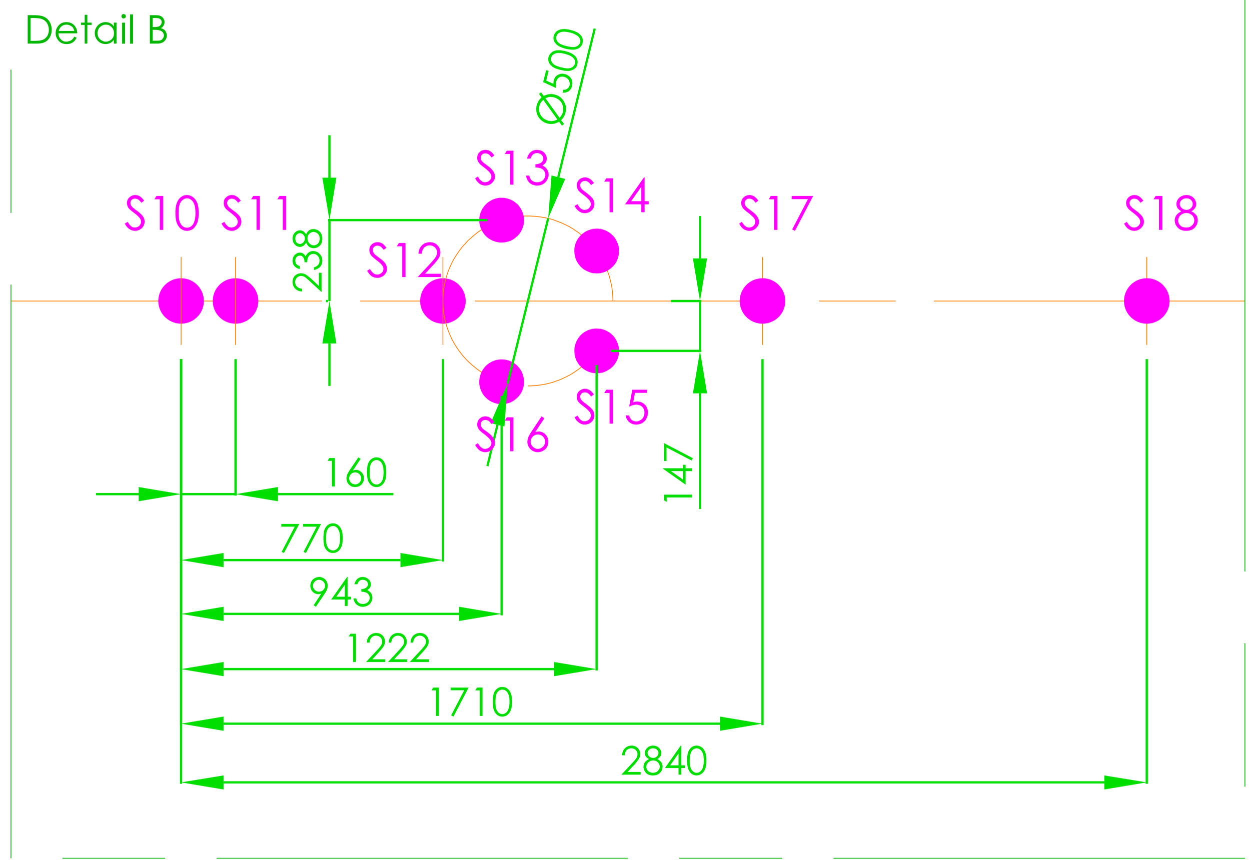
- The test setup description
- The test setup calibration results
- Measurement raw data
- Test results
- Video records of the tests

Basin set-up - Top view

Detail A



Detail B



Dimensions are given at millimeter model scale.

Océanide

Citeph - Wave propagation in ice-covered seas

Calibration of environmental conditions

Port de Bregaillon
83502 La Seyne sur Mer cedex
Tel: 33 (0)4 94 10 97 40
http://www.oceanide.net

Folio	Scale	Number of drawing	REV	STAT	DATE	By	Ch.
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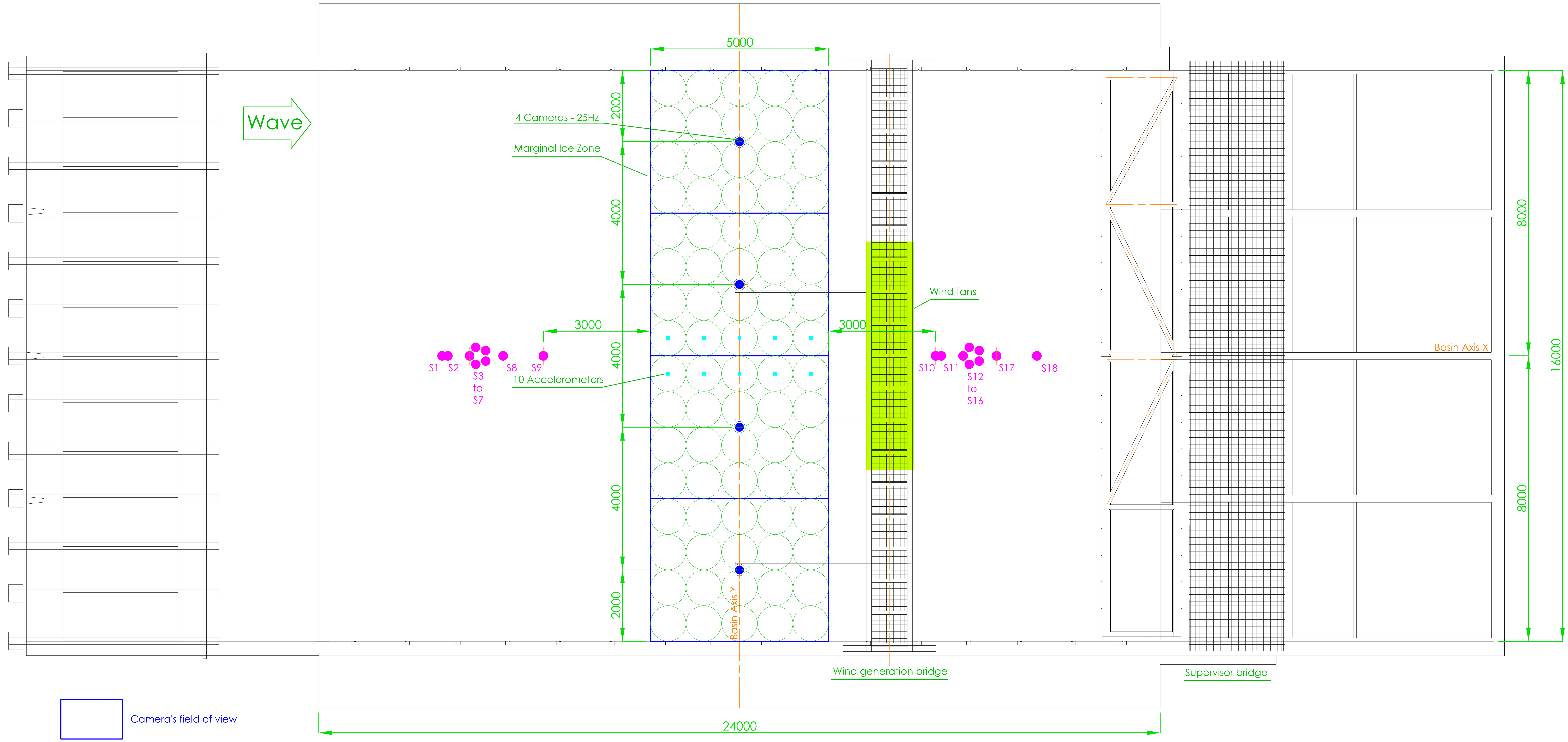
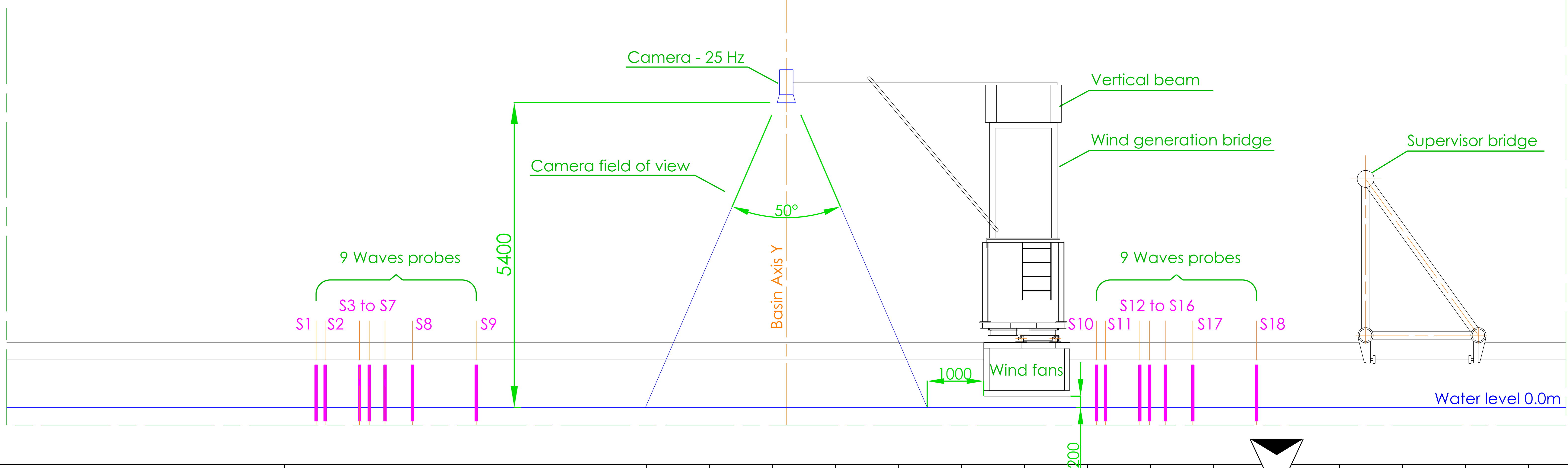
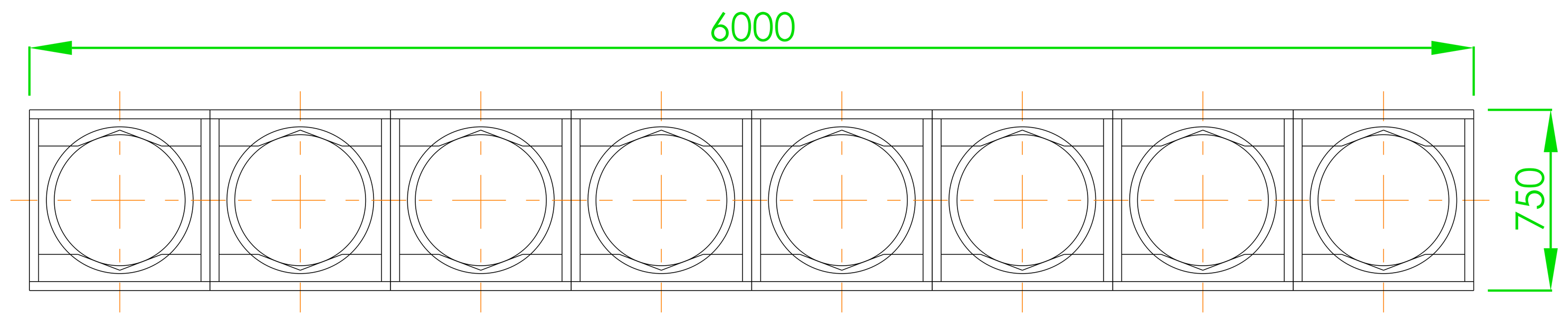
Basin set-up - Top view



Basin set-up - Side view



Wind fans - Front view

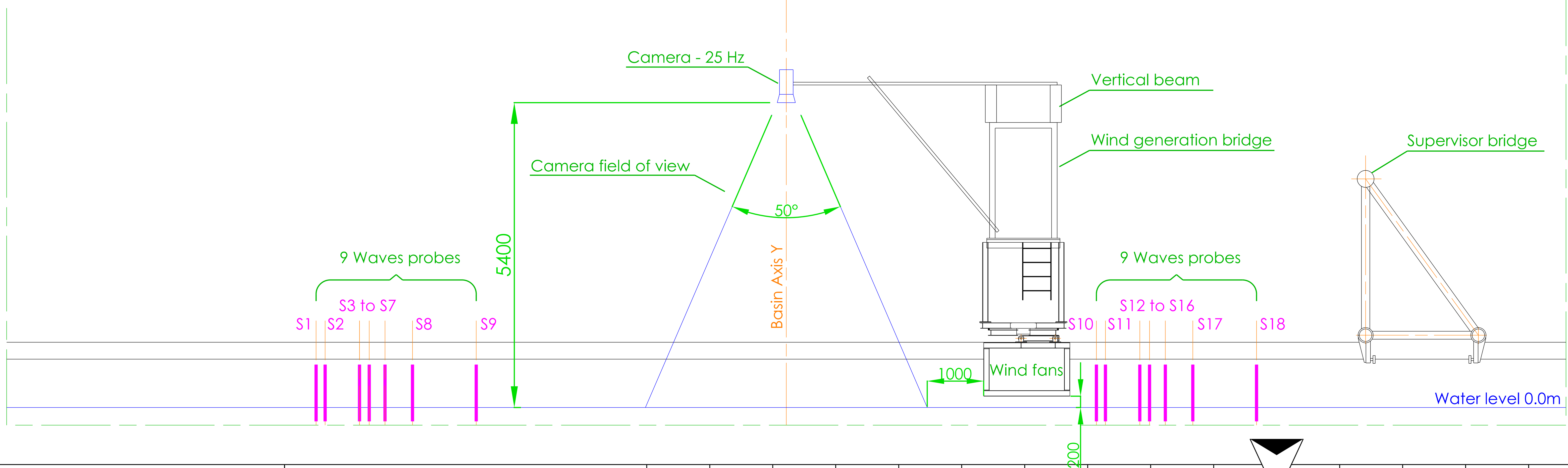


Dimensions are given at millimeter model scale.

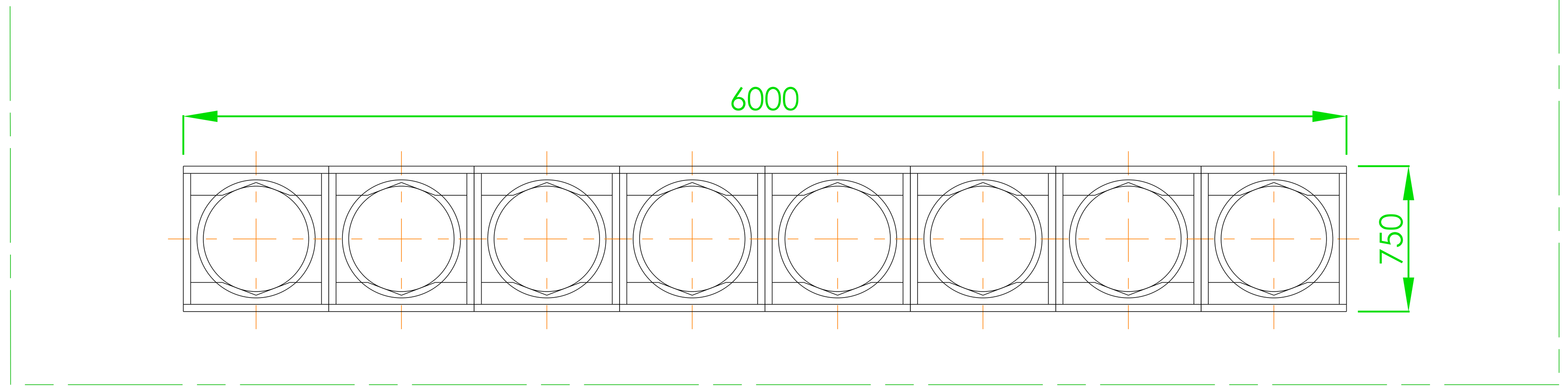
Océanide	Citeph - Wave propagation in ice-covered seas						
	Wave attenvation tests Set-up - 77 % concentration						
	Port de Bregaillon 83502 La Seyne sur Mer cedex Tel: 33 (0)4 94 10 97 40 http://www.oceanide.net	Folio	Scale	Number of drawing	1	Prel	01/07/2013	BQ	FP
			1/1	CIT-11-2-053-002	0	Prel	20/06/2013	SC	FP
				CIT-11-2-053_Plan.dwg	REV	STAT	DATE	By	Ch.

Basin set-up - Top view

Basin set-up - Side view



Wind fans - Front view



Dimensions are given at millimeter model scale.

Citeph - Wave propagation in ice-covered seas

Wave attention tests
Set-up - 38 % concentration

Océanide
Port de Bregaillon
83502 La Seyne sur Mer cedex
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Folio	Scale	Number of drawing
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		CIT-11-2-053_Plan.dwg

REV	STAT	DATE	By	Ch.
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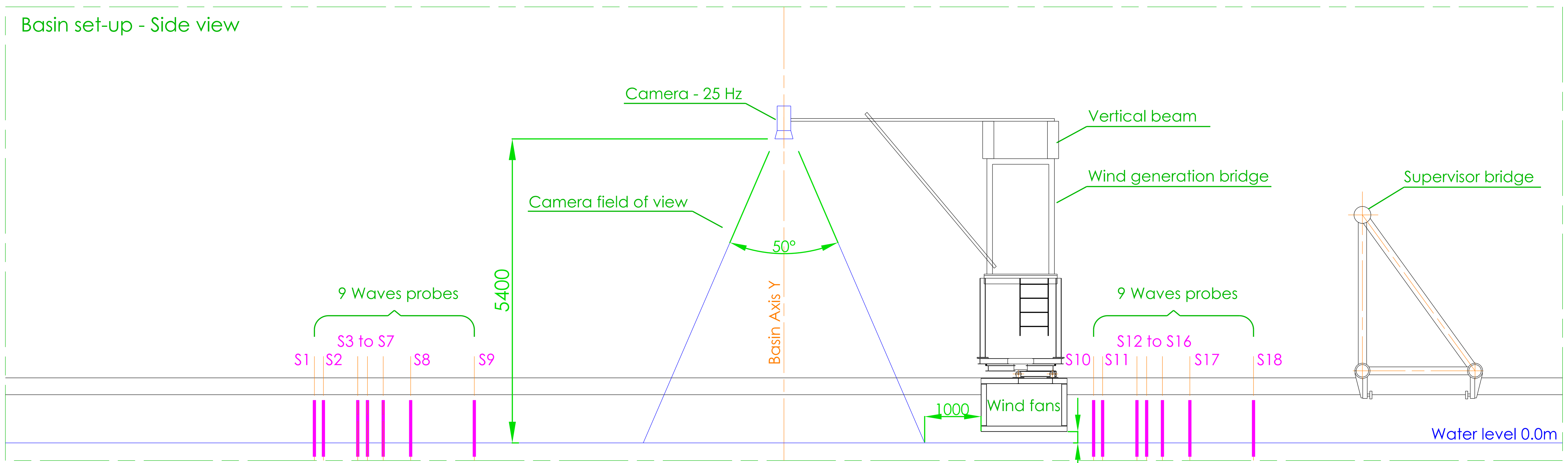

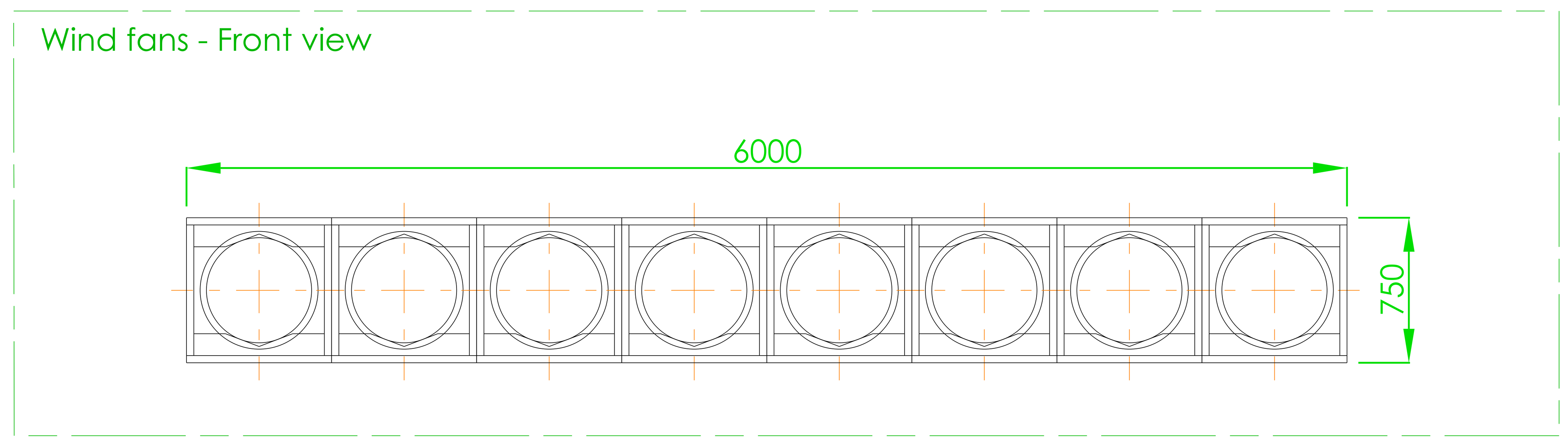

Dimensions are given at millimeter model scale.

Citeph - Wave propagation in ice-covered seas

Rheology tests
Set-up - 77 % concentration

Océanide

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83502 La Seyne sur Mer cedex
Tel: 33 (0)4 94 10 97 40
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Folio	Scale	Number of drawing
	1/1	CIT-11-2-053-004
		CIT-11-2-053_Plan.dwg

REV	STAT	DATE	By	Ch.
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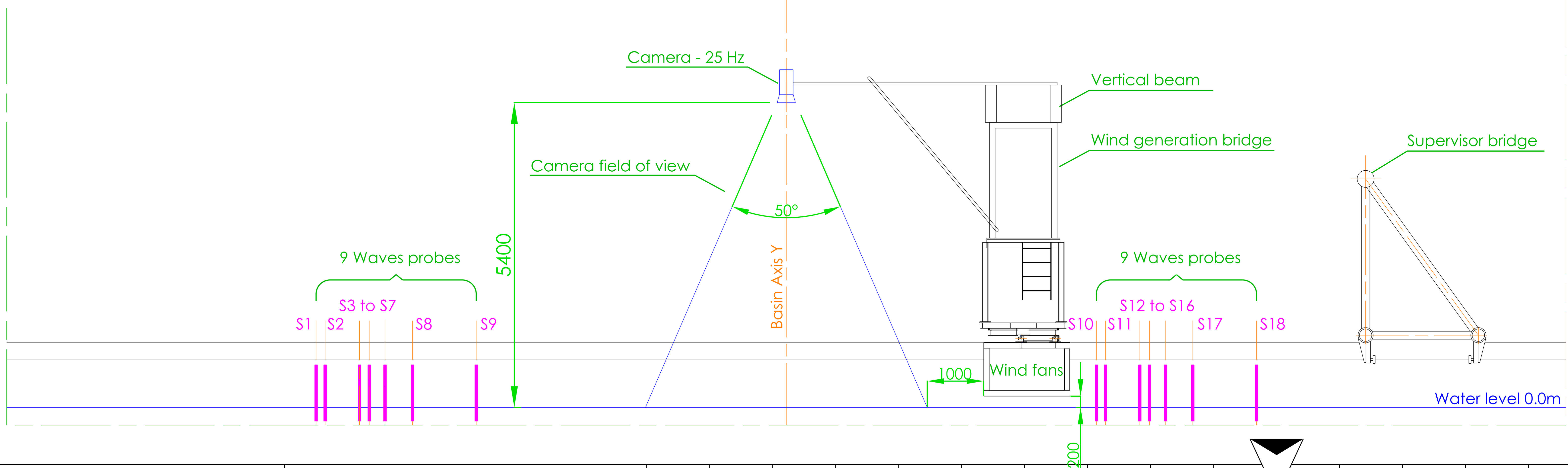
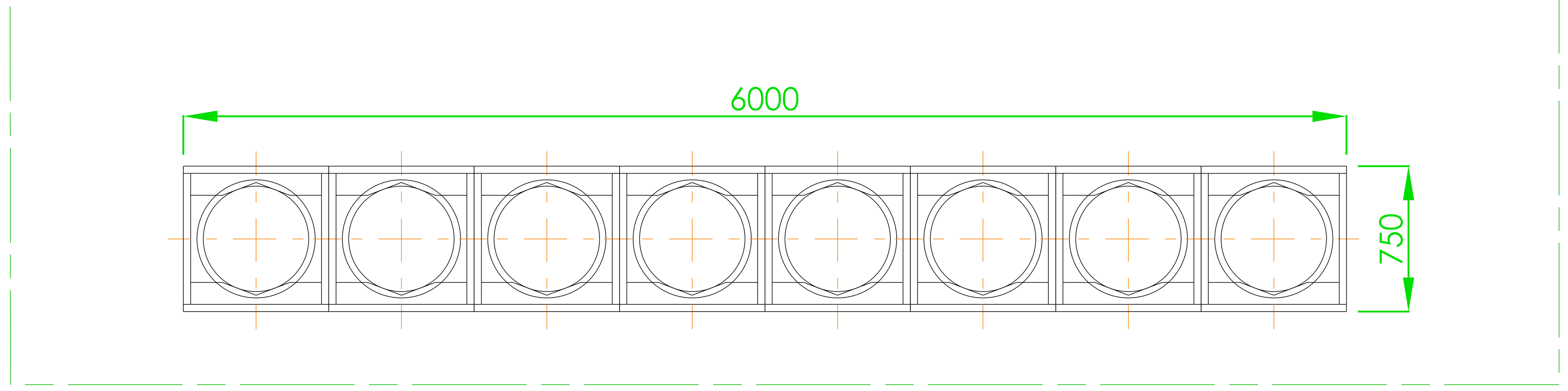
0	Prel	20/06/2013	SC	FP

Basin set-up - Top view

Basin set-up - Side view



Wind fans - Front view

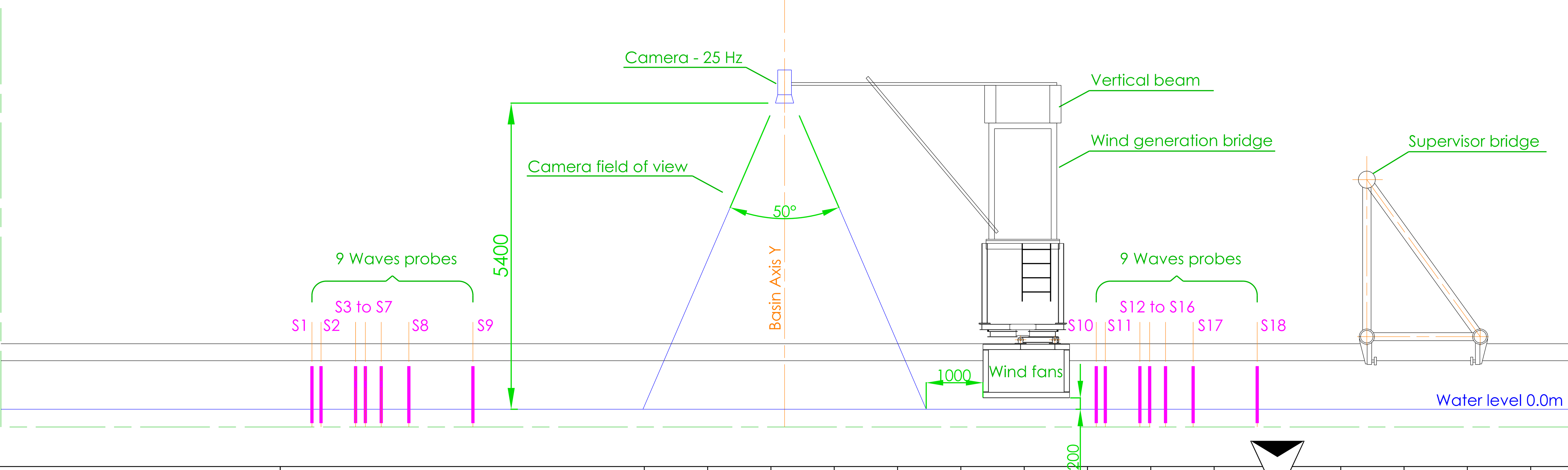


Dimensions are given at millimeter model scale.

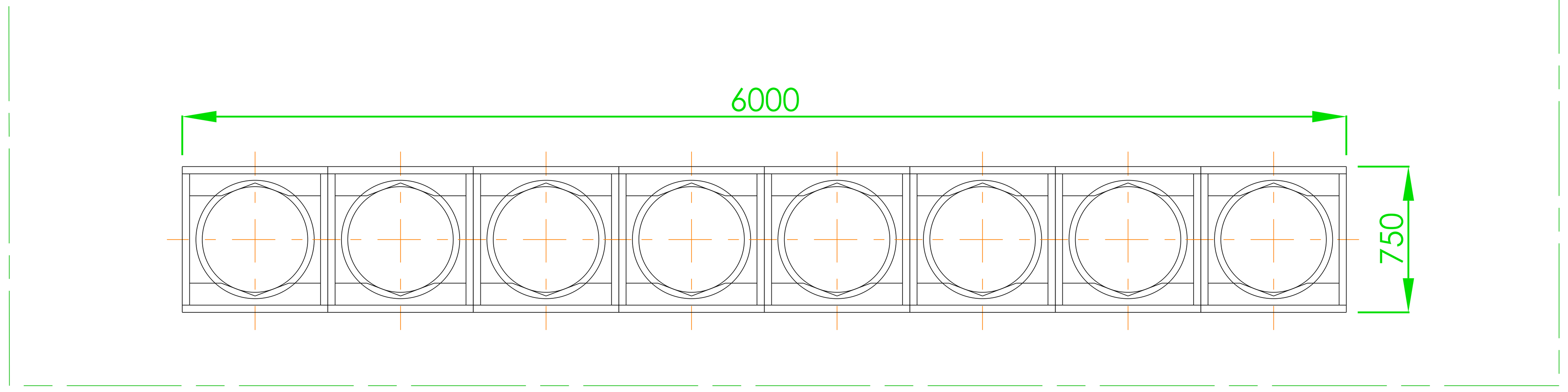
Océanide	Citeph - Wave propagation in ice-covered seas					
	Rheology tests Set-up - 48 % concentration					
Port de Bregaillon 83502 La Seyne sur Mer cedex Tel: 33 (0)4 94 10 97 40 http://www.oceanide.net	Folio	Scale 1/1	Number of drawing CIT-11-2-053-005 CIT-11-2-053_Plan.dwg	REV 0	STAT Prel	DATE 01/07/2013
				By BQ	Ch. FP	

Basin set-up - Top view

Basin set-up - Side view



Wind fans - Front view



Dimensions are given at millimeter model scale.

Océanide

Citeph - Wave propagation in ice-covered seas

Rheology tests
Set-up - 67 % concentration

Port de Bregaillon
83502 La Seyne sur Mer cedex
Tel: 33 (0)4 94 10 97 40
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Folio	Scale	Number of drawing
	1/1	CIT-11-2-053-006
		CIT-11-2-053_Plan.dwg

REV	STAT	DATE	By	Ch.
0	Prel	01/07/2013	BQ	FP

Krypton target

Dimensions are given at millimeter model scale.

Citeph - Wave propagation in ice-covered seas

Floes

Océanide	Port de Bregaillon 83502 La Seyne sur Mer cedex Tel: 33 (0)4 94 10 97 40 http://www.oceanide.net	Folio	Scale 1/1	Number of drawing CIT-11-2-053-007 CIT-11-2-053-Plan.dwg	0	Prel	01/07/2013	BQ	FP
					REV	STAT	DATE	By	Ch.

OCEANIDE
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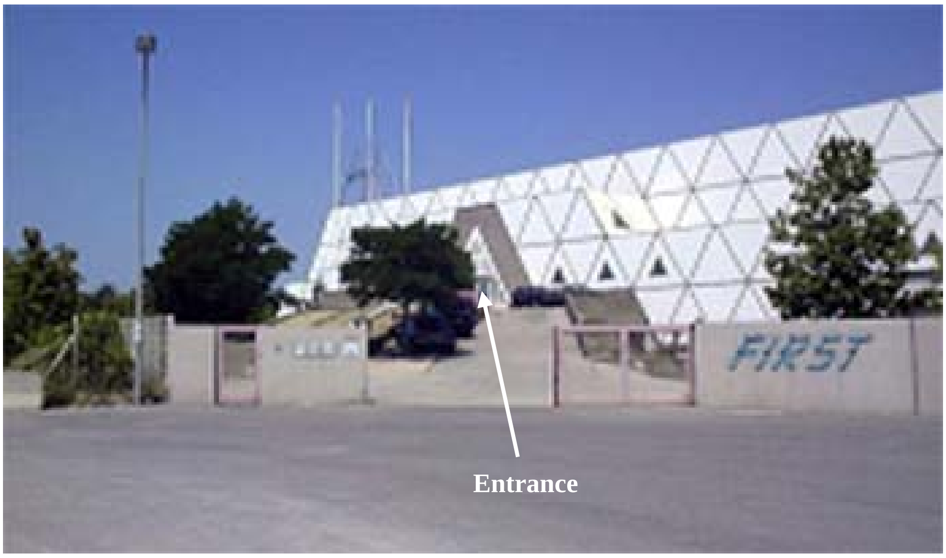
83 502, La Seyne sur Mer, Cedex
France

Tel : +33 (0)4 94 10 97 40
Email : contact@oceanide.net
Web : www.oceanide.net

Location

OCEANIDE is located in the city of La Seyne sur Mer (south of France), in the « zone portuaire de Brégaillon », along « avenue de la 1ère armée française Rhin et Danube ». The company is based in a large white building called FIRST, shown on photograph here-below. The entrance is at floor one, as shown hereunder.



FIRST building where OCEANIDE is located

Access map

Travelling to us by flight

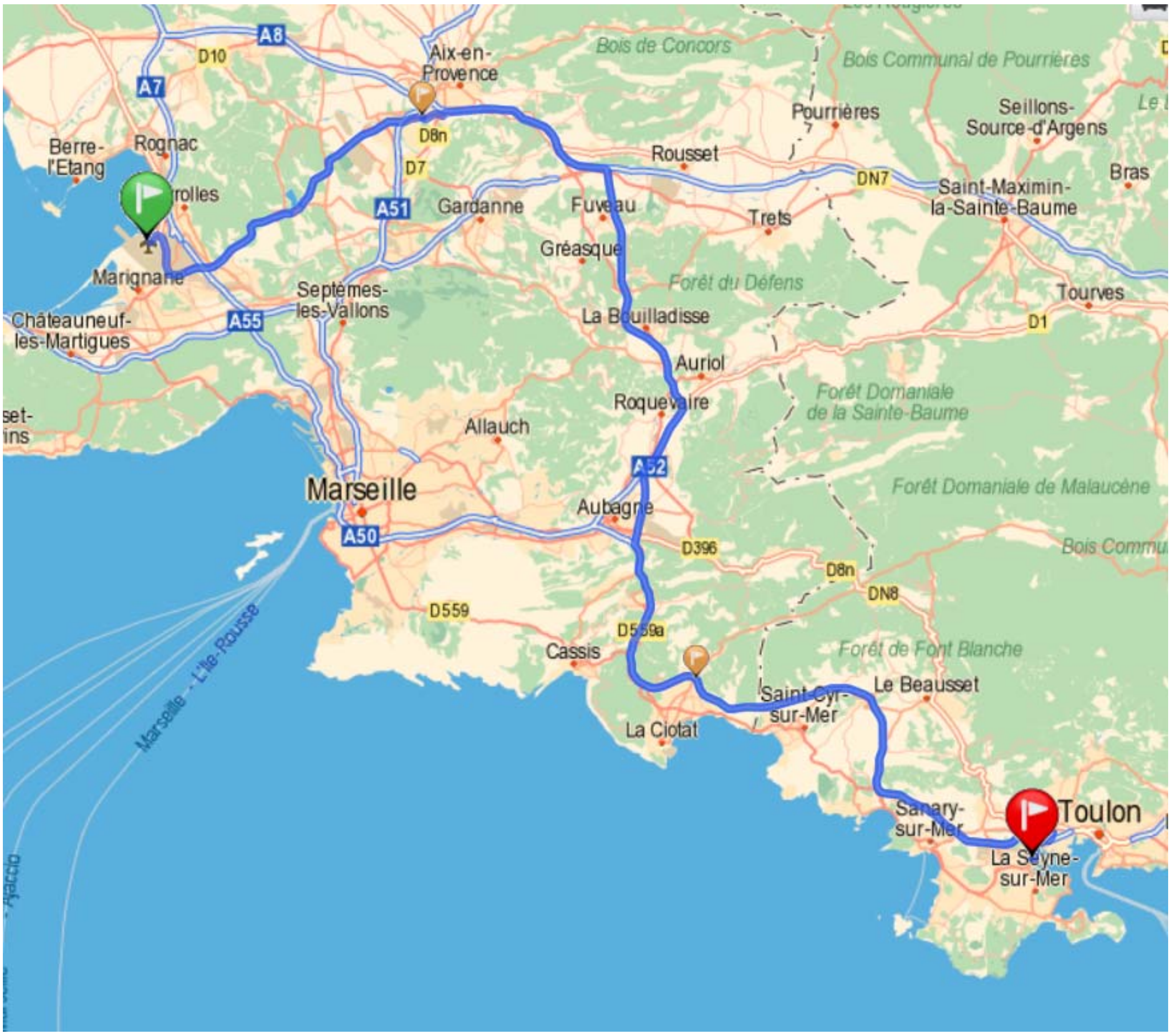
There is an airport in Toulon but with only a few flights. To come to us by flight, the best option is to land in Marseille airport called “Aeroport Marseille Provence” or “Marignane”.

From Marseille airport, there is a 1h20 drive, by highway only. The GPS will make you drive through Marseille tunnel but it may be closed (it sometimes closed for maintenance) or there may be a lot of traffic jam. Therefore, the best is to avoid Marseille by driving through Aix-En-Provence.

When exiting the airport, follow “Toutes directions”, then “Aix-En-Provence” (through D9 then highway A51), then “Aubagne” (through highway A8 then A52), then “Toulon” (through highway A50).

Exit the highway A50 at exit n°15 just before Toulon, and follow « Zone Industrielle de Brégaillon – La Seyne/mer ». The building will be on your left, after about a kilometer.

As an alternative, you can take a taxi. From Marseille airport to us, the taxi would ask for about 200 euros <u>in cash</u> (only a few are equipped with credit card payment).



Road map from Marseille airport (green flag) to OCEANIDE (red flag)

Coming from Marseille airport to La Seyne sur mer by train is possible but not easy at all as you would have to change of train in Marseille station. It is much easier and quicker to use a taxi or to rent a car.

It is also possible to land in Nice airport but it is a longer drive (about 1h45, if there is no traffic jam when crossing Toulon).

Travelling to us by train

Toulon is at 4 hours by train from Paris Gare de Lyon. We are at 15 minutes from Toulon train station by car (or taxi). There is also a train station in La Seyne sur mer that is closer to us but it may be difficult to find a taxi there and it would be difficult to find your way by walk, so please book a taxi in advance or call us.

Taxis

Note that taxis are usually requesting cash. Only a few are equipped with credit card payment.
"Les taxis seynois" : +33 (0)4 94 93 51 51

Hotels

The closest hotel is Kyriad hotel, located in La Seyne sur Mer harbour. By car, from the highway, just follow the same way than indicated here-above, down to the city centre.

You may go from the hotel to us by walk (about 20 minutes) but it is not a very nice walk so people usually prefer renting a car or using a taxi.

KYRIAD PRESTIGE LA SEYNE SUR MER ***
PORT DE LA SEYNE SUR MER
QUAI DU 19 MARS 1962
83 500 LA SEYNE SUR MER

Tel : 33 4 94 05 34 00
Email: toulon.laseynesurmer@kyriadprestige.fr
Web : www.kyriad.com/Hotel-La-Seyne-Mer

Kyriad hotel photograph

Road map from OCEANIDE (green flag) to Kyriad hotel (red flag)