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TCP 2

VERITAS Report No. 503080 - 54/1

Subject Group

Title of Report

DESIGN, FABRICATION AND INSTALLATION
RÉSUMÉ FOR
CONDEEP TCP 2 - CONCRETE STRUCTURE
FRIGG FIELD

Client/Sponsor of project

ELF AQUITAINE NORGE A/S

Work carried out by

Det norske Veritas

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TECHNICAL REPORT

VERITAS Report No. 503080 - 54/1	Subject Group
Date 1.12.1977	
Department IOD	Project No. 503080

Title of Report
DESIGN, FABRICATION AND INSTALLATION RÉSUMÉ FOR CONDEEP TCP 2 - CONCRETE STRUCTURE FRIGG FIELD

Approved by
[signature]

Client/Sponsor of project
ELF AQUITAINE NORGE A/S

Client/Sponsor ref.
H. Lye

Work carried out by
Bjørn Røland and N.E. Askheim

Reporters sign.
[signature]

TCP.7.

TASK 188.

IIS No. 2012 DO: in addition to main fouling, also some debris lying on the slab. Have to be removed prior to cleaning operations.

see video of Task 197, shift 3 & 5.

~~Shift. ct.~~

Some loose bolts on wire clamps.

CONTENT:

1. INTRODUCTION

The present DFI-resume for the concrete structure should be considered somewhat premature as the platform was resently installed at Frigg Field (June 1977) and as-built summary reports from Norwegian Contractors, the main contractor, related to the phases of design, fabrication and installation of the platform have not yet been issued and approved. However, the following data and information, as filed by DnV through control and inspection of all DFI-phases, are considered to be up to date and no changes or additions should be expected.

For the approval of the TCP 2 platform as fit for hydrocarbon production, DnV has been engaged as main consultant to Norwegian Petroleum Directorate for design control and inspection during fabrication inshore, offshore, during towing and installation at Frigg. This work has been carried out in accordance with "Scope of work for control and inspection of fixed offshore platform TCP 2 FRIGG FIELD on behalf of NPD" dated 14.1.1977.

With reference to the above "Scope of work" only one recommendation remains to be given by DnV for NPD-approval to be given as per today for TCP 2, namely:

7. Approval for platform to be taken into use of hydrocarbon production.

Based on results from DnV inspection of offshore works presently going on, such recommendation and approval will be given by DnV/NPD in 1978.

The aim of the DFI-resume for the concrete structure is to establish a basis for planning inservice inspection programs in order to:

- maintain the NPD-approval in the operation phase of the platform

- provide assurance to Elf that platform will perform safely in the operation phase

DFI-resumes for TCP 2 deck and gas riser pipes will be prepared separately by DnV.

2. DESIGN RESUME

2.1 General

Main dimensions of the concrete structure are shown in Fig. 1. The structure is designed, built and installed by Norwegian Contractors. Apart from the condensate storage tank in shaft 5, the platform is filled with water for ballast only and no plans are known for future hydrocarbon storage in the structure.

Construction period (Åndalsnes): January 1975 - June 1977
Towing to Frigg: June 1977
Positioning and installation at Frigg: 22.6.77
Underbase grouting: finished 6.7.77.

Position at Frigg Field site:

N: 59° 52' 48, 446"
E: 2° 3' 59, 536"

The orientation defined as a line with direction from cell no. 9 to cell no. 15 is 29° west of true north, refer to Fig. 2.

Positions of the risers are shown in Fig. 3. DFI for the risers will be worked out separately. Risers R1, R2 and R3 were successfully installed through tunnels T1, T2 and T3 shown in Fig. 4. Note that all risers are located inside shafts 3 and 5 in the splash zone.

2.2 Structural identification system

i) Foundation slab:

Points/areas on the cantilevered foundation slab identified in the general X-Y reference system given on Fig. 5.

ii) Outer caisson walls

An area on the outer surface of the outer cell walls may generally be identified by:

- cell number
- upper and lower boundaries given as absolute levels relative skirt tip elevation
- values of the coordinate a measured from the intersection between cells in anticlockwise direcition, see Fig. 5.

Example: CELL 10 - 40,50 - 10,20

Cell number N_1 N_2 S_1 S_2

iii) Star cells

S star cell is identified by the symbol ∇ and the number of the surrounding cells.

Example: ∇ 1-6-2

A starcell wall is defined in the same way
Example: W 1-6-2, means wall of cell 6 adjacent to cells 1 and 2.

iv) Upper domes

An area in the upper domes is generally identified by the symbol DOME, cell number and number of relevant sector, see Fig. 6.

Example: DOME 8-1 which defines the 60 degrees sector in cell no. 8 adjacent to cell no. 7 and no. 9.

The exact location on a dome could also be given by polar coordinates relative to the center of each dome and angle given clockwise as positive with reference axis corresponding with the x-axis in Fig. 6.

radius ——— angle
e.g. DOME 8-R 8.45-32°

v) Shafts

An area in the shafts is identified by the notation SHAFT number, upper and lower elevations and values of the distance S, see Fig. 7.

Example: SHAFT 3 - 80,90 - 10,20

2.3 Environmental data

Water depth = 102.20 m (LAT)

Design 100-year wave: Height = 29.0 m
Period = 16.0 sec

Operating wave: Height = 20.0 m
Period = 13.0 sec

In order to investigate the reduction in overturning moment on the caisson due to cantilevered slab, the design 100-year wave has been investigated for the periods: 14, 16, 18 and 20 secs. It has been shown that the total overturning moment on the platform is reduced 25 - 30 % due to presence of the cantilevered slab compared to the standard Condeep structure.

Storm current profile:

1.35	m/sec	at the water surface
0.70	"	30 m below water surface
0.30	"	at sea bottom

2.4 Loads

2.4.1 Environmental loads

Loads on structure due to waves have been calculated by Norwegian Contractors for different wave angles and phase angles (see reference system Fig. 8).

Loads due to wind and deck loads have been calculated by Kværner Engineering, responsible for design of deck.

Wave angle direction used in the static finite-element global analysis is $\delta = 120^{\circ}$. Forces from deck loads are conservatively considered to act in the same direction.

A summary of total loads is given in Table 2.4.1 and Table 2.4.2.

TABLE 2.4.1 TOTAL MOMENT AT MUDLINE (KNm)
$\delta = 120^{\circ}$

Type of loading \ Phase angle	280	300	320
Waves	6489000	7184220	7221170
Pipes	43130	99420	199280
Wind	718950	718950	718950
Deck load Live+dead	1096890	1096890	1096890
Dyn. ampl.	648900	718422	722117
SUM:	8.996.870	9.817.902	9.958.407

TABLE 2.4.2 TOTAL HORISONTAL FORCE AT MUDLINE (KN)
$\delta = 120^{\circ}$

Type of loading \ Phase angle	280	300	320
Waves	464530	431780	349130
Pipes	270	680	1550
Wind	6060	6060	6060
Deck load Live+dead	11570	11570	11570
Dyn. ampl.	46453	43178	34913
SUM:	528.883	493.268	403.223

Note that 10 % dynamic amplification of wave forces is accounted for in the above tables.

Model tests for TCP2 to verify calculated wave forces were not required as the correspondance between calculated and model test wave forces is well established by tests on the previous 4 Condeep Platforms.

2.4.2 Hydrostatic loads

Maximum external hydrostatic pressure on the structure occurs at submergence for deck mating and submergence for installation at Frigg Field site. Maximum net hydrostatic pressure = 102 T/m^2 and occurs during deck mating. However, for reasons given in 2.6.5 internal air pressure was introduced to limit maximum net hydrostatic pressure to approx. 60 T/m^2.

In platform operation phase the structure is subject to a permanent external hydrostatic overpressure = 25 T/m^2, a main feature of the Condeep Platform type. (See 2.6.5).

2.4.3 Other loads

Loads on structure due to collision with floating objects are assumed in accordance with DnV technical notes A 6/5 (see 2.6.1). Load due to shock pressure from braking waves on the columns are assumed in accordance with DnV technical note A 6/1 (see 2.6.1).

These loads are calculated by Ing. Grøner (NC's structural consultants) and are described in more detail in 2.6.5.

2.5 Foundation soils and seabed conditions

As consultants to Norwegian Contractors, Norwegian Geotechnical Insitute (NGI) is responsible for the geotechnical documentation. The documentation has been accepted by DnV.

2.5.1 Soil investigations

The thickness of top sand layer varies from 1.7 to 5.0 m, estimated average is 3.0 m. The sand is classified as fine the medium. The underlaying soils consist mainly of clay down to about 80 m. As seen from NGI-drawings Figs. 9 and 10 the stratigraphy is complex, and the following profile is an idealized approximation:

Depth	Soil type
0 - 3 m	sand
3 -11 m	clay (overconsolidated)
11 -20 m	sand
20 -80 m	clay silty
80 m -	sand

2.5.2 Design soil profiles

For stability calculations the assumed undrained shear strength profile is shown in Fig. 11. These values are strength prior to cyclic loading. For the upper clay layer the reduction in undrained shear strength has been taken as 20 % for the case that the strain developed by the cyclic loading has been $\pm$ 3 % (linear strength reduction in strain range 0 to $\pm$ 3 %). The top sand is assumed to have a relative density of 85 - 100 % and a friction angle equal to 38°. Unit weight of top sand is 1.0 t/m^3.

Assumed soil parameters for settlement calculations are shown in Fig. 12.

For penetration and contact pressure calculations the cone tip resistance in the upper sand layer is assumed in the design to be

Depth (m)	qc (t/m^2)
0	0
0.5	600
1.0	1100
1.75	1500
3.00	1500

For this analysis the angle of internal friction in to sand is assumed to be 40 - 43°.

2.5.3 Sea Floor conditions

According to bathymetric map rev. August 1975 from SCOP OCEANGRAPHIE the sea floor is sloping 1:100 (downwards) towards NNW as shown in Fig. 13.

From "Intersub Bathymetric Survey" local dive 20.3.75 the sea floor was assumed to be relatively flat, i.e. no significant local spotheights.

2.5.4 Geotechnical calculations

The geotechnical documentation is prepared by NGI according to summary list of documentation in Fig. 14. From calculations for platform operational phase the following is quoted from NGI:

Stability:

Minimum submerged weight of platform = 160.000 t
If one shaft (3 or 5) is emptied the reduction in min. subm. weight will be 20.000 t

Safety against sliding in upper day:

	Safety factor SF = τ_f/τ
Recommended design profile (Ref. Fig. 11)	1.91 (1.98)[x)]
Lower bound profile (Ref. Fig. 11) τ_f = 9.5 t/m² instead of 11 t/m² in top clay layer	1.60 (1.72)

Safety against sliding in top sand:

Platform submerged weight (t)	Average excess pressure assuming radial drainage	Factor of safety, sliding
160.000	3.2 t/m²	2.0 (2.4)[x]
140.000	4.4 t/m²	1.5 (2.1)
120.000	6.4 t/m²	0.9 (1.8)

x) Numbers in parantheses give calculated safety factors if excess pore water pressure due to cyclic loading was neglected.

It should be noted that the presence of circular skirts under the caisson cells and along the perphery of the cantilevered slab is not considered in the calculations leading to the above factors of safety. The skirts are built to ensure stability of platform during and just after installation. After grouting under platform is completed, the effect of skirts are not accounted for in stability calculations, and are then to be regarded as secondary structural elements. However, the integrity of the steel skirt along the cantilevered slab is considered desireable for confining and protecting the mass of grout mass inside that skirt.

It should also be noted that the above safety factors assume no seabed material to be removed by scouring. (see 2.5.6).

Settlement:

- Immidiate settlement (at application of load, also including consolidation settlements in sand)	: 8 cm
- Primary settlement (time dependent on dissipation of pore pressure 1 year after installation)	: 10 - 15 cm
- Secondary settlement (residual settlement in platform life 1 cm/year in 20 - 30 years)	: 20 - 30 cm

Total settlement : 38 - 53 cm

2.5.5 Drainage system (antliquefaction system)

During wave loading especially during storms the foundation soils below the platform may build up internal water pressures. As such pressures will reduce the capasity of the foundation, a drainage system has been installed on the skirts and dowels of the platform. NGI has designed the system and it is described in NGI-report 74810-1 dated 18.5.1977 "Antiliquefaction system operation manual". Location of wells is shown on Fig. 16. For operational details reference is made to the above NGI-report and to NGI's letter RKJ/Sob dated 20.9.1977 (Enclosure 1).

It should be noted that the flow of water from the drains does not necessarily express the efficiency of the anti-liquefaction system. The important parameter to be monitored is the pore water pressure build-up especially during storms. Such monitoring will be made primarily by deep and shallow pore pressure sensors (See par. 5) but may also be made by means of the drainage system (Refer to above NGI-report par. 4.4).

2.5.6 Scour Protection

Plans for installation of scour protection in the corridor between TP1 and TCP 2 in October 1977 have been submitted to DnV, termed phase 1 of scour protection. Elf has indicated that plans for a phase 2 scour protection around TP1 and TCP 2 will also be submitted. As per today it is reason to believe that the planned scour protection will not be installed until summer 1978. Problems with scour are certainly observed around TP1, and discussions are presently going on regarding conditions to be fullfilled if installation of scour protection in TP1 - TCP 2 area is postponed till summer 1978.

Scouring around TCP 2, especially in the area between TP1 and TCP 2, for inservice inspection both in the short and long term.

The plans for phase 1 scour protection, as given in Elf letter dated 19.9.77, are given in Enclosure 2.

2.5.7 Platform deck level

The determination of lowest level of platform deck is the result of environmental conditions, platform installation and geotechnical documentation. For TCP 2 the distance between tip of steel skirts and underside of lowest deckgirder is accepted:

Lat	102.5 m	
Uncertainty	0.5 m	
Penetration		
lower domes	0.5 m	
Settlements	0.4 m	
Wave crest	16.8 m	
Storm surge	0.6 m	
Extreme tide	1.7 m	
Caisson effect	2.5 m	
Air gap	1.5 m	
Subsidence	0.5 m	
Steel skirts (fig. 1)	1.7 m	
Extra uncertainties	0.5 m	
SUM	129.7 m	(i.e. el. + 129.70)

2.6 Structural analysis and design

2.6.1 Design Criteria

The structural design and construction of the concrete structure have been carried out to comply with the following criteria:

A. NORWEGIAN CONTRACTORS/ GRØNER — Elf-Norge A/S, Frigg-TCP2 Concrete Design Criteria dated 14.11.1974. (Enclosure 3)

These criteria are based on the Norwegian Standards:

NS 3473	Norwegian Code of Practice for design of concrete structures.
NS 3474	Norwegian Code of Practice for construction of concrete structures

B. ELF-NORGE A/S — Specifications for engineering, Procurement and construction of Frigg Treatment & Compression Platform no. 2 (TCP-2) June 1974.

C. DET NORSKE VERITAS — Concrete design criteria. Special requirements from DnV (28.11.1974) (Enclosure 4)

For DnV approval of TCP 2 concrete structure on behalf of NPD, it is assumed by DnV that where discrepancies exist between the specifications A and B and C, B is valid before A and C before A and B.

Special Design Criteria:

i) Guidance to the use of load factors for ULS-design as given in the above DnV-criteria is given in Minutes of meeting 8.4.1975 (Enclosure 5).

ii) In accordance with recommendation from DnV, NPD has accepted a deviation from NS 3473, par. 5.2.4 regarding shear capasity of concrete in sections subject to shear and axial tension. The principle set out in ACI Building Code (ACI 318-71) section 11.4.4 is accepted as basis for the deviation.

iii) The following criteria are accepted for Dywidag prestressing bolts (St 110/125) used for transition concrete shafts/steel deck:

a) Tensioning: Bolts to be overstressed to 85 % of yield strength without tightning nuts Then decrease force to75 % of yield at tightning of nuts. (i.e. 0.75 fy = locking stress) 2-3 minutes after unloading of jacks, tension bolts to 0.75 fy for retightning if necessary.

b) Operating condition (operational wave): Compression of the whole area between the steel-deck ringbeams and concrete shafts.

c) Extreme Condition (100-year wave), SLS: Maximum tensile stress in bolts = 0.7 fu or 0.8 fy.

d) Extreme Condition (100-year wave), ULS: same as c).

- chords? Pancages?
- Risers : in 1978 general visual survey of the conditions of risers, riser supports anodes and coatings

100 · 1.000.000

1.000.000

- cantilevered slab page 8

- $\frac{0,2 \times 10^{-2}}{48,25} = \frac{x}{127} \Rightarrow x = 127 \times \frac{0,2 \times 10^{-2}}{48,25}$

- paragraph 2-5-6 important
- page 21 → Dywidag bolts
- page 26 → areas of stress concentration
- page 31 → dernier paragraphe → star cells
- page 33 → base of shafts
- page 34 - Δθ between inside and outside of the walls.
- page 34 water level in pipes in upper domes of cells el 44,60
- page 37 anchorage of stress cables to be checked in shafts 3-5 when emptied for inspection of risers
- page 39 41 cathodic protection:
  ↘ cracking in concrete cover between steel deck and concrete
- page 42 dernier paragraphe.
- page 49 deck-shaft connection because of Dywidag bolts
- page 50 Construction joints
- page 51, 52, 53 points 1-2-3-4.
- page 53 3-7 Embedded steel plates

- Instrumentation page 58 - 59

- Imperfections in upper part of cell walls at elevation +42

It should be noted that in DnV's opinion the steel quality chosen for the Dywidag bolts is vuluerable to stress corrosion and brittle fracture and at the design stage DnV/NPD has accepted the bolts provided periodic inspection by Ultrasonics from the top is carried out. Refer to DnV-telex no. 7786 dated 11.5.1976 (Enclosure 6). Refer also to par. 3.1.5, ii.

- Elf has required the platform to be designed for the load combination "loss of hydrostatic underpressure + extraordinary environmental loads". A load factor of 1.05 on all loads is used in ULS and stress in reinforcement to be less than 260 N/mm^2.

  DnV/NPD has not required the platform to be designed for this load combination provided it is verified that PLS (progressive limit state) is not reached by such load combination. (Refer to DnV telex no. 871 dated 21.1.76 Enclosure 7).

iv) Impact loads on shafts:

The following DnV Technical Notes are used as loads criteria:

A 6/5 "Offshore platforms - impact loads from boats" (Enclosure 8)

A 6/1 "Gravity Structures - shock pressure on columns" (Enclosure 9)

2.6.2 Material Specifications

Concrete:

Class C45 (according to NS 3473/74)
28 - days cube strength = 45 N/mm^2

The concrete mixes in table 2.6.2. were proposed by Grøner-Noteby (consultants to Norwegian Contractors on materials and quality control) for the main parts of the structure. The proposed concrete mixes resulted from extensive testing on trial mixes to optimize the requirements of workability, strength and durability for the various structural parts.

TABLE 2.6.2. Concrete Mixes

Structural Part	Cement PC 300 DALEN kg/m^3	Sand (0-10 mm) Veblungsnes kg/m^3	Coarse Aggr. (10-25 mm) Ørlandet kg/m^3	Water L/m^3	Admiz-tures Betokem LP/P/L L/m^3	Slu-mp cm	Air cont %
Concr. skirts	460	800	980	185	6/2/-	10	
Lower domes	420	800	980	180	6/2/-	14	
Cell walls	480	880	880	190	3-6/-/-	8-12	
Upper domes, A	460	800	980	190	6/2/-	8-10	
B	480	790	970	195	6/2/-	10-14	
Shafts	480	790	970	190	1-3/-/0.1	8-10	4

Concrete specification requirements:

- air void content in splash zone : 4 - 6 %
- water/cement ratio :
  - submerged zone : ≤ 0.45
  - splash and atmospheric zone : ≤ 0.40

For additional requirements reference is made to "Elf-Norge A/S Frigg TCP 2 - Concrete specification Part II - Construction" dated February 1975.

Steel skirts:

Outer skirts : Rst - 42 - 2
Inner skirts : Rst - 37 - 2

Reinforcement:

KS 40 (Yield strength = 400 N/mm^2)

Prestressing steel:

FREYSSINET 12 T 15 post-tensioning system.
The 12T15 tendon is made up of 12 strands of 0.6" (15 mm) diameter. Each strand is made up of 7 wires of 5.1 mm diameter (Area of strand = 143 mm^2)

Yield strength of steel ($f_{0.2}$) = 1566 N/mm^2

Breaking strength of steel (f_u) = 1783 "

Post-tensioning anchorages:

Active anchorage Freyssinet type 12 TI5 (model 294)

Passive anchorage STUP type 12 T15 and 12 T15 A.
For Dywidag bolts used in deck/shaft connection, see 2.6.1.

Grout batch weight:

Cement : 100 kg

Water : 40 liter

Admixture : 1.5 % INTRAPLAST B or 1.5 % BETOKEM IN (B)

2.6.3 Static analysis

The detailed structural analysis is based on linear theory of elasticity using finite element models. The analysis results are used directly in design without considering redistribution of forces due to cracking of the concrete. Normally this approach will be on the conservative side with regard to design of reinforcement in areas with pronounced stress peaks.

Table 2.6.3 gives a summary of the main finite element models that has been used in structural analysis

TABLE 2.6.3

Finite element Model	FEM Program	Date of output listing	Main basis for design of
1: 1/12-sector analysis. Fig. 17	Seasam 69 NV 332 (A/S Computas)	24.6.75	Lower domes and start of cell walls. To be verified by globalanalysis.
2. Global analysis Fig. 18	Nastran (Control Data Sweden AB)	17.9.75	Caisson up to el. +16.31, in combination and as verification of 1/12-sector anal.
3. "	"	21.11.75 25.2.76 (control run)	Upper part of caisson in combination with ASKA - segment symmetrical nonsymmetrical and local analyses
4. Segmentsymmetrical analyses Fig. 19 x)	ASKA (IKOSS)	4.2.76	Base of shaft 1, upper domes and upper cell walls in combination with global analysis
5. Non-segment-symmetrical analysis Fig. 20	ASKA (IKOSS)	10.2.76	Base of shaft 3 and 5, upper domes and upper domes and upper cell walls in combination with global analysis
6. Shaft/deck frame analysis Fig. 21	Stardyne (Kværner)		Shafts, especially upper parts and transition to steel deck

x) The ASKA - analyses are based on input from the global analysis and the Kværner - analysis of shafts.

For main input description to the global analysis reference is made to the following documentation from Ing. Chr. F. Grøner A/S (structural consultants to Norwegian Contractors):

"Global analysis - load cases" revised 6.3.1975

"Global analysis - load combinations" revised 17.2.1976

The various analyses have revealed stress concentrations in the following areas:

- intersection cell walls/lower domes (el. +6.07)
- " " " /upper domes (el. +42.70)
- " between cells
- areas in upper domes adjacent to shafts
- base of shafts (el. + 45.52)
- top of shafts at transition to steel deck (el. + 129.70)

2.6.4 Dynamic Analysis

The dynamic analysis is carried out by Norwegian Contractors (Høyer-Ellefsen) and the main reference documentation is:

(1) STF 60 F 75043 "Report no. 5 - Dynamic Amplification factors" dated 16.4.1975.

(2) H-E report no. 7502 "Dynamic analysis of the Elf/Frigg TCP 2 platform" dated 1.8.1975.

(3) H-E report no. 7523 "Elf/Frigg TCP 2 Dynamic Analysis III" dated 26.9.1975

Report (1) was presented as documentation of dynamic amplification factors (DAF) to be used in the wave load input for the static global analysis. Only the DAF = 1.05 was accepted to be applied to the global forces at mudline.

Report (2) gives the results from an analysis on an improved model of the platform to calculate dynamic effects for

- the maximum wave loads
- fatigue analysis

Report (3) is an extension of Report 2 taking into account

- geometrical soil daming reduction by 50 %
- a lower and upper bound on the soil shear modulus for the shorter wave periods (near resonance)

From the analysis the first resonance period (lowest mode) is given below dependent on an upper and lower bound for soil shear modulus (G):

	$G = 2000\ t/m^2$	$G = 4000\ t/m^2$
First resonance period (secs)	2.9	2.16

Based on the above reports DnV has accepted the following DAF's for the various parts of the structure on the assumption that the most conservative factors are chosen for each of the G-values the calculations have been performed for, and that transient effects have been added for the design wave:

DAF	Wave period					
	2.16	4	6	8	11.2	14 x)
DAF shaft top	7.89	1.89	1.12	1.12	1.17	1.23
DAF shaft bottom	2.93	1.31	1.05	1.04	1.09	1.09
DAF mudline	-	-	-	-	-	1.05

x) 100-year design wave

These values used in the fatigue analysis for the structure.

The dynamic model and data used in Reports (2) and (3) are shown in Enclosure 10.

2.6.5 Design

2.6.5.1 Concrete cover to reinforcement:

	below el. +85.70	above el. 85.70
Minimum cover to ordinary reinforcement	7.5 ± 1.0 m	8.5 ± 1.0 m
Minimum cover to prestressing steel ducts	10 cm	10 cm

Construction Tolerances:

Reference is made to "Concrete construction tolerances" revised 9.5.1977 (Enclosure 11) submitted by Norwegian Contractors. This document was accepted by all parts as a standard for construction and to be accounted for in design.

Cell wall stability

The stability against buckling of the cell walls subject to external hydrostatic pressure has been checked by Ing. Grøner in accordance with NS 3473, section 5.5 assuming the critical number of buckling waves for the cylindrical shell n = 3. Consequently buckling lengths may be calculated. The check for stability is essentially a check of capasity in ULS showing that computed strength is larger than the sum of load effects. The load effects are:

i) Moments and forces from global analysis

ii) Moments from assumed imperfections (ref. to concrete construction tolerances above)

iii) Moments from structural deformations computed from the relationship between stress and strain in NS 3473 section 4.5.

DnV has carried out an independent analysis with FEM-program CONFRAME taking account of material non-linearities, 2nd order effects and true cracking development in reinforced concrete members.

Both analyses verify stability of cell walls at the planned maximum ext. hydrostatic pressure during deck mating and installation at Frigg (p_{max} = 102 T/m^2).

However, the max pressure was never attained, as internal air pressure was introduce to reduce the net pressure to about 60 T/m^2.

Internal air pressure

As mentioned in 2.5.3 the elastic FEM-models are normally a conservative basis for design. However, somewhat late in the platform design and construction DnV proved the design approach so far used for the transverse reinforcement between cells (see Fig. 22), based on the global analysis, to be in-adequate. By detailed FEM models it was shown that the transverse reinforcement provided would be stressed beyond yield when the platform was subject to maximum external hydrostatic pressure during deck mating and installation at Frigg. Emptying shaft 3 was also critical in this respect. The reason for this situation is the inadequate local modelling of the global analysis in this area to represent truly the effects of the "caisson-effect" being typical to the Caisson Structures. (The "caisson-effect" is simply the restriction put on the caisson

Norwegian Contractors and DnV shows stresses in cells to deform by the stiff membrans represented by lower and upper domes, which leads to considerable local tension at the location of the transverse reinforcement). Due to risk of excessive and uncontrolled cracking (indicated in Fig. 22), DnV laid down requirements in November, 1976 for limitation of the net water pressure during the critical operations. As the construction had progressed beyond any possibility of increasing the transverse reinforcement, the proposal of use of temporary internal air pressure as a remedy was made and accepted by all parts. The level of air pressurisation decided upon would reduce max net pressure from approx 102 T/m^2 to approx 60 T/m^2 in the caisson and is documented extensively by Norwegian Contractors. The pressurisation levels during deck mating, towing phase and installation phase are given in Figs. 24, 25 and 26 and was accepted by all parties.

Norwegian Contractors and DNV showed stresses in transverse reinforcement to be well within the elastic rauge during maximum loading phases, and also to fullfill SLS-criteria for allowable stress and crack widts in platform operation phase.

TV-inspection was made at Åndalsnes after completion of deck mating, and no cracks were detected in the star cells.

As this matter was somewhat controversial it is recommended that a moderate inservice inspection in the star cells is carried out. Levels of highest stresses in transverse reinforcement is el. + 10.00 to + 14.00.

Emptying of shafts 3 and 5

The platform is originally designed for the loadcase emptying shaft no. 3. With reference to similar problems during emptying as mentioned above regarding the transverse reinforcement, Elf required an internal concrete ring to be bilt inside shaft no. 3 (Fig. 26A).

The emptying of shaft 3 was accepted by DnV without the internal ring.

As shaft no 5 is designed to the same strength as shaft 3, DnV has also accepted emptying shaft no. 5 on the conditions given in our telex no. 101669 dated 28.10.77 (Enclosure 12).

The emptying of shaft 3 and 5 will be carried out to facilitate inspection on the risers and J-tubes located in the shafts.

Fatigue

For base of shafts fatigue calculations are carried out in accordance with criteria given in 2.6.1, mainly based on the method given in Elf/TNO - specification "Fatigue strength procedure for concrete offshore structures" report no. B-75-304/04.2.3043 dated 30.10.75.

The fatigue calculations for base of shafts show a low usage factor as represented by Minor's sum. The calculations include dynamic amplification of wave loads

Shaft 1 Minor's sum $\Sigma(\frac{n}{N})_1$ = 0.0005 (50-year period)

Shaft 3 Minor's sum $\Sigma(\frac{n}{N})_3$ = 0.0004 (50-year period)

Shaft 5 Minor's sum $\Sigma(\frac{n}{N})_5$ = 0.0008 (50-year period) n = number of waves (= $10^{8.7}$ in a 100-year period)

N = allowable number of waves according to fatigue calculations using Wöhler and Goodman diagrams for concrete.

The calculation show for the concrete section at base of shafts:

For operating wave load (SLS): compression over full section
For 100-year wave load (SLS): minor tension zones

The base of shafts, section pl. el. +45.52, is considered to be well designed, but as the structural performance of these areas of major importance of the integrity of the whole platform structure, they should be given special attention during inservice inspection.

Temperature in shafts:

A water cooling system in shafts no 3 and 5 has been designed in order to limit temperature loading effects on the structure due to heating of water in the shafts by the hot risers.

The cell/shaft walls of shafts no 3 and 5 are designed for a temperature gradient of 8°C, i.e temperature difference between inside and outside of shafts = 8°C.

The water cooling system is based on natural circulation of water through holes in shafts 3 and 5 shown in Fig. 27 and 28. To facilitate closing of holes for emtying of shafts, special valves are fitted to the sleeves on the inside of shafts, see Fig. 29.

The temperature difference (gradient) over the shaft/ cell walls in shafts 3 and 5 are to be checked during inservice inspection.

Underpressure in structure (draw-down):

A main feature of the Condeep structure is the underpressure in the whole structure except in shafts no. 3 and 5 where water level is equal to external sea water level. In TCP 2 the draw-down is 25.0 m and is controlled by the over flow system, simply one standpipe from each cell filled to el +80.00 and emptying freely into the annulus of shaft 1 at elevation +81.00 if water should rise in the pipes.

As shown in Fig. 30 the pipe inlets in the upper dome of cells is at el. +44.60 and top point inside dome is at el. +46.80. Consequently a compressed air cushion is trapped in top of dome with volume approx 44 m^3 under a pressure 35,4 T/m^2. As this air may dissolve in the water and escape through overflow pipes, reducing the water levels in overflow pipes and hence increasing the draw down, the waterlevel in these pipes should be checked during inservice inspection of the structure to ensure that itended draw-down is maintained.

Design for collision with floating objects and wave shock pressures

As mentioned in 2.4.3 and 2.6.1 DnV technical notes A 6/5 and A 6/1 are taken as criteria to calculate and design for these loads.

Collision:

i) Operational condition

Platform to be designed not to suffer any damage from collision.

Design criteria:

- boat with displacement = 2500 t
- boat speed = 0.5 m/sec.
- added mass: 40 % of boat displacement

Resulting load = 634 tons, for which the columns are designed in combination with other relevant loads, including loads from waves with max height = 3.0 m.
Motion energy taken up by boat = 90 % (calculated)
Motion energy taken up by shaft= 10 % (calculated)

ii) Accidental condition

Platform damage is accepted to an extent not leading to progressive collapse of platform.

Design criteria:

same as for operational, but with boat velocity = 1.5 m/sec.

Resulting calculated damage: hole in the shaft wall with diametrer approx. 1,5 m.

It is shown by calculations that a shaft with a hole diameter approx. 7.0 m still has capasity to withstand other external forces.

Motion energy taken by boat : 50 % (assumed)
Motion energy taken by shaft : 50 % (assumed)

Shock pressures:

Load from shock pressure due to braking waves has been calculated to approx. 623 tons, i.e. of the same magnitude as collision load (opeational phase).

Refer to Grøner's calculations:

Part XII C1 "Impact loads from boats. Shock pressure from waves" dated 29.4.76.

Part XII C2 "Impact loads: Accidental loads" dated 21.5.76.

Prestressing

Prestressing with materials described in 2.6.2 is used at the following locations:

i) Cantilevered slab (el. +3.00)

Prestress radially mainly to ensure required fixing of steel skirt at tip of slab.
Distance between cables = approx 50 cm.
Prestressing and live anchors at tip of slab.

ii) Intersection upper domes/cell walls (el. +43.00)

Prestress circumferentially by 5 cables anchored at anchor blocks on each cell and in the starcells as shown on Fig. 31.

iii) Condensate tank in shaft 5 (see Fig. 1)

Tankwall is prestressed vertically and circumferentially and dome is prestressed radially in order to fullfill the criteria of 0.5 N/mm^2 at the following pressure load:

Internal pressure head	: el. + 135.00 m
External pressure head	: el. + 90.00 m
Cables in dome	: STUP 12 Ø7
Cables in ring beam	: 12T 15
Cables (horis) in walls	: 12 Ø 7
Cables (vertically) in walls	: Steel type DJP 110 26 mm dia. bars

iv) <u>Shafts</u>

The shafts are prestressed vertically by 12 T 15 cables. All cables are anchored and stressed internally in the shafts at the following elevations:

Shafts		Elevations	
1	+35.00	+30.50	+26.50
3	+36.50	+32.00	+27.50
5	+33.50	+29.00	+24.00

The anchorage zones at these elevations are formed as continous rings inside shafts as shown in Fig. 32.

Condition of the anchorage zone should be check visually inside shafts 3 and 5 when these are emptied for inspection of risers.

Main purpose of vertical prestressing of shafts is to ensure section at base of

shafts (el. +45.52) to be in compression
for all wave loading in SLS (see 2.5.2)
Number of cables in section +45.52:

- Shafts 3 and 5: 186
- Shafts 1 : 120

The number of cables are terminated gradually by dead anchors in accordance with Figs. 33, 34, 35.

60 cables in each shaft is anchored at top of shafts (el. + 129.40) with "live" anchor blocks to facilitate stressing from top if necessary.

2.7 Corrosion Protection

Detailed evaluation of the corrosion protection design on the TCP 2 has been carried out on the riser system including J-tubes, supports, tunnel spools etc.
See separate DFI-resume.

2.7.1 Cathodic protection:

The main principles for corrosion protection is given in Secco "Note on Corrosion Control and Cathodic Protection System of the Steel Structure" of 15.5.75. A welded rebar system is installed for the purpose of electrical bonding as shown in Condeep drawings UC. 330-1745-00-011-012.

The concrete reinforcement is protected against corrosion by the concrete cover, and the prestressing system and bolt connection between deck and columns by grouting.

Calculations on the cathodic protection design critiria and sacrifical anodes for the steel skirt are also described in the above mentioned Secco note. The criteria used are:

Current density requirement for bare steel:

- in sea water	130 mA/m^3
- in mud on sea bed	30 "
- in grout	20 "
- in sound concrete	1 "

Electrical resistivity:

- in sea water	30 atm cm
- in mud on sea bed	150 "
- zinc anodes, U.S. mil. Spec. 18001 H	11,85 kg/A year
- anode lifetime	20 years
- anode utilization factor	80 %

The cathodic protection system is designed with extra anode capacity on steel skirt and connected pipelines for delivery of current to the concrete reinforcement.

During construction it was observed that some sacrifical anodes on built-in steel items were consumed to a much higher degree than expected according to the design calculations. New design calculations were carried out by Elf/Secco/Solus Schall and 500 kg's additional zinc anodes were installed externally on domes and internally in columns 3 and 5. See DFI-resume on the TCP 2 riser system.

2.7.2 Coatings

Specifications for coating of steel parts are

- Elf Standard Specification S.G. P 07 "Coating for Marine Structures", March 1975.
- Elf-Norge "Frigg Field Painting Specification for Steel Structures", March 1974.
- Elf-Norge "C.S.T.P. Coating Systems for Steel Structures of Phase II" D.E.P. 1052 No. 5 - 498, October, 1975.
- Kværner Engineering "Coating Specificatoins Ballast System TCP-2 Frigg Field", 8.3.1976.

Other coating specifications for items related to the riser system are listed in the riser DFI-resume.

Main items to be coated excluding the riser system are the steel deck and transition zone deck/concrete shafts sea water piping systems, pump casings, mooring system, platforms etc. internally in shafts, and temporary embedment plates.

Some coating on items in top of shafts and on deck remained to be finished when the TCP 2 left Åndalsnes.

The temporary embedment plates outside the shafts above elevation +85 m were decided to be coated, and plates inside the shafts above + 75 m for shaft 1, above +85 m or +95 m for shaft 3 and 5 and plates above + 75 m outside cell 20.
For coating of temporary embedment plates Betokem epoxy P2 was used.

2.7.3 Areas for inservice inspection

Special attention should be given to anode consumption and current distribution from additional sacrifical anodes during future potential measurements.

Observed cracking in concrete cover in transitional zone between steel deck and concrete should be given close attention in future inspection.

The point coating on items of importance structurally or regarding safety, especially an underside of steel deck, should be maintained in good standard.

Detailed evaluation of the sea water piping systems corrosion protection has not been carried out. A report on the as built situation has been requested.

The possibilities of internal corrosion in process piping and equipment on deck should be investigated in connection with such investigation on risers and pipelines on Frigg.

Concerning the possibities of corrosion on concrete reinforcement, attention should primarily be given to internal and external tidal/splash zones, great depths, cracks in concrete cover, embedment plates, and anchors for prestressing cables.

3. FABRICATION RESUME

3.1 Concrete quality

3.1.1 Materials data

Total volume of concrete	: 60.000 m^3
Total weight of reinforcement steel	; 13.500 tons
Total weight of prestressing steel	: 533 tons

From tests:

Modulus of concrete	: 3.77×10^4 N/mm^2
Poissons ratio	: 0.22

Air content in splash zone:

The air-void characteristics of the following concrete mix used in the shafts above el. +85.70 (splash zone) has been tested at NTH-Trondheim:

Shaft concrete mix:

Cement (PC 300 - Dalen)	: 480 kg/m^3
Sand (0 - 10 mm, Årdal)	: 790 kg/m^3
Course Aggreg. (10-25 mm, Ørlandet)	: 970 kg/m^3
Water (total)	: 192 L/m^3 (w/c = 0,4)
Betokem LP	: 1 L/m^3
Betokem L	: 0,1 L/m^3
Air content (fresh concrete)	: 4 %
Slump	: 12 cm

Microscopical examinations (ASTM - C457) at NTH of air-void characteristics of this concrete indicate very good air-void characteristics with a spacing factor of 0,17 and specific surface of 41 mm^{-1}.

A freeze-thaw test according to Fagerlunds method is also carried out and the results from this test reviewed in connection with air-void characteristics indicate a sufficient freeze - thaw resistance.

3.1.2 Concrete strength

The results of a statistical analysis of total production for compliance with criteria in NS 3473 and NS 3474 for different parts of the structure are given in the following table:

TABLE 3.1.1 CONCRETE QUALITY RESULTS

Part of structure	No of tests	Compressive Strength (mean) 10 cm cubes, N/mm²					Concrete grade
		3 days	7 days	28 days	56 days	90 days	
Concrete skirts	26	44.2 (3.0)	48.2 (2.3)	57.3 (2.2)	60.6 (2.2)	63.8 (2.3)	C54
Lower domes							
cell no. 19	23		45.5 (2.5)	54.5 (2.7)	58.0 (3.2)		C50
cell no. 9	21		48.3 (2.1)	55.5 (2.1)	59.6 (2.4)		C52
cell no. 17	20	42.2 (2.1)	48.4 (2.0)	56.9 (1.8)	61.2 (2.3)		C54
cell no. 8	21	43.7 (2.3)	47.9 (1.9)	56.4 (2.0)	60.0 (2.7)		C53
cell no. 18	17	41.0	47.6 (2.4)	54.9 (2.1)	59.1 (2.6)		C52
cell no. 7	12	43.1	48.1 (1.7)	55.6 (1.2)	60.1 (1.7)		C54
cell no. 6	12	44.0	47.8 (2.3)	56.5 (1.2)	58.4 (2.5)		C54
cell no. 2	13		49.8 (2.3)	58.4 (1.6)	62.6 (1.7)		C56
cell no. 3	13	44.9	49.6 (3.0)	58.4 (2.5)	62.5 (3.3)		C54
cell no. 1	21	46.3	52.3 (2.4)	60.8 (2.6)	65.3 (3.1)		C57
cell no. 10 & 11	36	43.0 (2.2)	51.2 (2.5)	60.4 (2.3)	(63.9) (2.5)		C57
cell no. 20	46		48.0 (2.5)	54.2 (2.3)	58.4 (3.4)		C51
cell no. 4 & 5	10	42.6	49.2 (2.7)	57.0 (2.5)	61.5 (2.4)		C53
cell no. 15 & 16	14	46.7	49.7 (2.1)	58.2 (1.0)	63.1 (1.3)		C56
cell no. 12	7	40.6	49.4 (3.3)	56.7 (0.8)	60.4 (1.3)		C55
cell no. 13 & 14	14	41.5	46.9 (2.8)	55.3 (2.7)	59.2 (3.0)		C51
cell walls to + 16.31	113		47.7 (1.7)	55.0 (2.0)	58.5 (1.9)		C52
cell walls + 16.31 to 42.70	140	44.9 (2.7)	50.1 (2.8)	57.0 (2.5)	60.1 (2.8)	62.6 (3.4)	C53
Upper domes	69		46.9 (3.2)	56.1 (3.3)	60.0 (3.6)	61.9 (4.2)	C51
Shafts 1&3&5	90		44.2 (3.3)	50.6 (2.9)	53.2 (4.0)	54.0	C46

Figures in brackets are the corresponding standard devuations. Detailed results from testing are given in Enclosure 13.

As can be seen from Table 3.1.1 the concrete quality has been uniform and compliance with strength criteria of C45 in accordance with NS 3473/NS 3474 is satisfactory.

Table 3.1.1 also gives indication of strength development and results from concrete skirts and cell walls between +16.31 and 42.70 are given in the following example of strength development:

Part of structure	no. of tests	n/28 (mean values)				
		3 days	7 days	28 days	56 days	90 days
Concr. skirts	26	0.77	0.84	1.0	1.06	1.11
cell walls	140	0.79	0.88	1.0	1.05	1.10

TABLE 3.1.2 CONCRETE STRENGTH DEVELOPMENT

In-situ strength

A limited number of cores have been taken from as-built structure to investigate the relationship between in-situ strength and the laboratory cured specimens subjected to idealized compaction and curing conditions. The cores were taken from the concrete skirts and the results are given in table 3.1.3.

Core no	Location	Size of specimen (cm)	Age	Compr. strength N/mm^2	Equivalent cube strength N/mm^2
1	skirt no. 16	10 x 13	28	38.6	42.5
2	skirt no. 16	10 x 18	28	42.2	47.3
3	skirt no. 17	10 x 18	28	37.4	41.9
4	skirt no. 15	10 x 70	31	41.9	48.2
5	skirt no.14/15	10 x 70	31	43.0	49.4
6	skirt no.14/15	10 x 70	31	41.4	47.6
7	skirt no. 14	10 x 70	31	40.0	46.0
			Mean	=	46.1

TABLE 3.1.3 STRENGTH OF DRILLED CORES

The above results satisfy the criteria for strength of drilled cores according to BS 1881 and NS 427, del 2, 3.5.

Gunite

Gunite (sprayed-on concrete) has been used extensively to seal off the anchor blocks after completion of prestressing, especially on the cantilevered slab. It has also been used for minor repairs on the structure.

Gunite composition:

Cement	(PC 300 - Dalen)
Sand 1:2	(0 - 10 mm - Veblungsnes)
Betokem HS	(2 - 1 % of cement weight)

water/cement = 0.4

Compressive strength of gunite: approx 40 N/mm^2

The porosity and permeability of the gunite has been measured on drilled cores by NTH - Trondheim. The tests indicates relatively high values of both porosity and permeability compared to that of high quality concrete. Consequently the areas where gunite has been used is sealed by Betokem Epoxy ML-1.

3.1.3 Concrete Constituent materials

Mixing water, corse and fine aggregates, cement and reinforcement have been checked regularly for compliance with standards and specifications.

3.1.4 Permeability

The permeability of concrete has been tested by NOTEBY, Oslo. The test procedure consisted of subjecting a 10 cm thick concrete specimen, cast in a truncated steel cone at the site, to one-sided water pressure. After the specimen was subjected to a pressure of 4.8 kp/cm^2 for 3 weeks the penetration of water into the concrete was measured to 1.0 cm, which indicates acceptable permeability characteristics.

3.1.5 Grouting of cable ducts

Grouting of cables has generally been carried out with the mix given in 2.6.2.

In the shafts the following mix was used (one batch):

100 kg cement
45 liter water
0.6 kg PCB 208 admixture

Grouting of prestressing ducts has been carried out in accordance with accepted plans and procedures, and result of grouting is expected to be satisfactory with the following exceptions:

i) Grouting of cables no. 23 a+b, 24 a+b, 25 a+b, 26 a+b and 27 a in condensate tank in shaft 5 are grouted with mix containing sea water by mistake. These cables are replaced by additional cables shown on Fig. 36.

ii) Grouting of a number of prestressing bars in the deck/shaft connection.

Reference is made to:

- Fig. 37 A, 37 B and 37 C showing deck/shaft connections.

- Accepted procedure for grouting of anchor bolts, Enclosure 14.

- Deck/shaft connection as made report, Enclosure 15.

- DnV telex no. 51067 dated 20.5.77, Enclosure 16.

Calculations submitted by the designer has shown that the 10 suspect cables described in Enclosure 15 can be omitted to verify strength and compliance with criteria for the deck/shaft connection.

Based on the above documents and the statement in 2.6.1 regarding the steel quality chosen for Dywidag bolts, special attention should be given to the deck/shaft connections in periodic inservice inspections.

3.2 Geometry and dimensions

The overall construction accuracy is generally good and within accepted tolerances agreed upon prior to construction.

3.3 Construction joints

The main horizontal construction joints are located at

(1) El. + 6.07 lower domes/cell walls

(2) El. + 16.31 cell walls

(3) El. + 42.70 cell walls/upper domes

(4) El. + 45.52 base of shafts

(5) El. + 126.90 transition shafts/shaft ring beams

(6) El. + 129.40 normal concrete/Rescon Nonset 120

(7) El. + 129.70 top of shaft ring beams, deck/shaft connection

The construction joints have been sandblasted. A 9" PVC waterstop type F has been placed in the middle of the concrete section for joints below sea level.

Other construction joints of importance are located at:

- top closures in upper domes (el. +47.55), Fig. 37D
- closure of temporary openings in shafts at el. + 48.25 (see Fig. 38).

3.4 Structural Repairs

Minor repairs:

Standard procedures & materials used for minor repairs are given in Enclosure 17. Minor repairs should not be given special attention during inservice inspection.

Epoxies:

Apart from the epoxies used for minor repairs (Enclosure 17) the following epoxies have been used on the structure for various repairs:

Epoxy	Used for
Betokem Epoxy P2	Coating of temporary steel embedment plates in shafts (Refer to par. 2.7)
Betokem Epoxy P1	Repair of grouting outlets of dead anchored cables in shafts (2 parts Epoxy P1 mixed with 1 part dry sand (0 - 1 mm) plus Sylodex)
Rescon L Epoxy	Repair of cracks in 30 cm grouting under steel deck rings
Betokem ML - 1	Seal on gunite etc.

Major repairs

The following major repair should be given special attention during in-service inspection:

i) Repair of imperfections in upper part of cell walls at elevation +42.00.

The extensive imperfections were shown to be slipform lifting cracks during unfortunate circumstances at completion of slipforming of cell walls between el. +16.31 and +42.70.

Reference is made to DnV-report 541090-A "Report on repair of imperfections in upper part of cell walls at elevation +42.00" dated 15.9.1976. This report is enclosed as Appendix 1 to the DFI.

ii) Repaired area on shaft 3 due to spalling

Location:

Elevation +76.00 to +78.50, S = 38 m (according to Fig. 7).

Repair procedure:

- cleaning of area to be repaired
- epoxy glue Betokem P1
- conventional casting with a rich concrete mix

iii) Repair of cracks in concrete under steel deck ring

Top of shafts between +129.40 to +129.70 were cast by grouting with the special mortar Rescon Nonset 120. Possibly due to temperature effects during curing cracks developed uniformly distributed around the shaft circumferences at distances 35 cm and with crack width 0.1 - 0.2 mm. The extent of cracking on the inside of shafts was less than on the outside, and only cracks on the outside were sealed with Betokem Epoxy Rescon L. Refer to NC's report in Enclosure 18.

iv) Repair of concrete around 51 sleeves in shaft 3.

To facilitate emtying shaft 3, the embedded steel sleeves were extended on the inside of shaft for installation of special valves. Concrete around sleeves had to be chiselled away and subsequently repaired.

Reference is made to Enclosure 19.

3.5 Coatings

Due to dense reinforcement and possibility of spalling a coating by Betokem Epoxy ML-1 was applied to cell walls between el. +6.07 and +7.30 on cells 8, 9, 17, 18, 19.

3.6 Areas of congested reinforcement

Except for the dense reinforcement mentioned in the above paragraph, no area on the structure is recorded that could be specified significant for in-service inspection due to congested reinforcement. The dense reinforcement above was due to unfortunate detailing of shear reinforcement and was improved on the remaining cells.

3.7 Embedded steel parts

A considerable number of steel parts are embedded in or fixed to the structure, mainly steel fixing plates for riser, pipe supports and for temporary use by the contractor for supporting cranes, hoists etc.

Apart from contributing to consumption of anodes, these plates represents weak links in the concrete cover to the reinforcement and should not be allowed to corrode. The design of corrosion protection of these plates is described in par. 2.7 and with the exception of the fixing plates for the risers the condition of the great number of fixing plates should be given general attention during inservice inspection. The condition of riser plates are to be examined more closely, and reference in this respect is made to the DFI-resume for the TCP 2 risers.

4. INSTALLATION RESUME

4.1 General

All platform operations including towing, positioning and penetration at Frigg site, grouting, all ballasting and release of internal air pressure have been surveyed by DnV representatives to ensure compliance with approved criteria, plans and procedures.

4.2 Installation and grouting

The platform was installed at Frigg Field site 22.6.1977 in accordance with approved plans and procedures. Penetration of dowels and skirts was accomplished with soil resistance as expected. The platform was stable during initial penetration, no horizontal movement occured and the maximum stress in dowels was recorded to 140 N/mm^2 (σ_F = 260 N/mm^2). The sea bottom slope was approx. 1:100 downwards towards north, and during penetration uneven platform ballasting was necessary to keep the platform vertical.

Stop penetration situation:

Number of domes in contact	: 11
Max earth pressure on dome	: 13, p = 194 T/m^2
Tilt of platform	: 0.1^{o}
Direction of tilt	: 194^{o} (towards north)

Max penetration of dome 15 = 50 cm

No significant deviations from approved procedures were observed during the penetration operation, and underbase grouting was started immidiately after stop of penetration. The grouting operation was carried out according to approved plans and no significant deviations were recorded. Relevant data from grouting operation:

Start grouting	:	June 25th at 21.55 hr
Stop grouting	:	July 5th at 05.15 hr
Hours used	:	223 hr 20 min
Expected grout volum	:	14090 m^3
Actual grout volum	:	13725 m^3
Average grouting rate	:	61.5 m^3/hr
Max. skirt pressure	:	9.3 T/m^2
Platform inclination start	:	X-direction - 0.098 deg Y-direction - 0.008 deg
Platform inclination stop	:	X-direction - 0.084 deg Y-direction - 0.021 deg

Grout quality control results:

	Fresh density kp/cm^2	Grout bleeding %	Density of cubes 28 days	Compressive strength 28 days N/mm^2
Mean:	1.30	1.5	1.33	1.46

Foundation behaviour during installation:

A submarine survey, witnessed by DnV, was made immidiately after stop penetration of platform, and no significant "blow-out" of foundation was recorded. The amount of transportation of sand during the critical phase of steel skirt penetration was less than expected and within the limits accepted in the Offshore Installation Manual (Norwegian Contractors, March 1977).

4.3 Structural aspects

From a structural point of view, the platform was safely installed. The operations of water ballasting and air-pressurization were carried out in accordance with approved procedures. The internal air-pressure was released July 1977 and after a temporary solution, the permanent overflow system was put into operation in November, 1977.

5. INSTRUMENTATION

To comply with NPD's regulations for collection and analysis of environmental and platform data (E- and P-data), Elf has installed the following instrumentation systems on TCP2. The aim of the instrumentation is, through a control of the design assumptions and platform behaviour, to be able to assess the safety of the structures and their foundation in the operation phase.

TCP instrumentation (Refer also to Fig. 39):

Shaft 1:

- 8 strain gauges at el. +48.00
- 8 strain gauges at el. 124.4
- Lastersystem to measure deflection of shaft
- 4 linear and 2 angular accelerometeres at el. +45.00
- 32 shock pressure sensors from el. +108.95 to el. + 116.46.

Deck level:

- One wave height radar

Domes:

- 7 earth pressure sensors on the lower domes of cells 6, 9, 11, 13, 15, 17.

- 9 strain gauges on lower domes of cells 8, 10, 11, 13, 14, 16, 17, 19, 6

Foundation:

- 8 shallow pore pressure sensors. 3 installed above bottom edge of steel skirt and 5 installed 0.5 below bottom edge of steel skirt

- System of measuring differential settlement and horizontal settlement

- 4 deep pore pressure sensors located in hole P2 under shaft 3. These instruments are positioned in four different levels between 8 - 30 m below the sea bed.

- Pressiometry instruments. These instruments are placed in hole P1 and P3 under shaft 3 and 5.

The instruments are designed by Syminex and installed by Syminex/Solmarine.

The data aquisition and reporting of processed data will be made monthly by Elf in accordance with NPD regulations.

The instrumentation should be considered as complimentary to the manual in-service inspection to ensure safe operation of the structure.

1.12.1977
RØ1/AHE

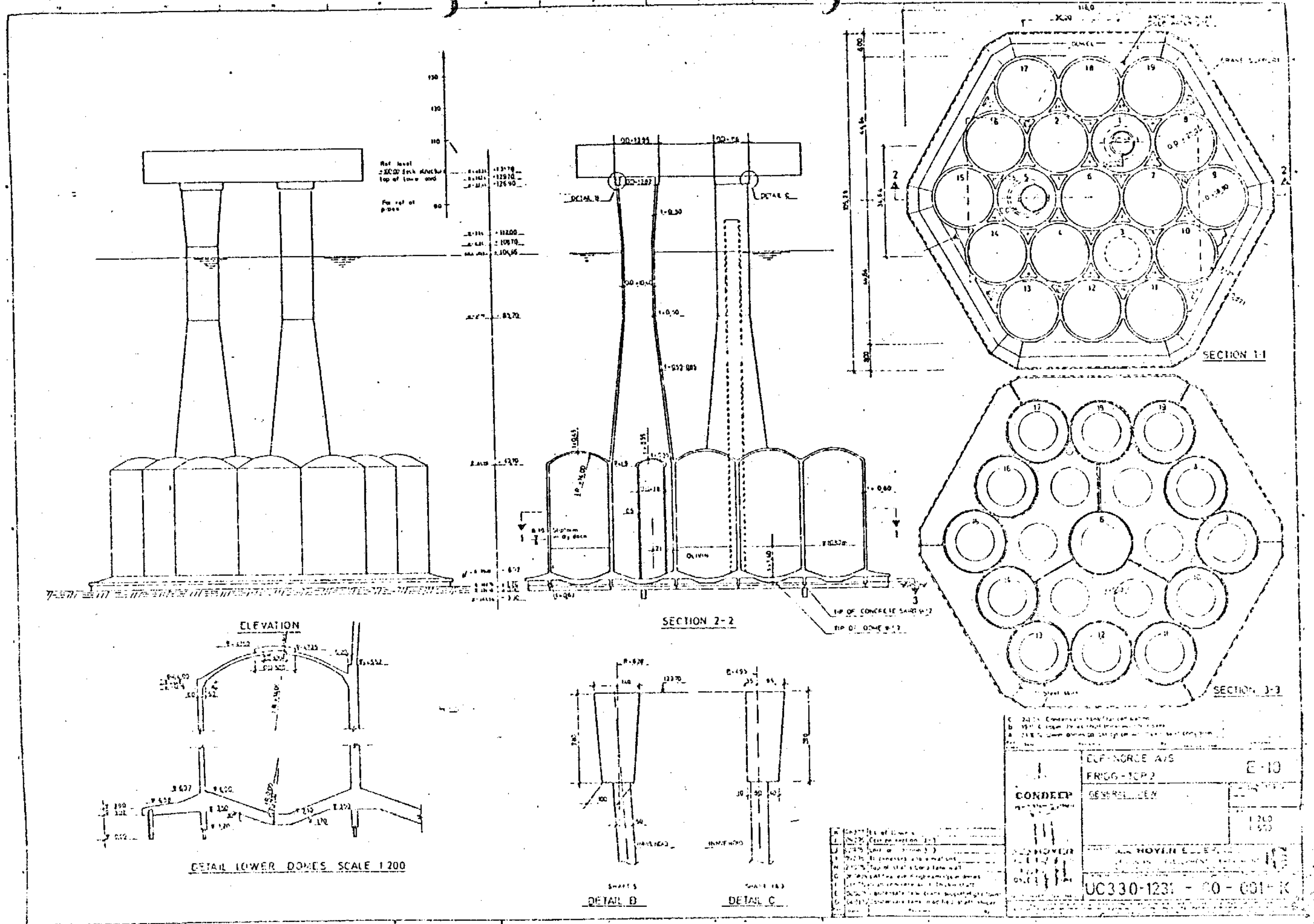
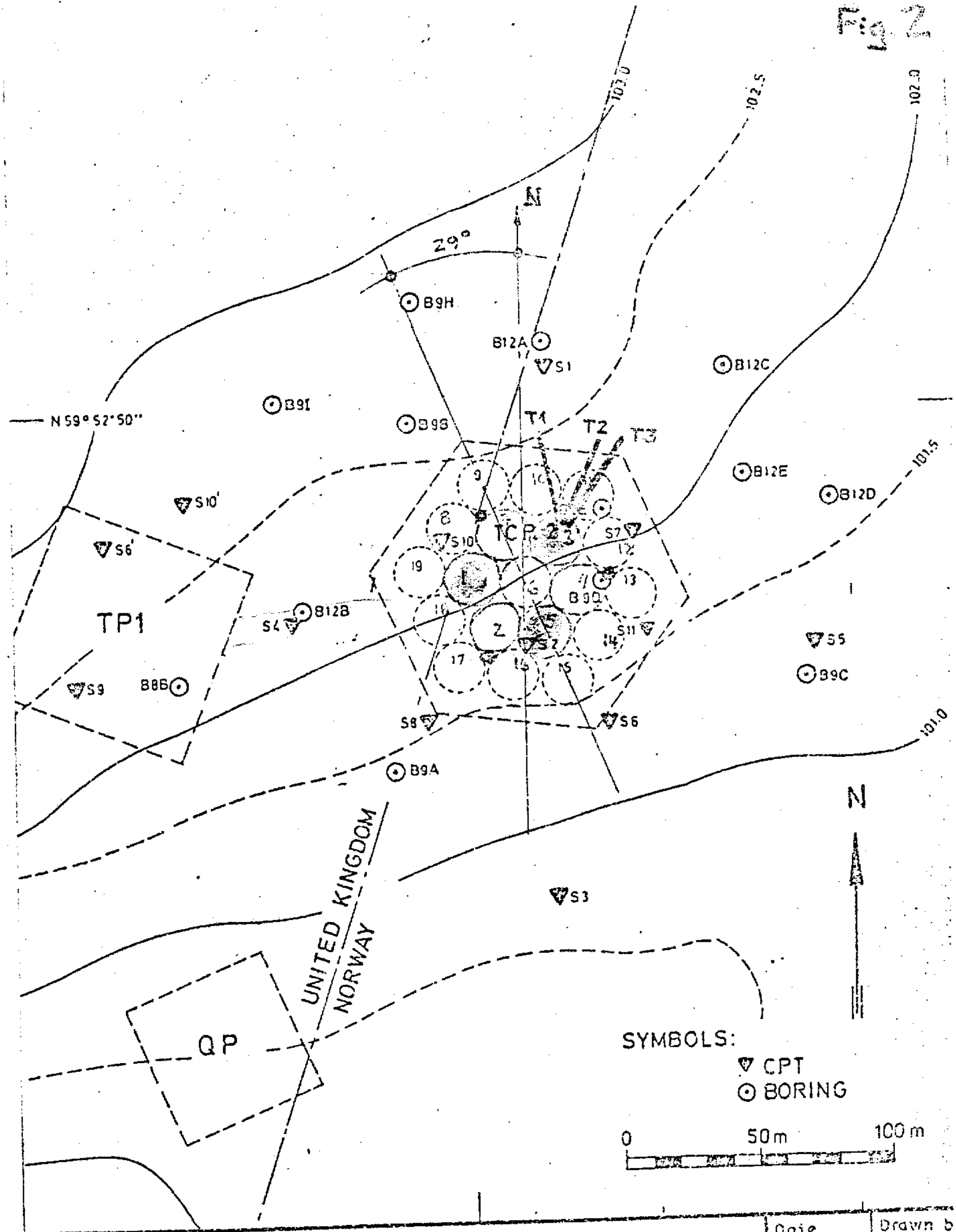
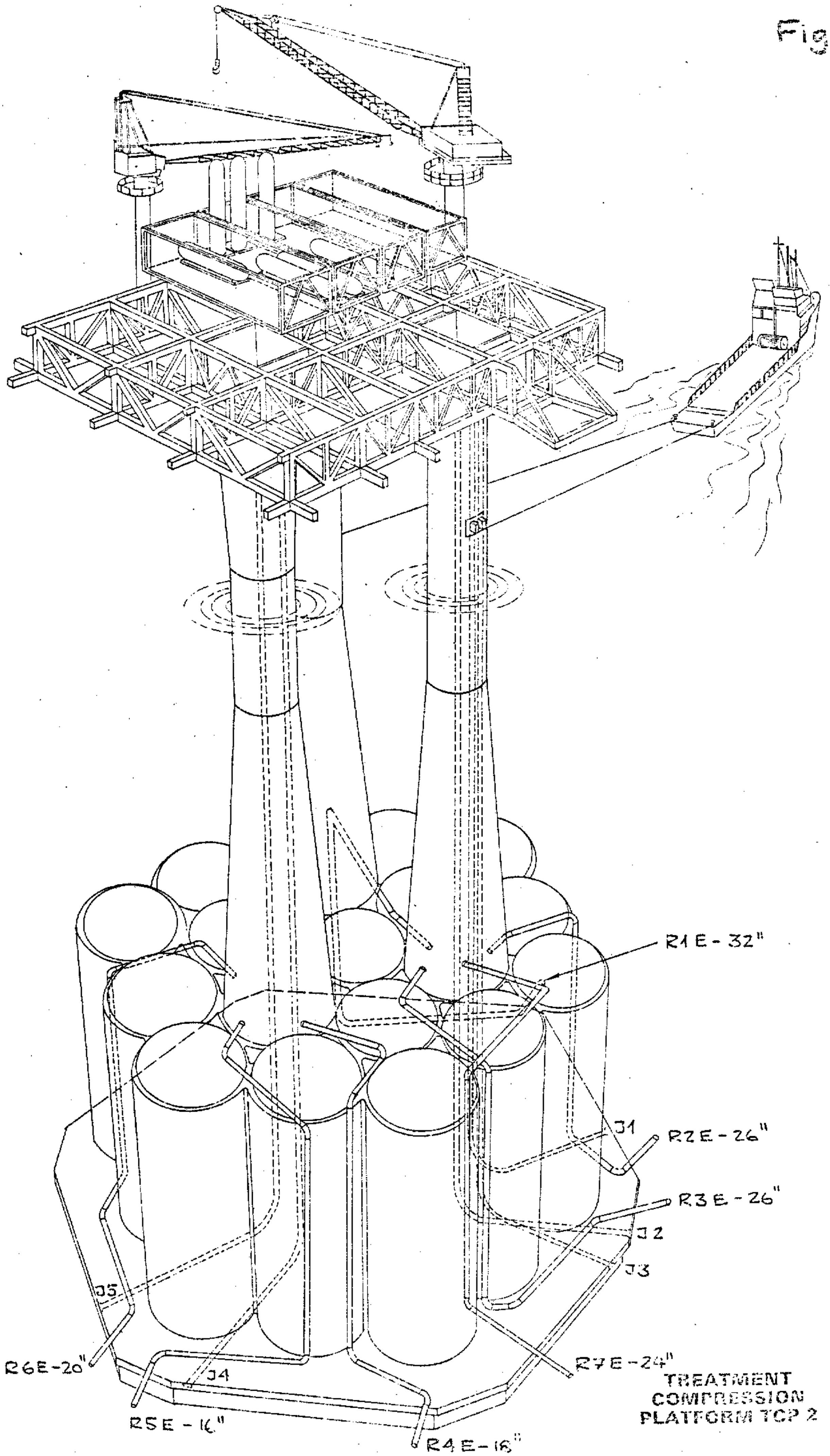

ELEVATION
SECTION 2-2
SECTION 1-1
SECTION 3-3
DETAIL LOWER DOMES SCALE 1:200
DETAIL B
DETAIL C
DETAIL B
DETAIL C
OLIVIN
CONDEEP
GENERAL VIEW
E-10
UC330-1231 - C0 - 001 - K

Fig. 2



FRIGG FIELD CONDEEP TCP2 PLATFORM	Date 28.1.77	Drawn b
SITE PLAN ALL DATA FORM refr. 6.	Approved	
	Project no. 73011	
Norwegian geotechnical institute	Drawing no. 50	

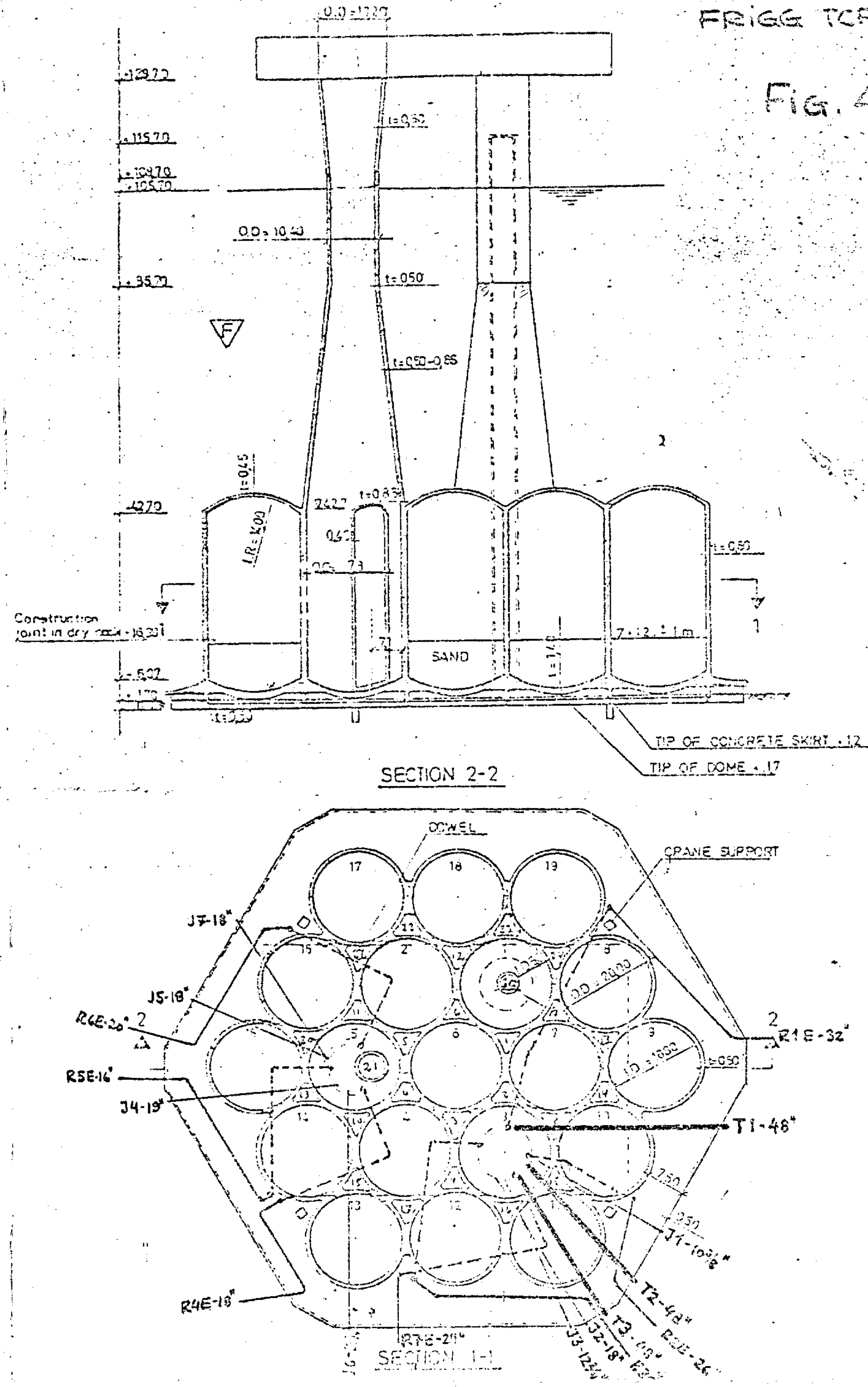
Fig. 3

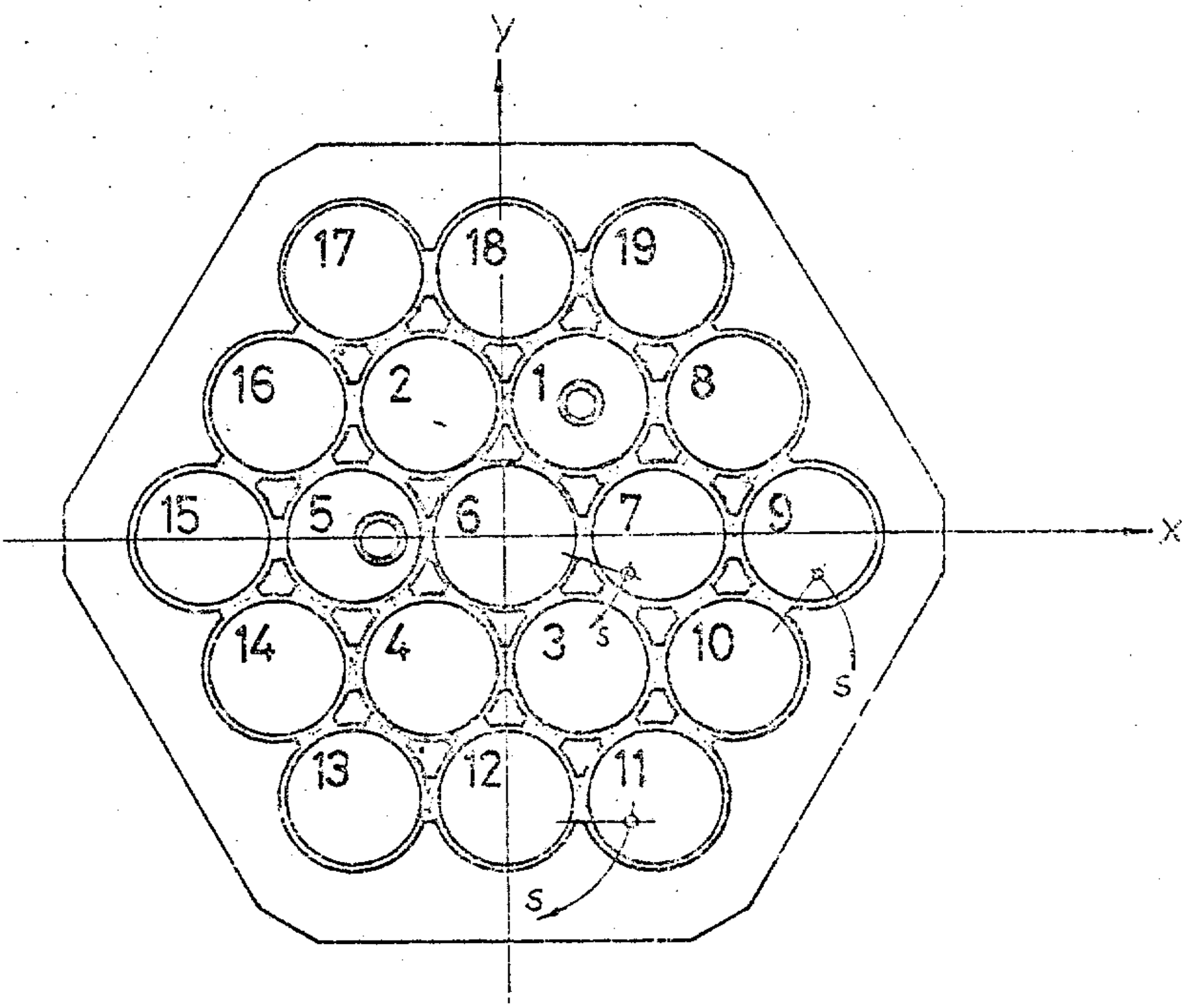


TREATMENT
COMPRESSION
PLATFORM TCP 2

CONDEEP
FRIGG TCP2

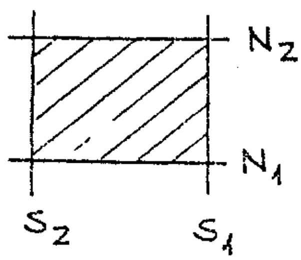
Fig. 4





Area on outer cell wall is defined by:

- CELL number
- Levels relative to tip of steel skirt (N_1, N_2)
- Distance S as shown (S_1, S_2) in meter



Area on inner walls (star cell walls) is defined in the same way.

Figure 5

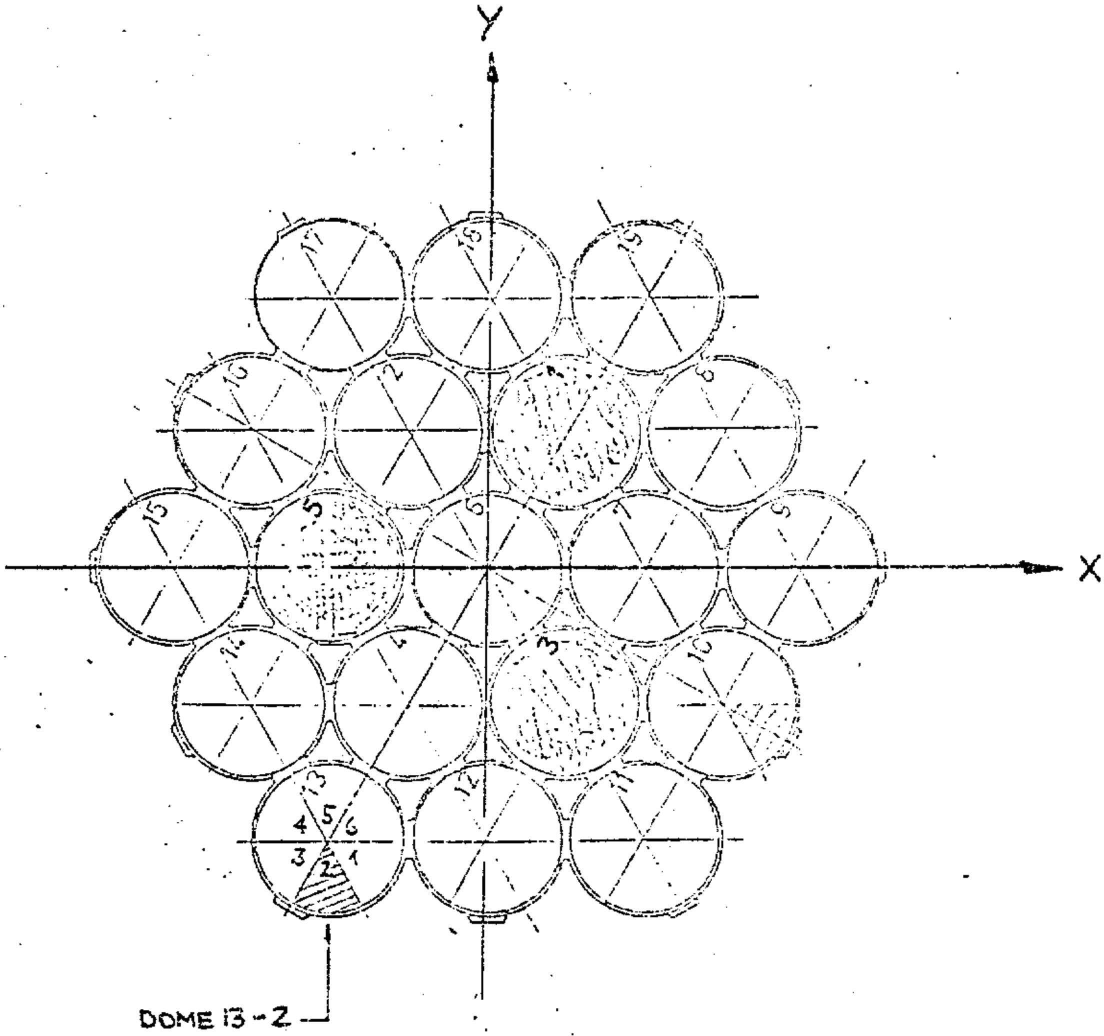
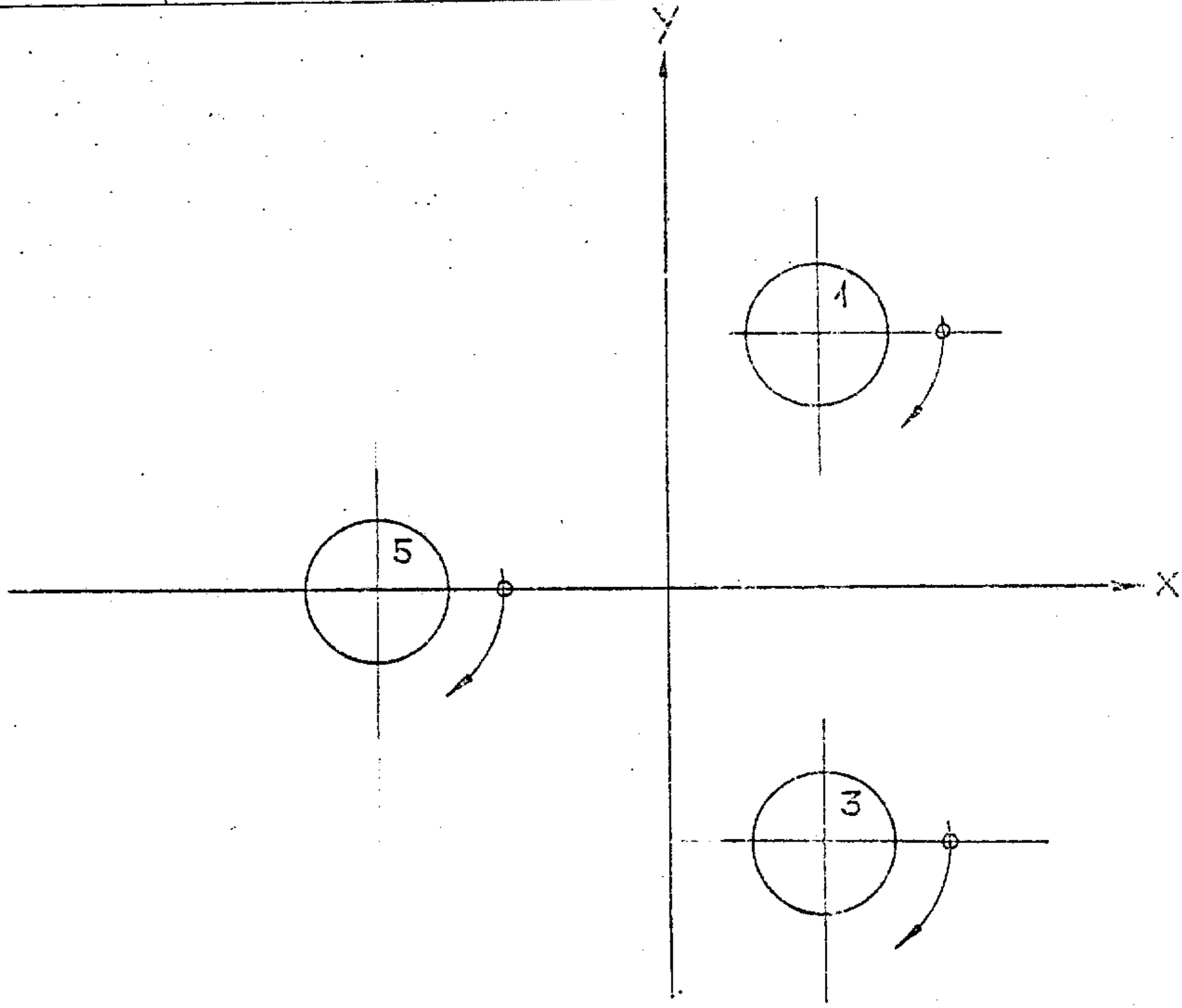


FIG. 6



Area on shaft walls (inside and outside) is defined by

- SHAFT number
- Levels relative to tip of steel skirt (N_1, N_2)
- Distance S as shown (S_1, S_2) in meter

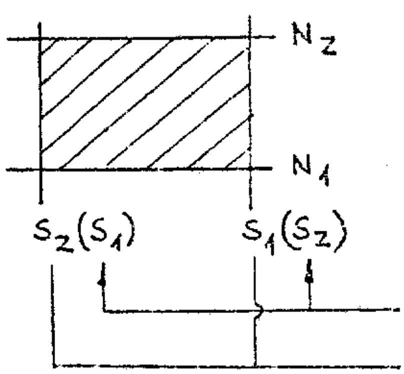


Figure 7

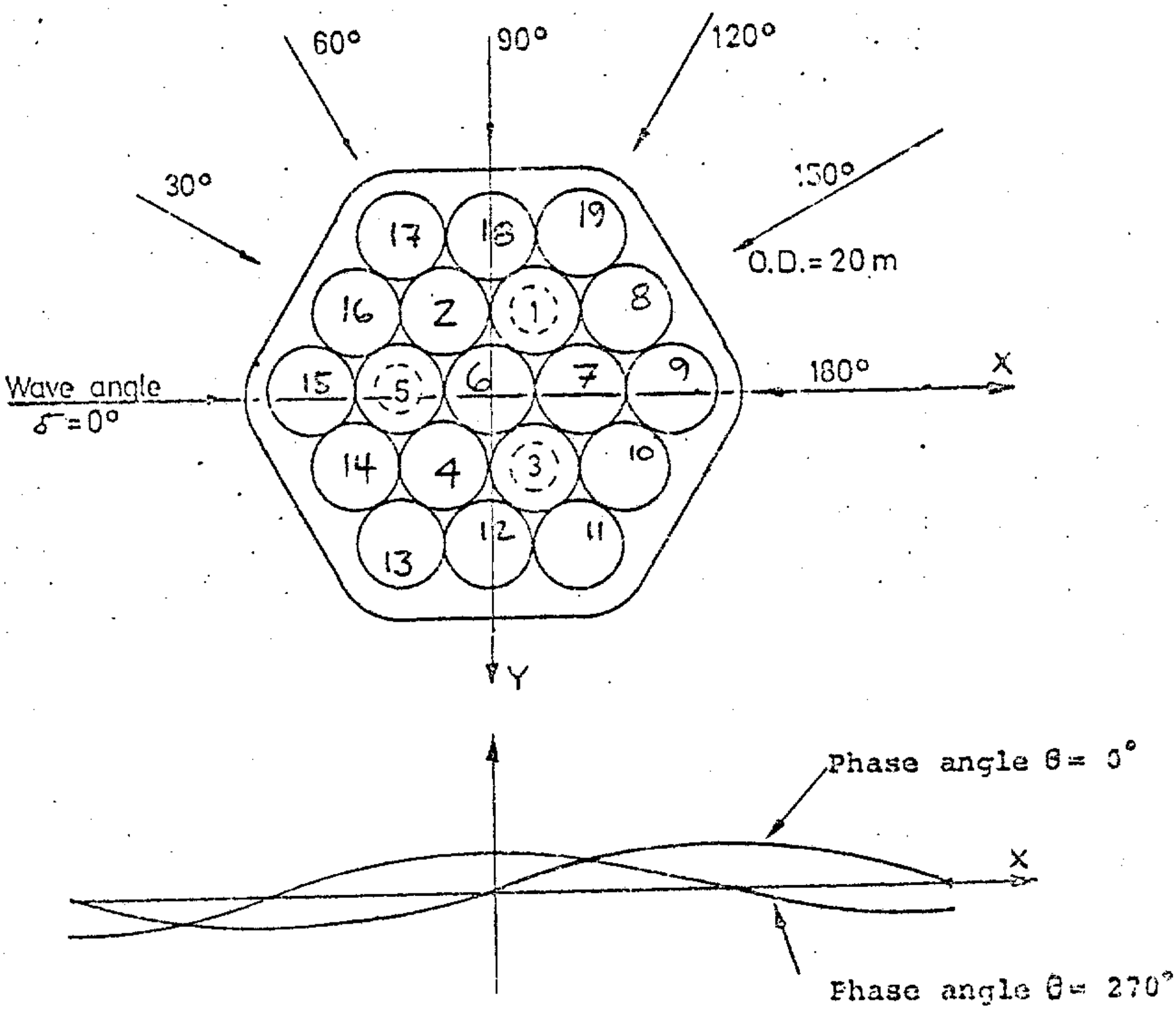


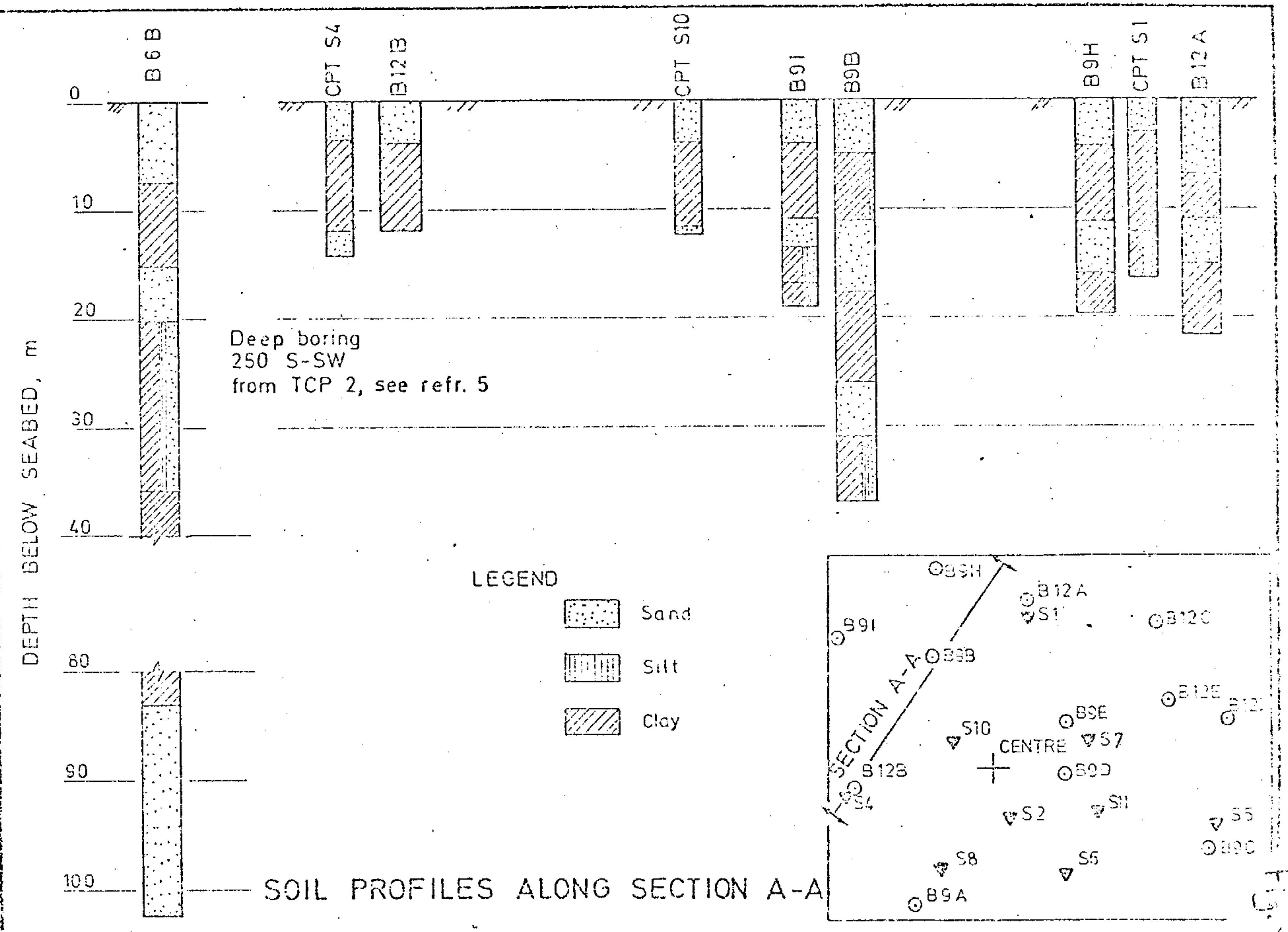
Fig. 8 Wave angles and phase angles

Norwegian geotechnical institute

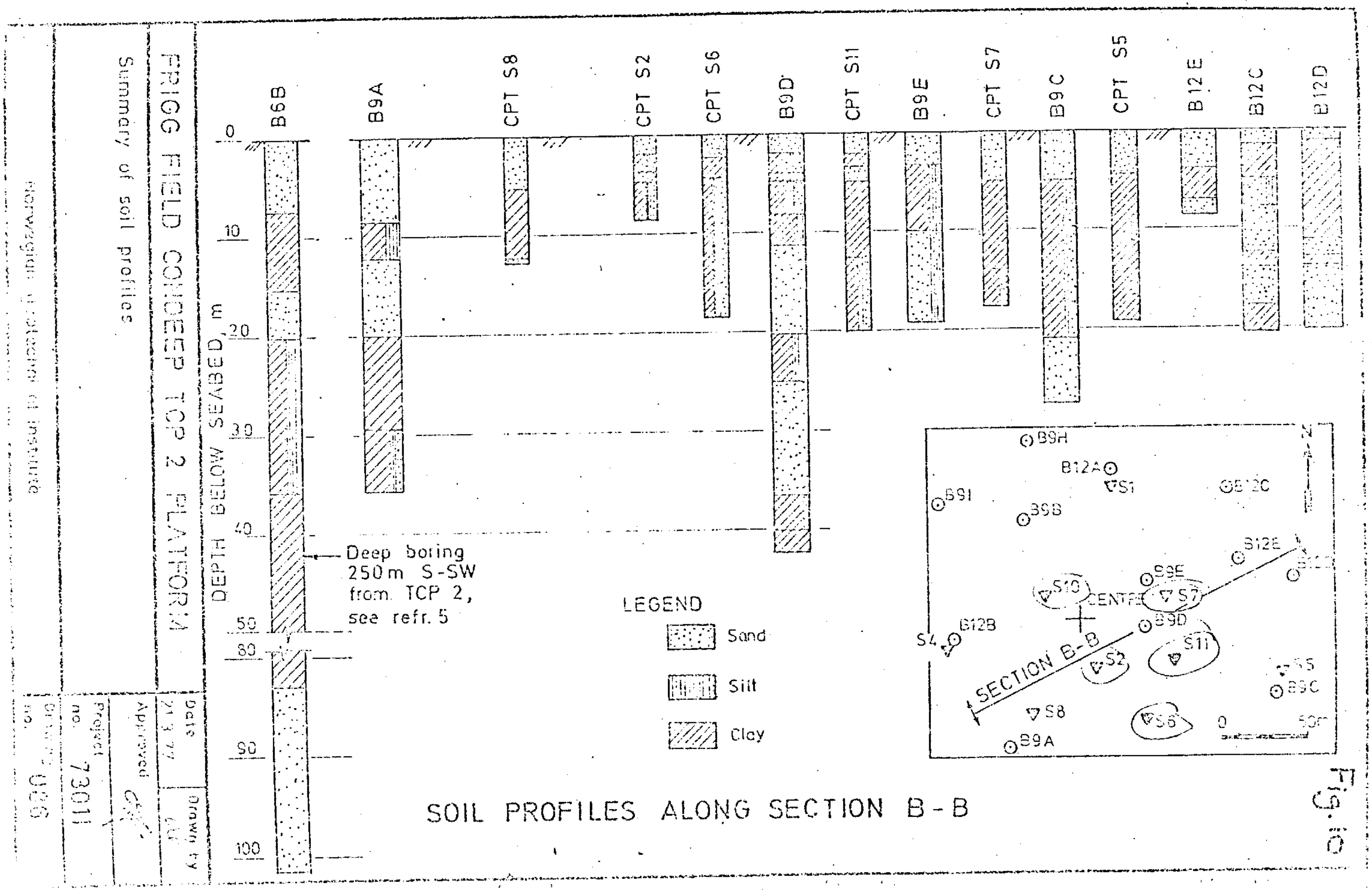
Summary of soil profiles

FRIGG FIELD CONDEEP TCP 2 PLATFORM

Date	Drawn by	Approved	Project no.	Drawing no.
21.3.77			73011	085



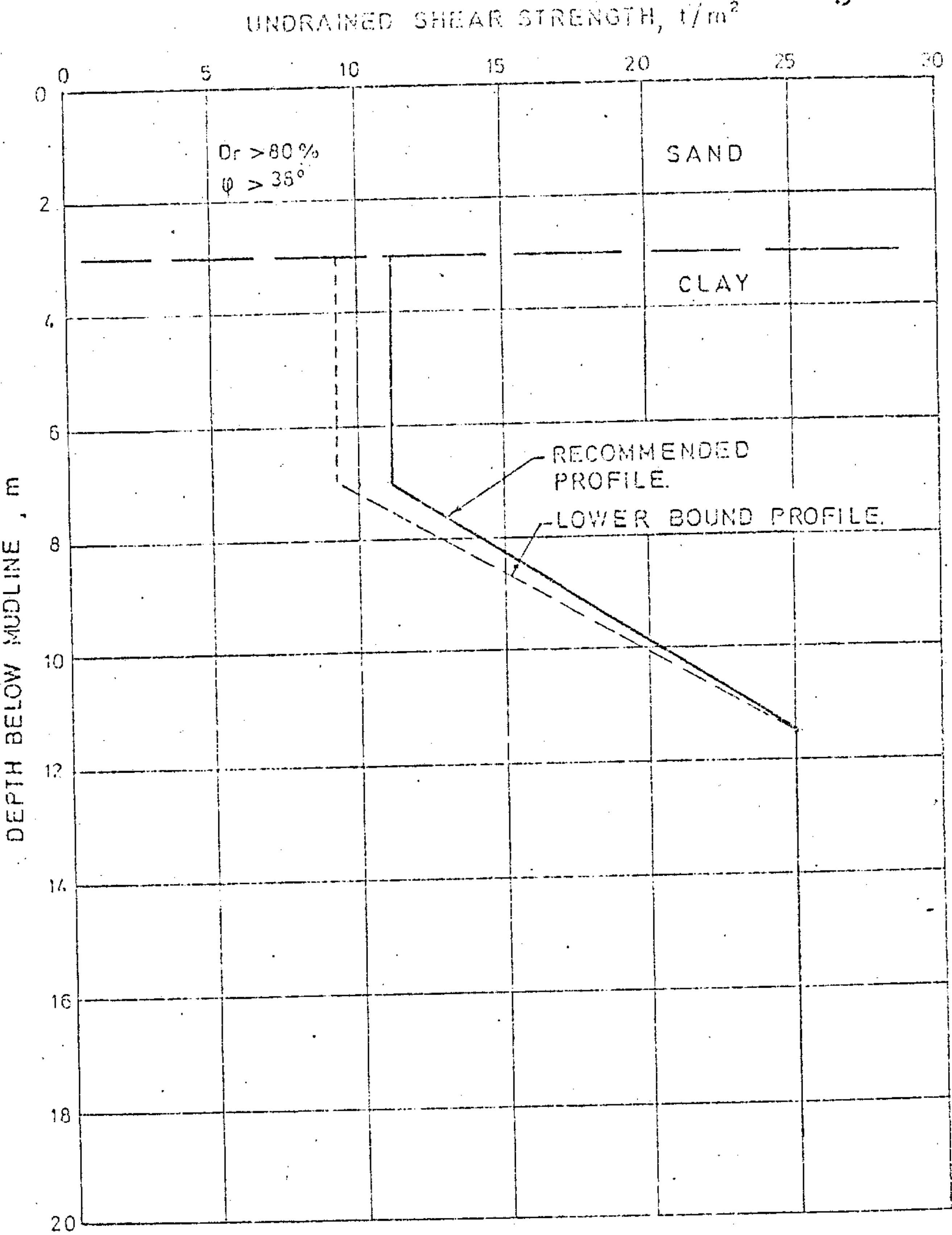
SOIL PROFILES ALONG SECTION A-A



SOIL PROFILES ALONG SECTION B - B

Fig. 10

Fig. 11



FRIGG FIELD CONDEEP TCP 2 PLATFORM

Design soil profile stability

Norwegian geotechnical institute

Date	23.2.77
Drawn by	
Approved	
Project no.	73011
Drawing no.	030

Fig. 12

SOIL PARAMETERS

DEPTH, m	SIGN	IDEALIZED SOIL PROFILE	UNDRAINED CONDITIONS	DRAINED CONDITIONS	
		SAND	$E = 700\sqrt{10\,\gamma' z}$, $\mu = 0.5$ $\gamma' = 1.1$	$M = 400\sqrt{p' \cdot 10}$	
10		CLAY	$E = 400\,\tau_f$ $\tau_f = 11 - 25\ t/m^2$ ref. drawing 047 $\mu = 0.5$	$E = 150\,\tau_f$ $\mu = 0.1$	$M = 5000\ t/m^2$ $C_v = 10\ m^2/year$
20		SAND	$E = 700\sqrt{10\,\gamma' z}$, $\mu = 0.5$ $\gamma' = 1.1$	$M = 400\sqrt{p' \cdot 10}$	
30		CLAY SILTY			
40 50 60 70 80		CLAY	$E = 400\,\tau_f$ $\tau_f = 30 - 50\ t/m^2$ $\mu = 0.5$	$E = 150\,\tau_f$ $\mu = 0.1$	$M = 9000\ t/m^2$ $C_v = 10\ m^2/year$
		SAND	$E = 700\sqrt{10\,\gamma' z}$ $\mu = 0.5$ $\gamma' = 1.1$	$M = 400\sqrt{p' \cdot 10}$	

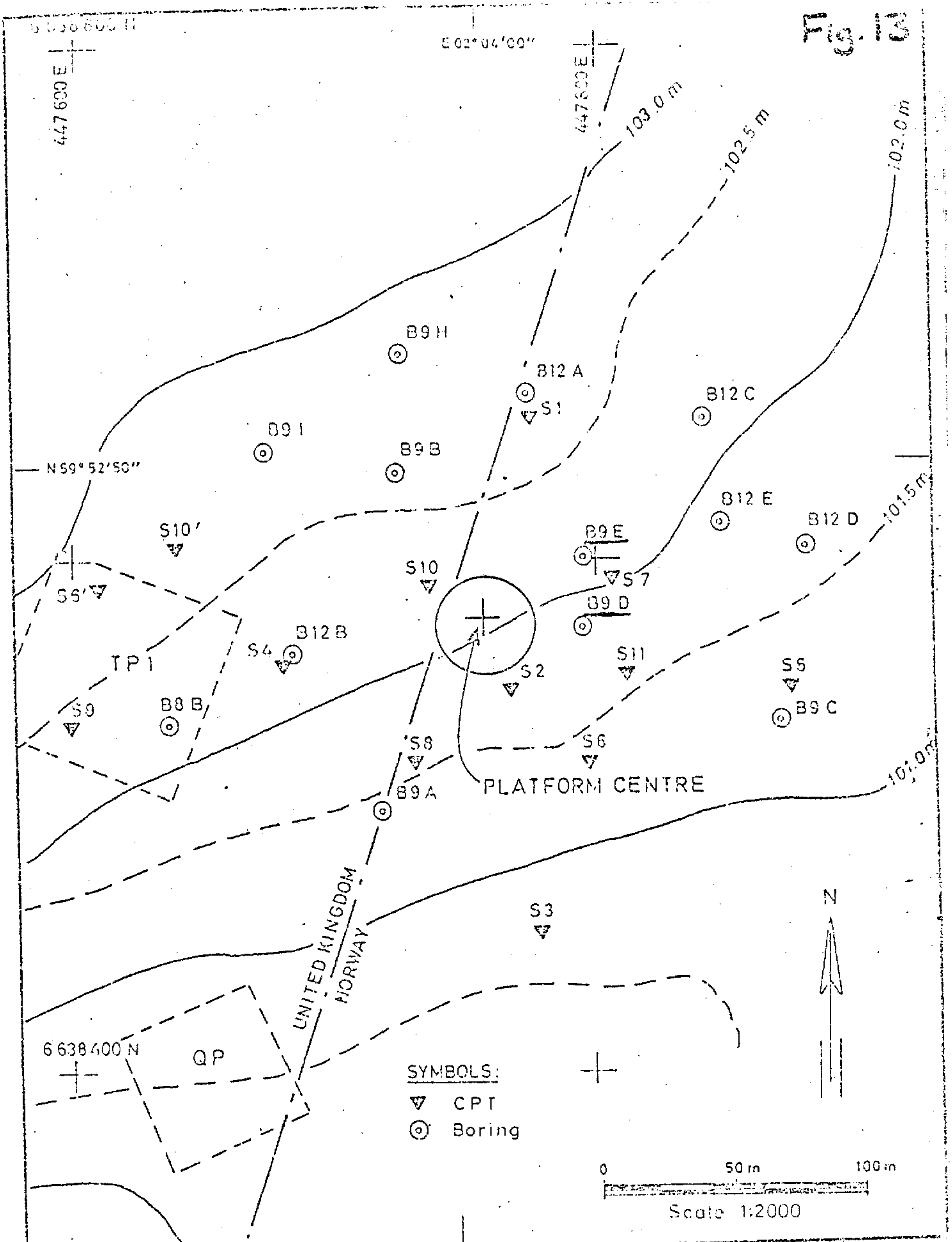
FRIGG FIELD CONDEEP TCP 2 PLATFORM

ASSUMED SOIL PARAMETERS FOR SETTLEMENT CALCULATIONS

Norwegian geotechnical institute

Date	24.11.75
Drawn by	[illegible]
Approved	[illegible]
Project no.	73011
Drawing no.	091

Fig. 13



FRIGG FIELD CONDEEP TCP 2 PLATFORM	Date 21.3.77	Drawn by
Site plan, location of borings and CPT's	Approved	
	Project no. 73011	
Norwegian geotechnical institute	Drawing no. 000	

Fig. 1?

Norges geotekniske institutt NGI

Geotechnical Documentation

Project: ELF-NORGE A/S, FRIGG FIELD, TCP2 PLATFORM

Date	Section	Title	Replaced Date
Aug. 30 -74	14. Miscel-laneous	Geotechnical Study of Modified Project	
Sep. 10 -74	7. Contact stresses	Preliminary Calculations of Contact Pressures on Bottom Domes	
Nov. 11 -74	6. Dowels	Maximum and Minimum Forces on one Dowel	Apr. 10 -75
Nov. 14 -74	7. Contact stresses	Contact Forces and Pressures on Bottom Domes	
Nov. 25 -74	9. Displace-ments	Displacement of Platform	
Nov. 25 -74	12. Drainage system	Calculations for Design of Anti-liquefaction System	
Dec. 10 -74	5. Skirts	Horizontal Stresses on Skirts	
Dec. 12 -74	5. Skirts	Design Loads for Concrete Skirts	
Jan. 29 -75	7. Contact stresses	Soil Reactions for Global Finite Element Analysis	Feb. 6 -75
Feb. 6 -75	7. Contact stresses	Soil Reactions for Global Finite Element Analysis	
Apr. 10 -75	6. Dowels	Maximum and Minimum Forces acting on one Dowel	
May 27 -75	5. Skirts	Horizontal Stresses on Skirts in Case of Drilling Mud on Sea Floor	
June 2 -75	7. Contact stresses	Effect of Non-Rigid Cantilevered Slab	
July 2 -75	7. Contact stresses	Contact Stresses on the Cantilevered Slab	
Aug. 14 -75	7. Contact stresses	Distribution of Shear Stresses beneath the Base	

Norges geotekniske institutt NGI

Geotechnical Documentation

Project: ELF-NORGE A/S, FRIGG FIELD, TCP2 PLATFORM

Date	Section	Title	Replaced Date
Nov. 28 -75	8. Settlements	Settlement Calculations	
Jan. 26 -77	5. Skirts	Penetration Resistance on Skirts and Domes	
Feb. 5 -77	14. Miscellaneous	Removal of Ballast Water in Shaft 3 prior to Grouting	
Feb. 20 -77	4. Stability	Review of Design Soil Profile for Stability Analysis	
Feb. 25 -77	4. Stability	Stability Analysis Permanent Conditions	
Mar. 9 -77	4. Stability	Stability Analysis Summer Storm Conditions	June 2, 1977
Mar. 11 -77	5. Skirts	Allowable Excess Water Pressure and Suction in Skirt Compartments	June 2, 1977
Mar. 17 -77	5. Skirts	Horizontal Skirt Capacities and Skirt Water Pressure during the Skirt Penetration Phase	
Mar. 21 -77	2. Soil and Sea Floor	Platform Site (prepared for the Installation Offshore Manual)	
Mar.30 -77	14. Miscellaneous	Water Level in Shaft 3 during the Installation Phase	
Apr.14	8 and 9. Settlements and Displacements	Review of Previously Calculated Displacements and Settlements	
Apr.21 -77	5. Skirts	Recommended Grout Pressure during Grouting Phase	
Apr.22 -77	2, Contact stresses	Review of Soil Properties Assumed for Previously Calculated Contact Pressures	
Apr.26 -77	2. Soil and Sea Floor	Summary of Soil Conditions at the Frigg TCP2 Site	

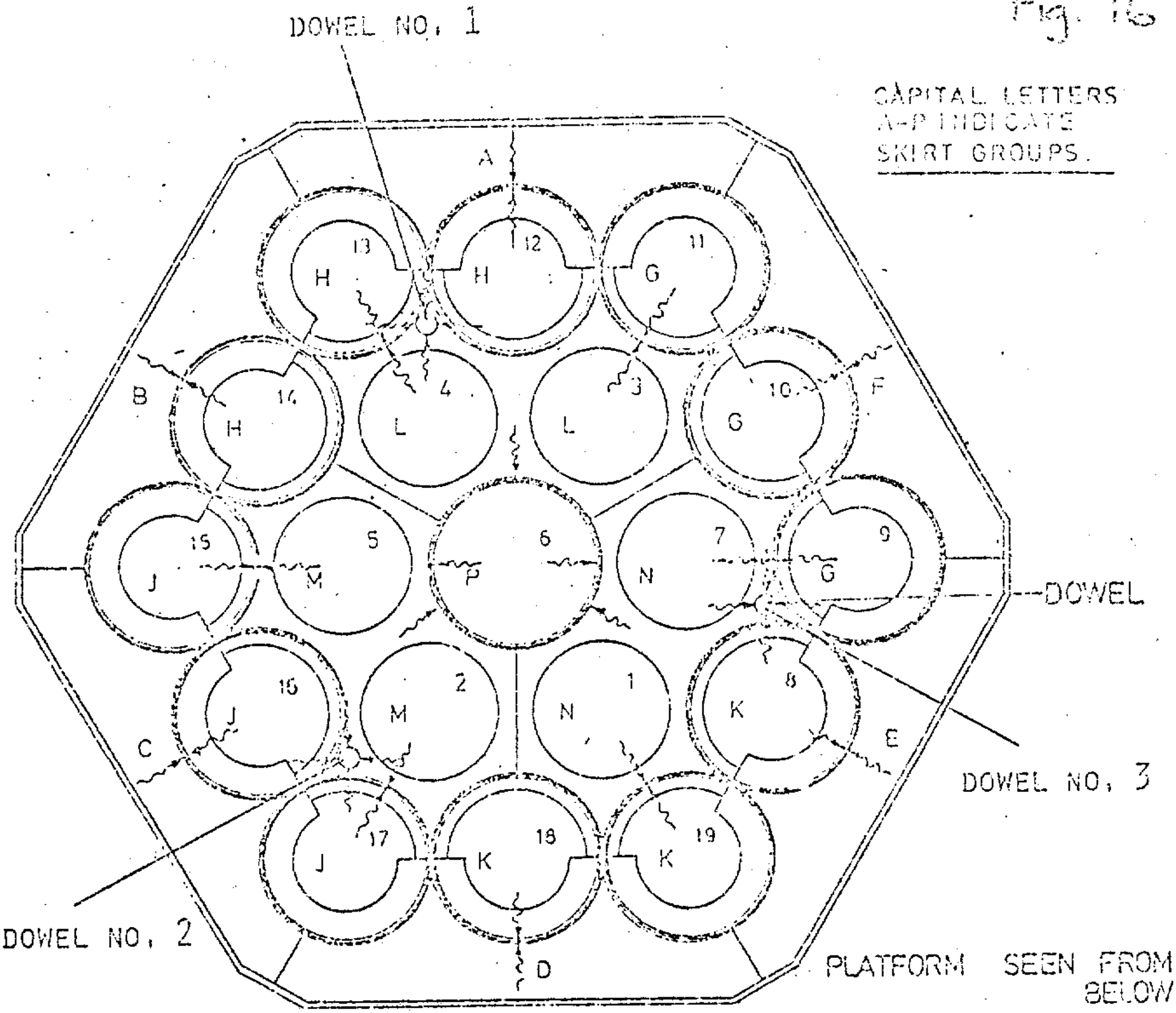
Norges geotekniske institutt NGI

Geotechnical Documentation

Project: ELF NORGE A/S, FRIGG FIELD, TCP2 PLATFORM

Date	Section	Title	Replaced Date
June 2 -77	5. Skirts	Horizontal Skirt Capacities and Skirt Water Pressure during the Skirt Penetration Phase	
June 2 -77	4. Stability	Stability Analysis Summer Storm Conditions	

Fig. 16



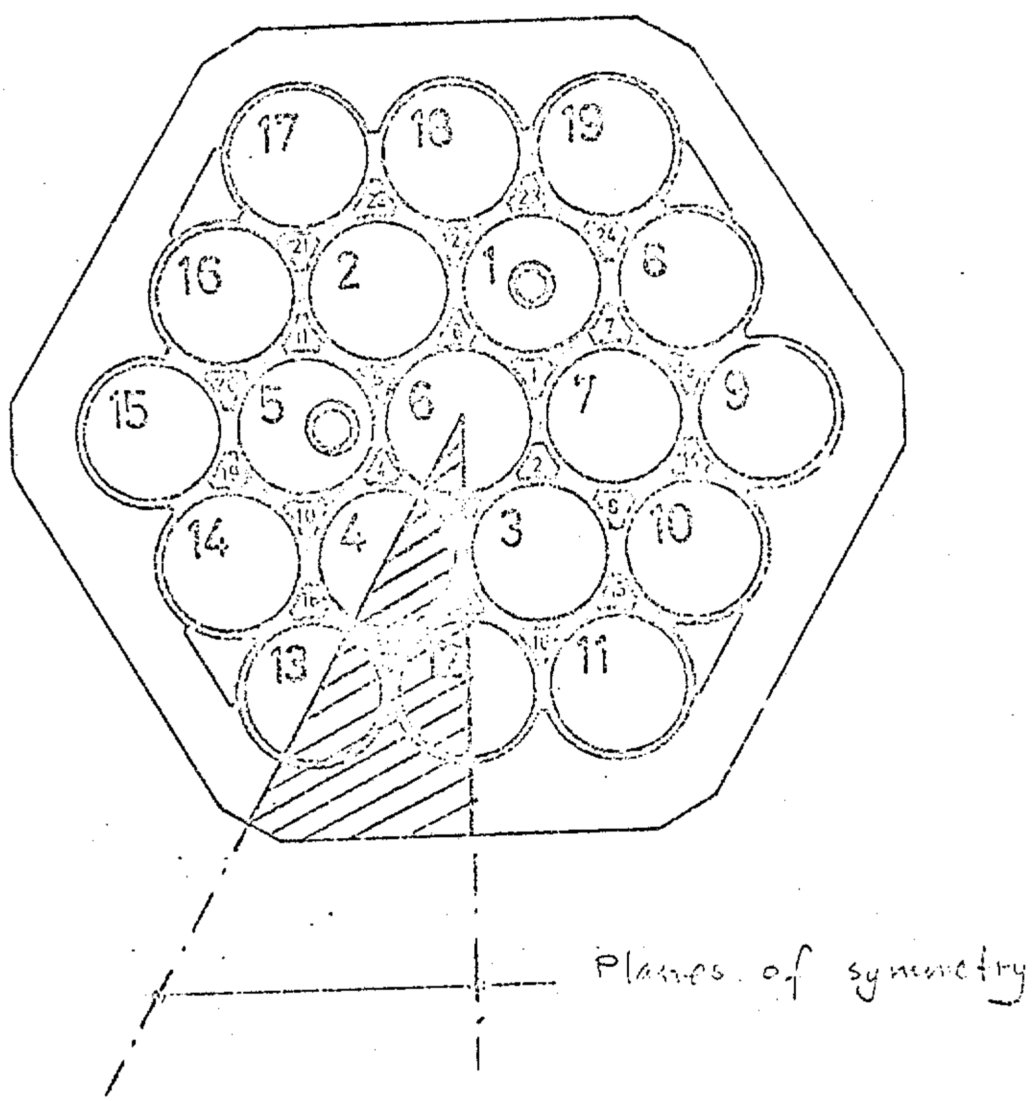
LOCATION OF DRAINAGE WELLS SCALE 1:500

2 OUTLETS AT THE LOWER SURFACE OF DOME CELL NO.6 see drawing no.UC.3311-74810-01-604
3 WELLS OUTSIDE THE STEEL SKIRT OF CELL NO.5 see drawing no.UC 3311-74810-01-603
4 WELLS ON EACH DOWEL see drawing no UC.3311-74810-01-605
12 GROUPS OF 2 WELLS COVERING:
1 WELL INSIDE THE STEEL SKIRT OF EACH OUTER CELL
1 WELL INSIDE EACH OUTER SKIRT COMPARTMENT } see drawing no UC 3311-74810-08-601
2 WELLS INSIDE EACH INNER SKIRT COMPARTMENT

ELF NORGE A/S PLATFORM FRIGG TCP-2	Date 20-5-76 · Drawn by R.K.J.
ANTI LIQUEFACTION SYSTEM LOCATION OF DRAINAGE WELLS	Approved Project no. 74810
Norwegian geotechnical institute	Appendix no. 1

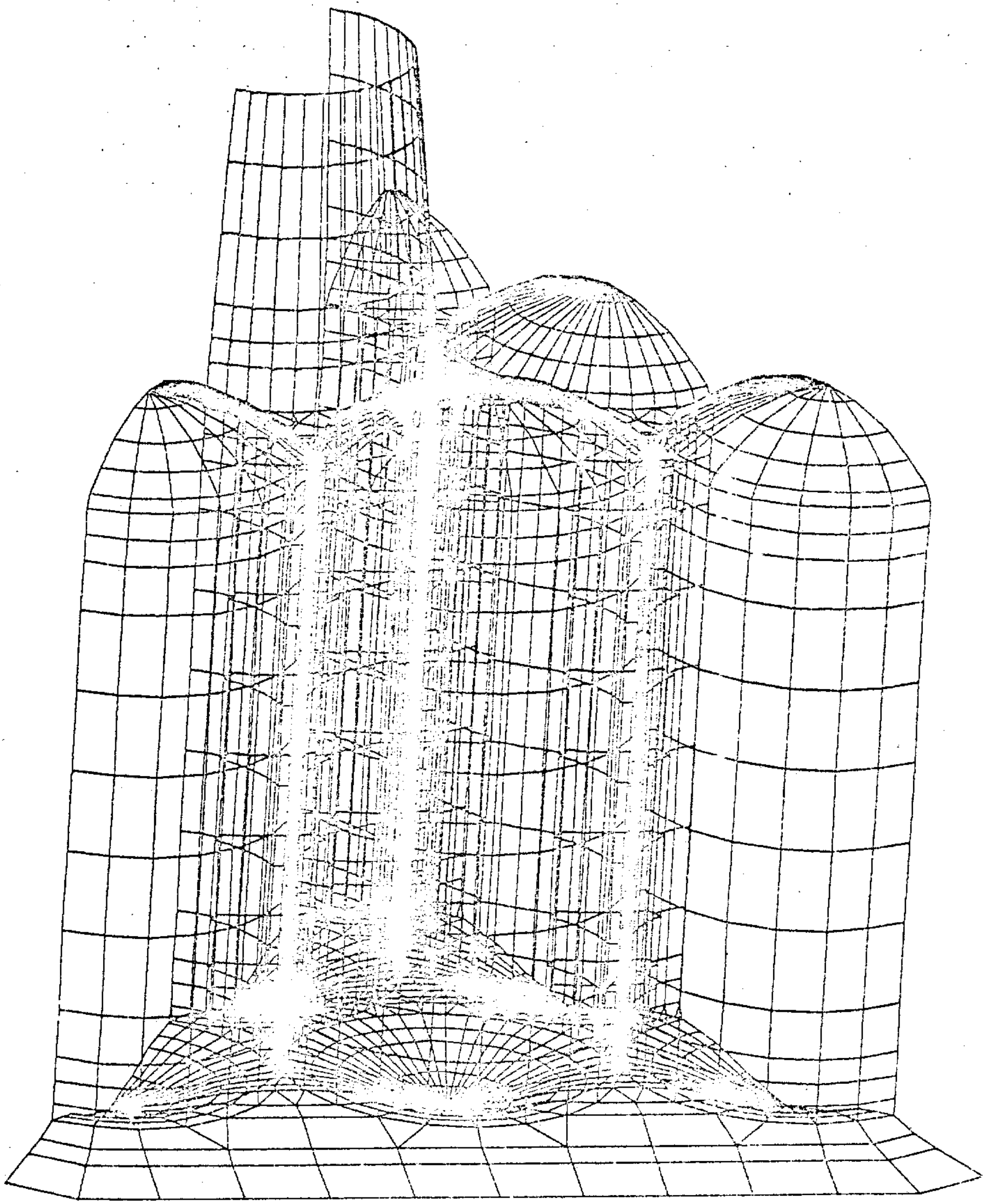
Sak nr.	Sak	Utf. av	Dato	Kontr. av	Dato

2. MAIN GEOMETRY OF MODEL



The model is detailed 1/12 piece of the bottom structure and lower part of cell walls. For technical discription of the model, please see report from A/S Computas on the subject.

Fig. 13A



COMPLETE SEGMENT

Fig. 18B

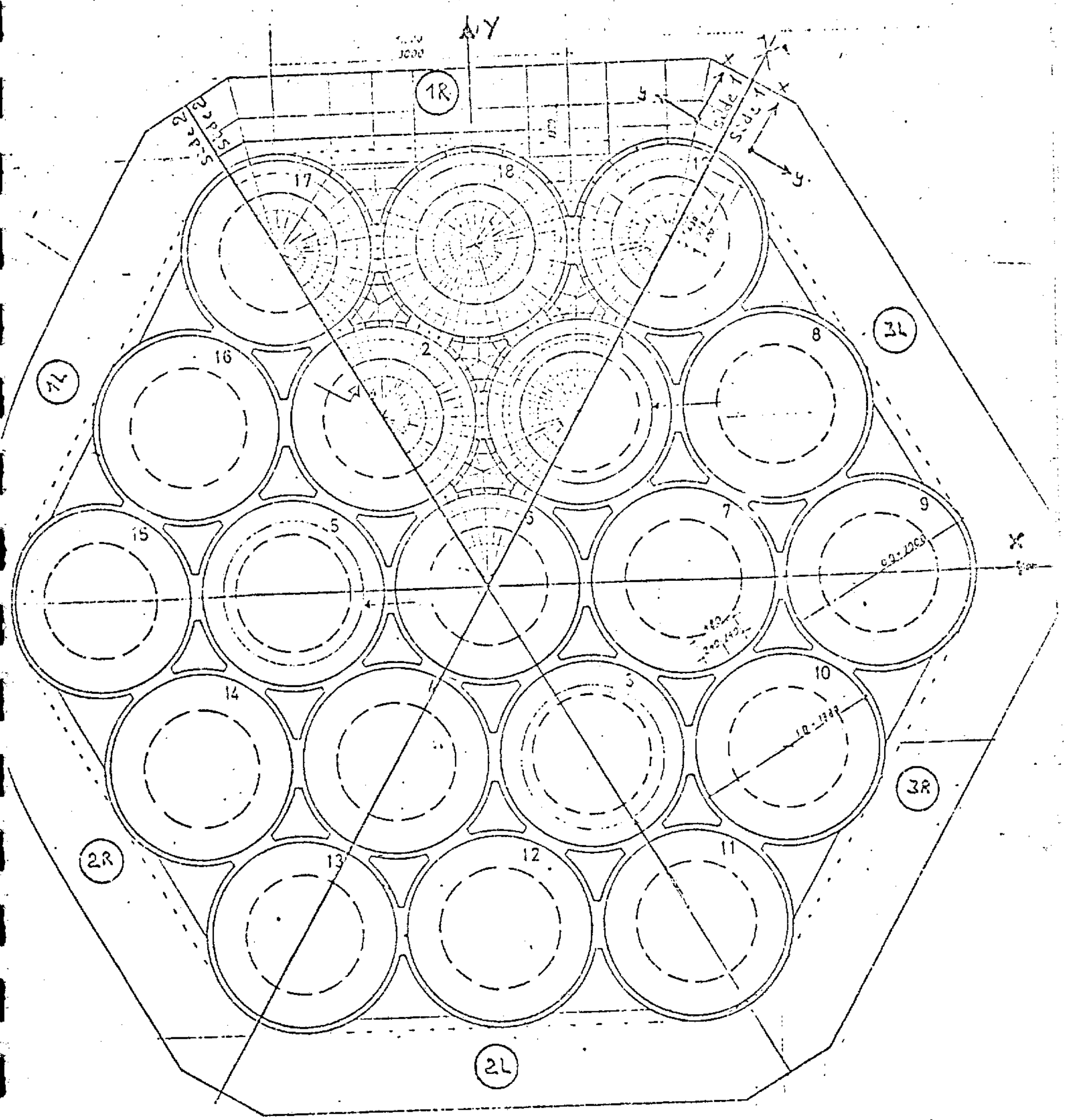


Fig 1

Segment division

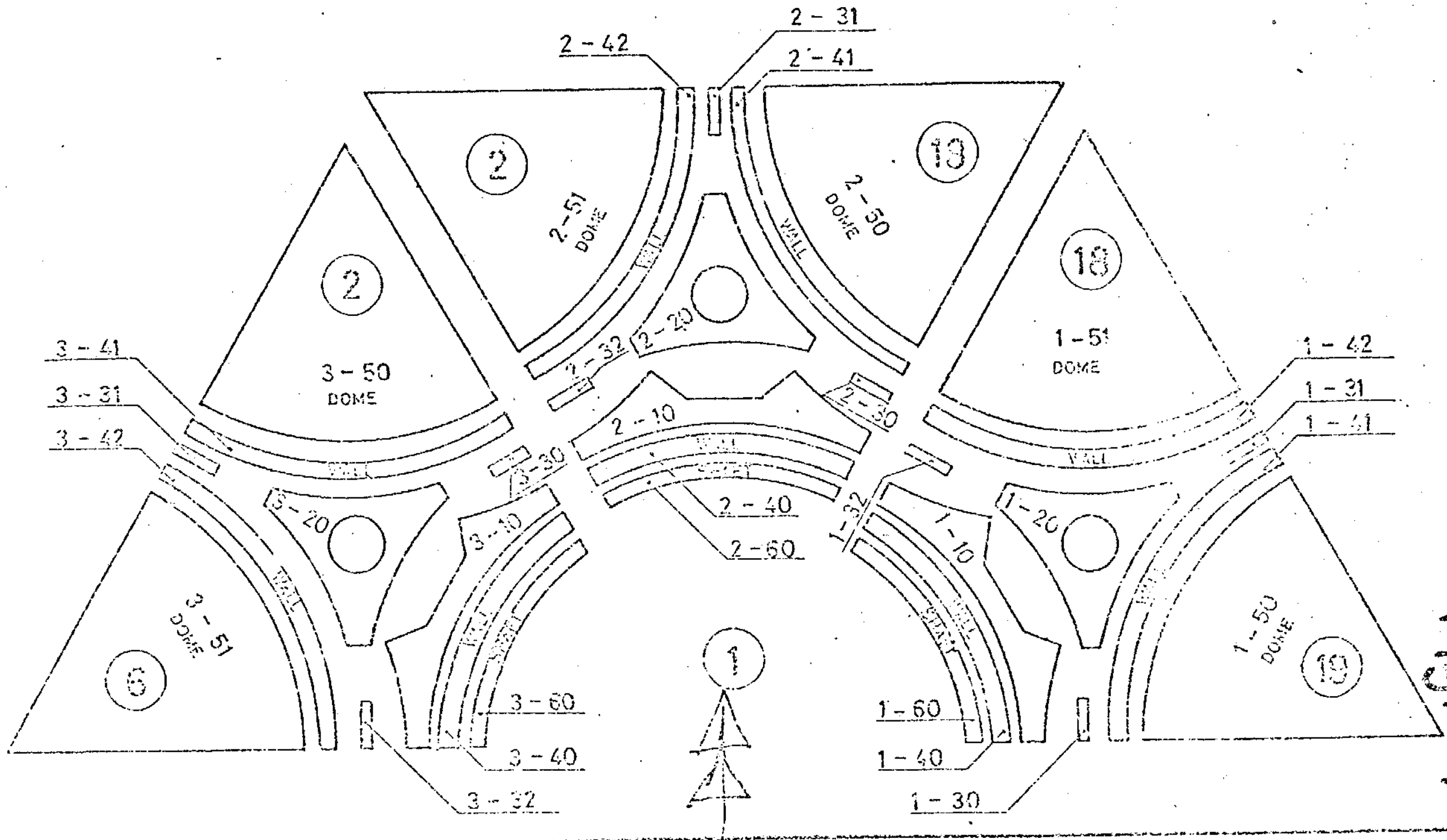
TCP-2 DETAIL

SEGMENTSYMMETRICAL ANALYSIS

LOADCOMB. SLS: ______

LOADCOMB. ULS: ______

LOADCASE: ______



TCP-2 DETAIL

NONSEGMENTSYMMETRICAL ANALYSIS

LOADCOMB. SLS:
LOADCOMB. ULS:
LOADCASE:

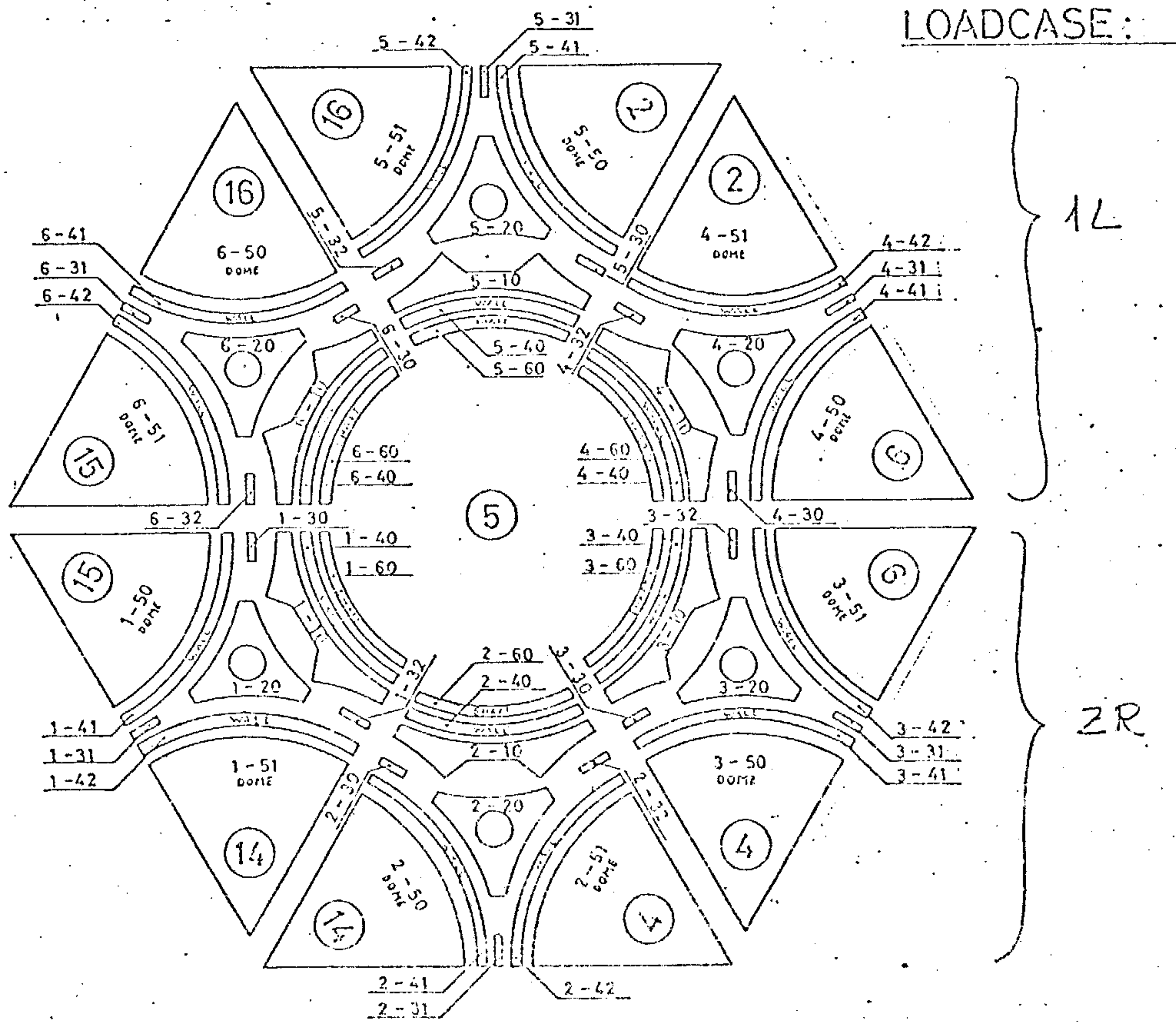
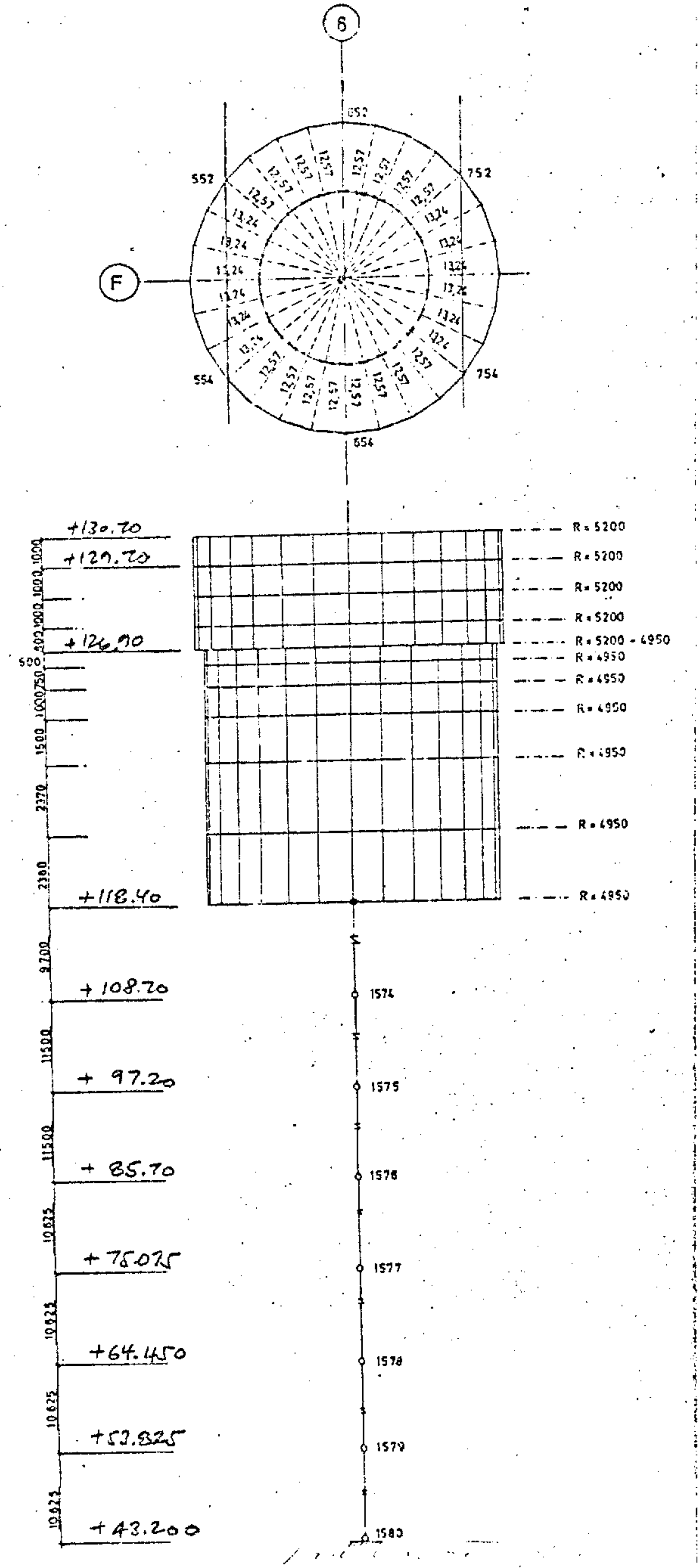


Fig. 20

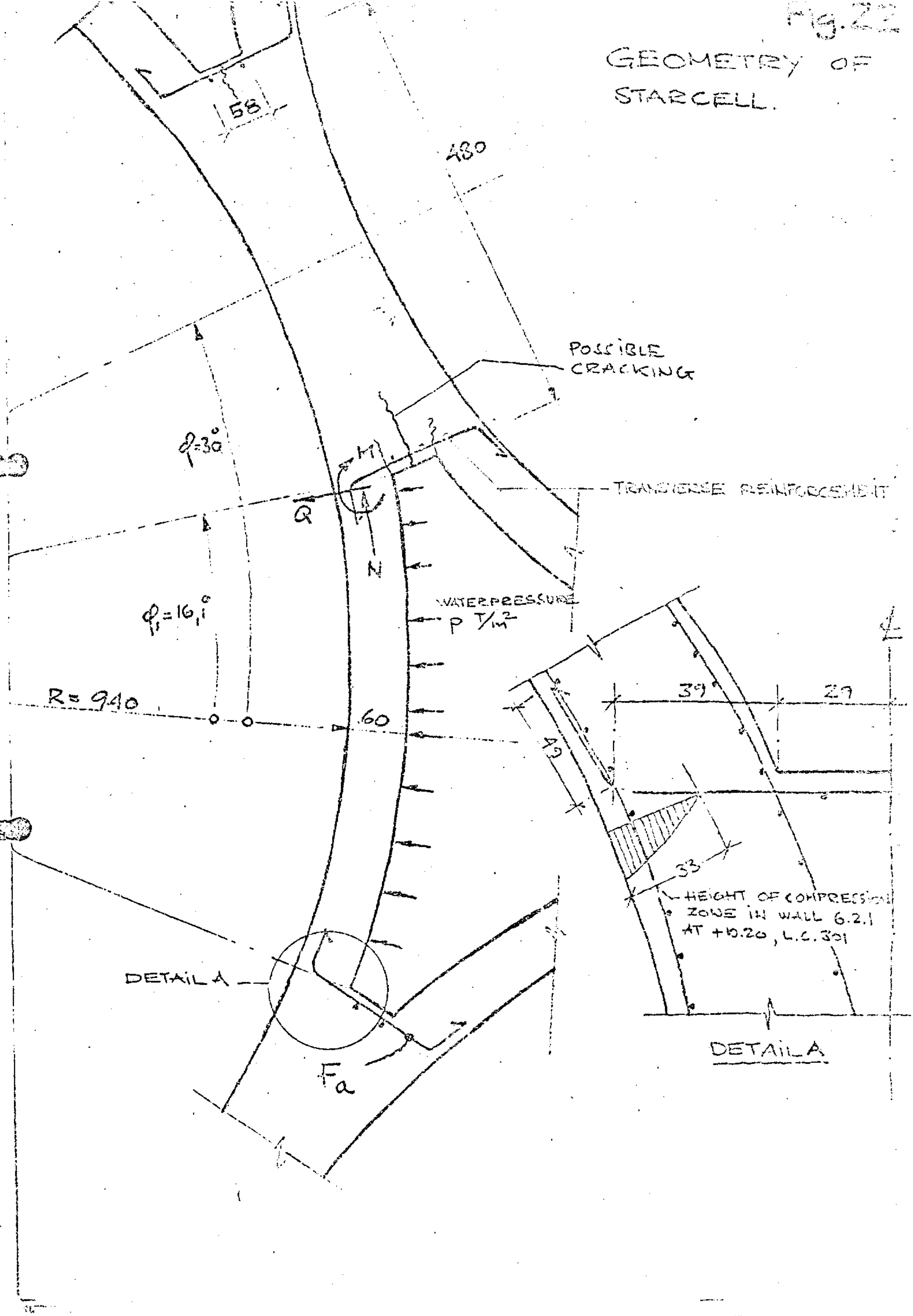
Fig. 21

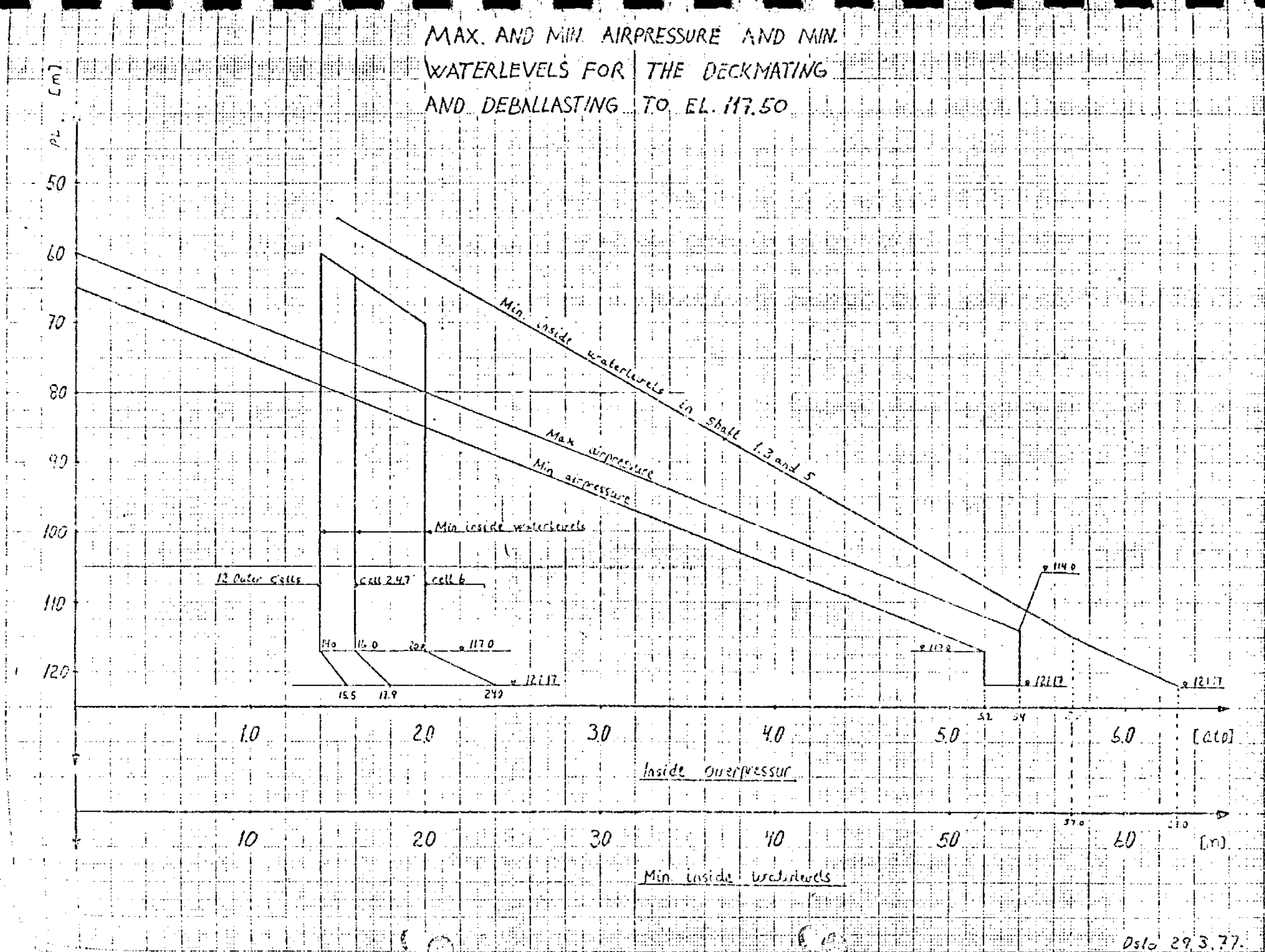


SKAFT 1 (F6)

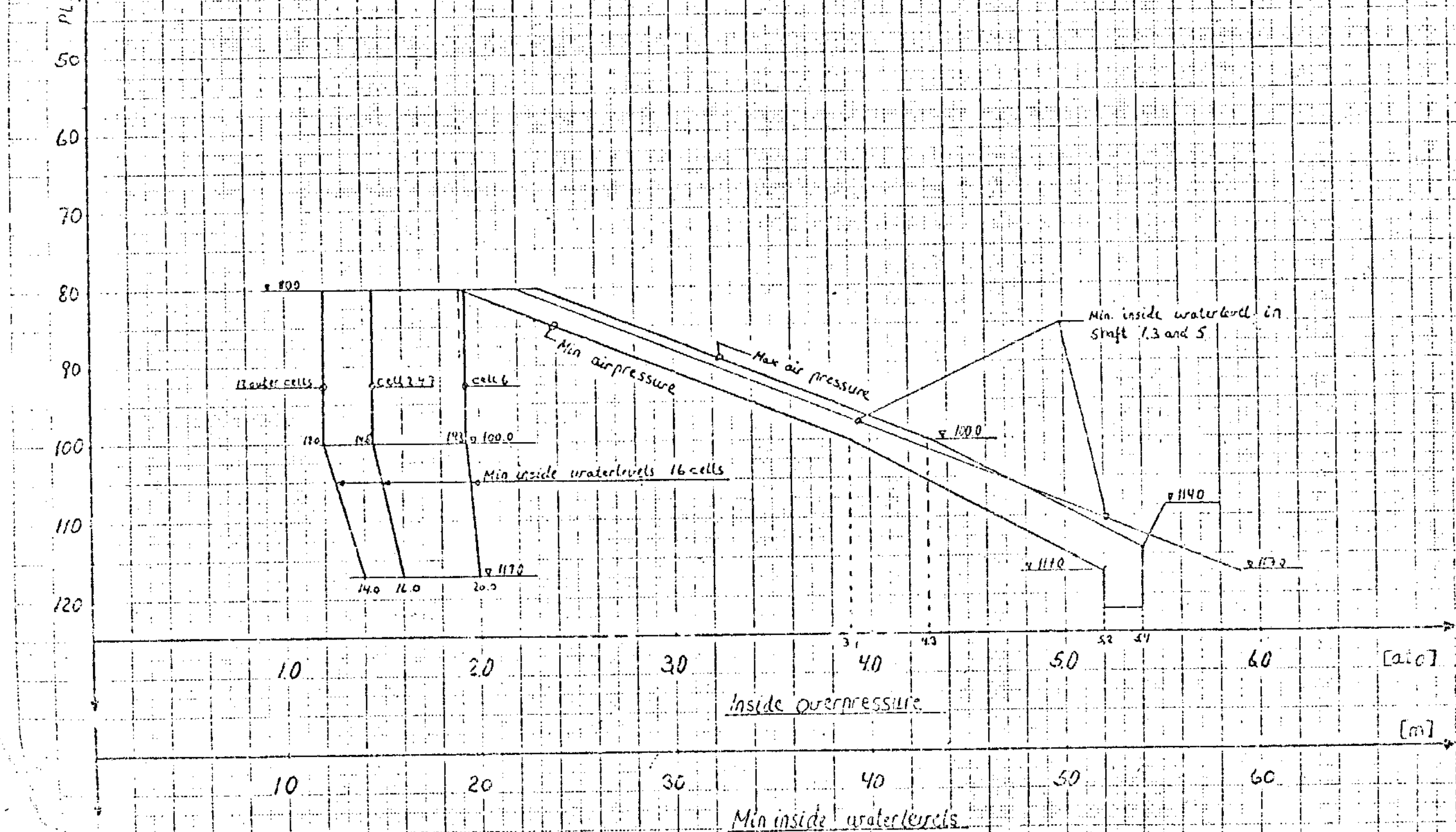
Fig. 22

GEOMETRY OF STARCELL.



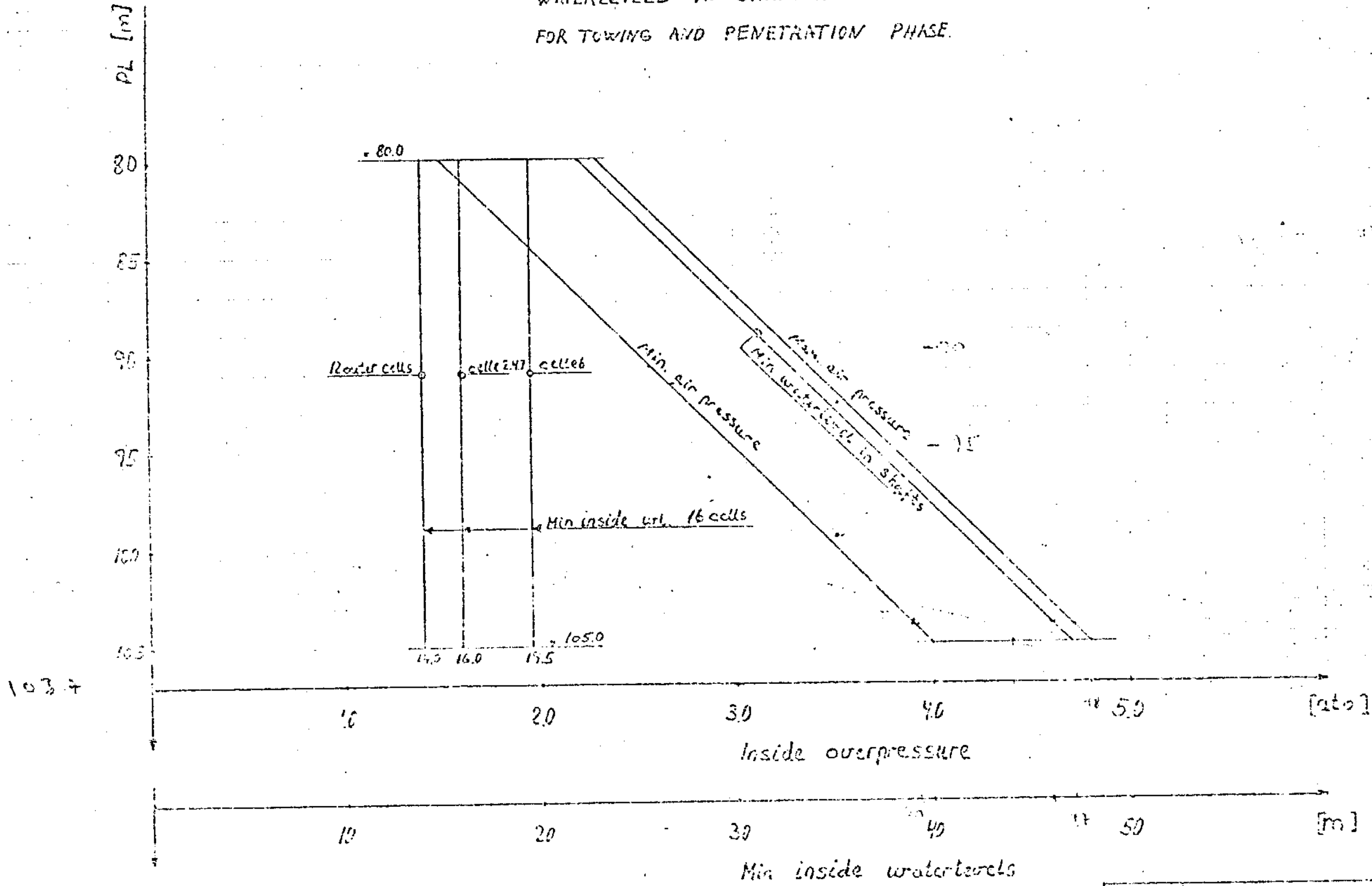

MAX. AND MIN. AIRPRESSURE AND MIN. WATERLEVELS FOR THE DECKMATING AND DEBALLASTING TO EL. 117.50
PL. [m]
50
60
70
80
90
100
110
120
Min. inside waterlevels in Shaft 1.3 and 5
Max airpressure
Min airpressure
Min inside waterlevels
12 Outer Cells
cell 2.4.7
cell 6
117.0
121.17
15.5
17.9
24.9
114.0
1.0
2.0
3.0
4.0
5.0
6.0
[ato]
Inside overpressur
10
20
30
40
50
60
[m]
Min inside waterlevels
Oslo 29.3.77.

MAX. AND MIN. AIRPRESSURE AND MIN.
WATERLEVELS FOR DEBALLASTING
FROM EL. 117.5 TO EL. 80.0



OSLO 27.3. 87

MAX. AND MIN. AIRPRESSURE AND MIN. WATERLEVELS IN SHAFT AND CELLS FOR TOWING AND PENETRATION PHASE.



TCP-2

Norwegian Contractors

Fig. 26^H

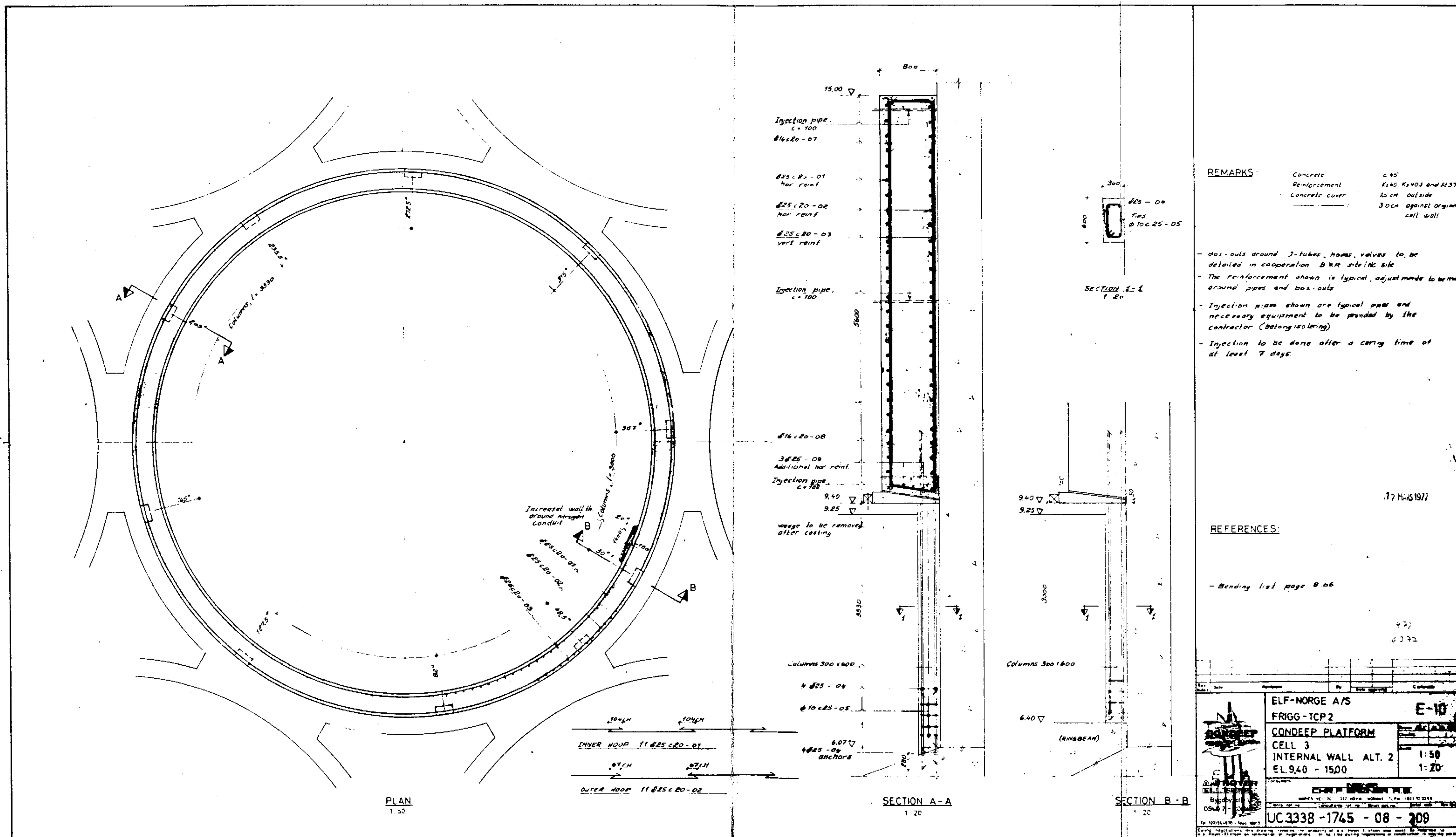
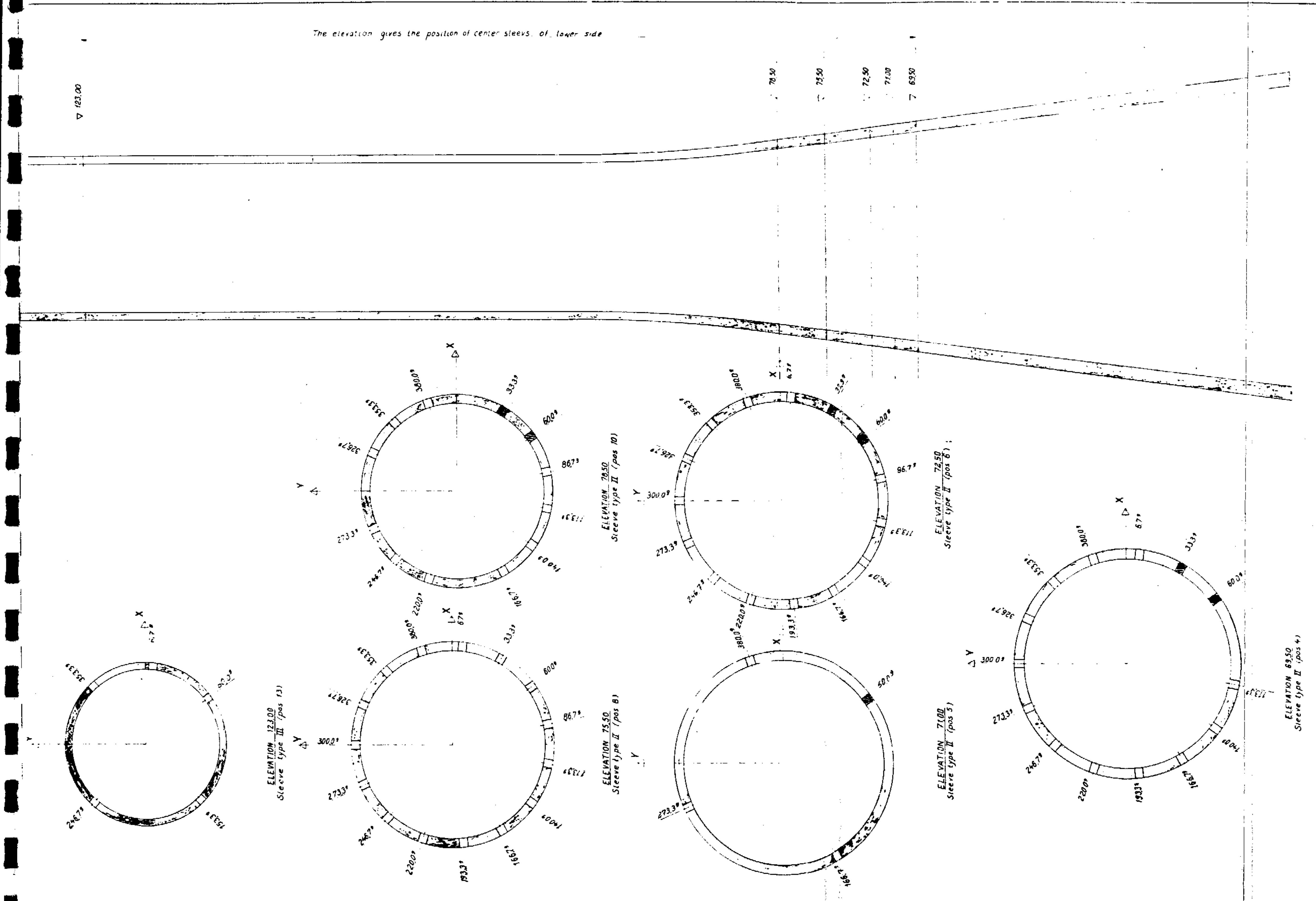
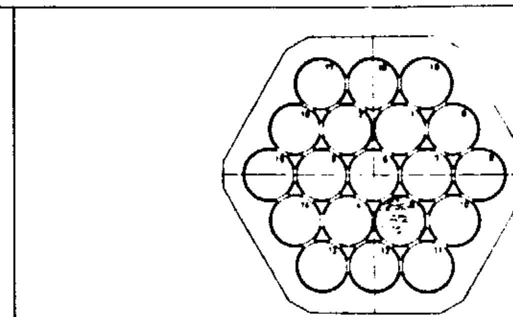

PLAN
1:50
SECTION A-A
1:20
SECTION B-B
1:20
SECTION 1-1
1:20
INNER HOOP 11 ∅25 c20 - 01
OUTER HOOP 11 ∅25 c20 - 02
REMARKS:
Concrete C45
Concrete cover 7,5 cm outside
- Box-outs around J-tubes, hoses, valves to be detailed in cooperation B&R site/NC site
- The reinforcement shown is typical, adjustments to be made around pipes and box-outs
- Injection pipes shown are typical pipes and necessary equipment to be provided by the contractor (betonginjisering)
- Injection to be done after a curing time of at least 7 days.
REFERENCES:
- Bending list page 8.06
ELF-NORGE A/S
FRIGG-TCP 2
E-10
CONDEEP PLATFORM
CELL 3
INTERNAL WALL ALT. 2
EL. 9,40 - 15,00
1:50
1:20
UC 3338 -1745 - 08 - 209

Fig. 27





REMARKS

CONCRETE COVER TO		
REINFORCEMENT		CM
TABLE	MIN	CM
EXTENDED INSPECTION		
CONCRETE GRADE	C45	
STEEL QUALITY		

- The sleeve are placed perpendicular to the walls
- Holes closed with concrete acc to dwg 08-207

REFERENCES

- Positions of external riser seals see dwg 07-412
- Sleeve type II and III see dwg 07-414
- Position of holes to be closed see Elf telex 76 5578 and revisions on site
- Closing of holes see dwg -745-08-207

C	17.3.77	AS BUILT	KLS
B	180576	REFERENCES	KDP
A	200476	ELEVATION 78,5	KDP

ELF-NORGE A/S
FRIGG - TCP 2
E-10

CONDEEP production platform

CONDEEP PLATFORM
CONCRETE SHAFT
NO. 3
POSITIONS OF HOLES

KDP 160376

Scale 1:100

NOYER
Bygdøy allé
OSLO 2 - NORWAY

UC 333.7 - 1745 - 07 - 103 C

Fig. 28

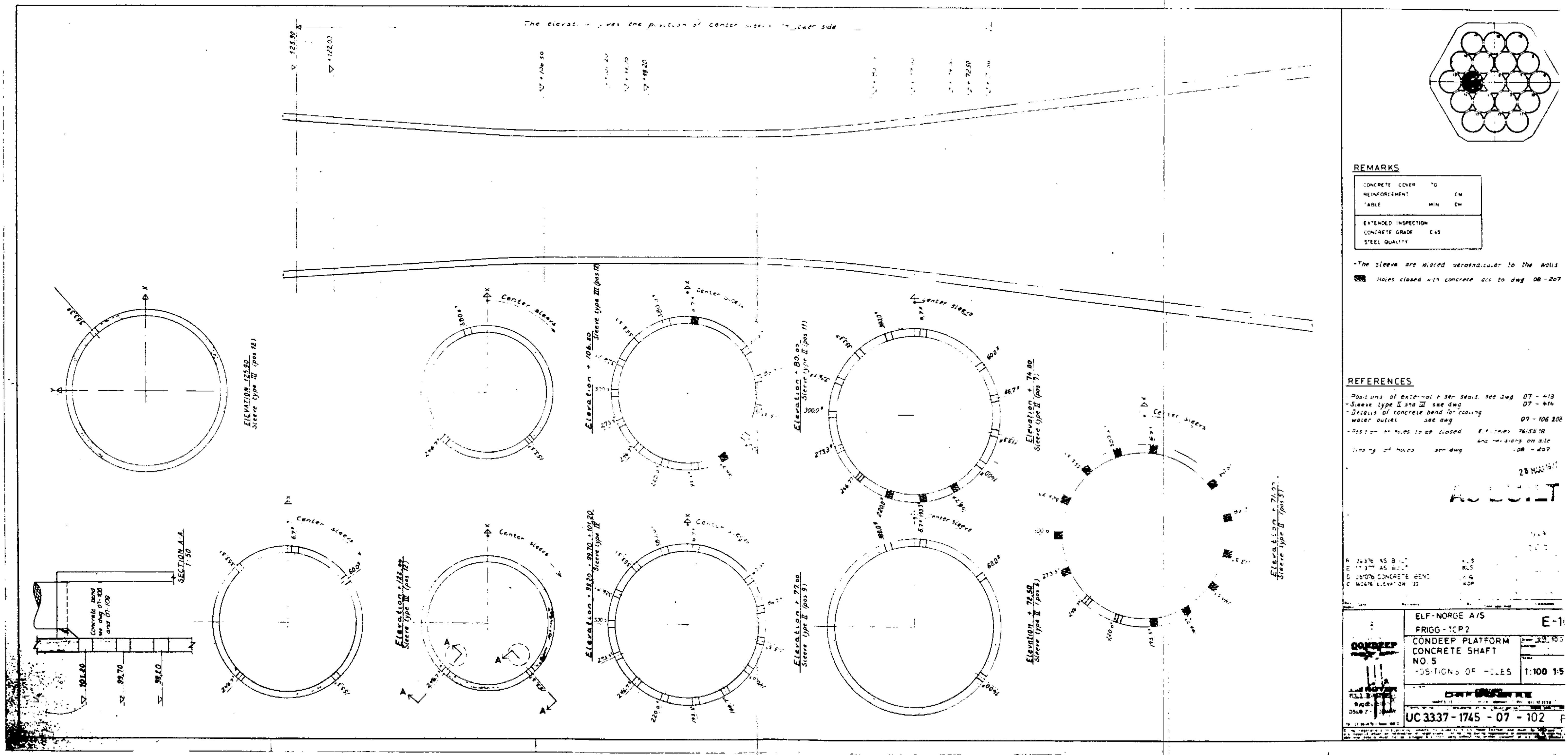
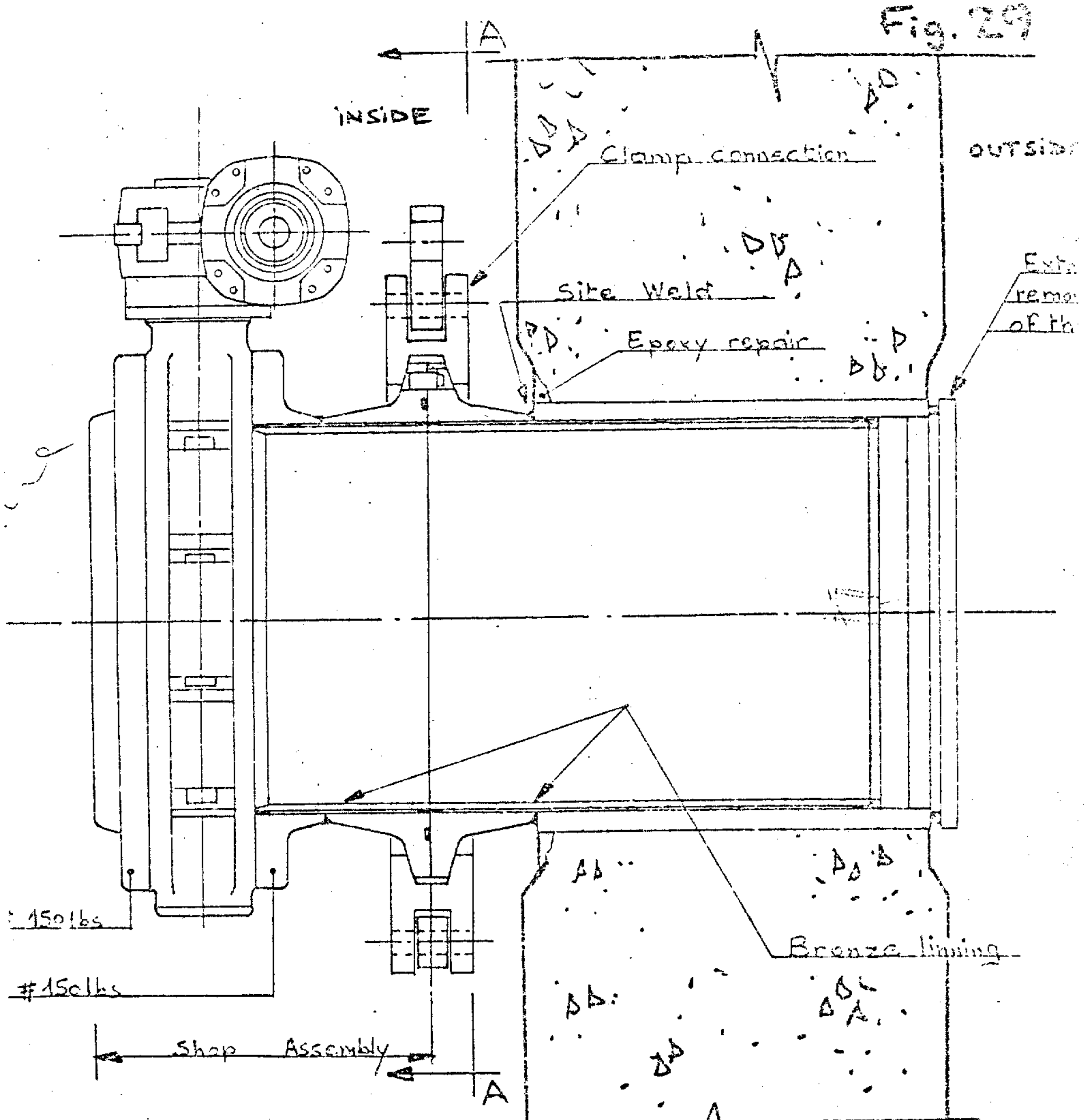

REMARKS
CONCRETE COVER TO
REINFORCEMENT CM
TABLE MIN CM
EXTENDED INSPECTION
CONCRETE GRADE C45
STEEL QUALITY
REFERENCES
Center sleeves
SECTION A-A 1:50
ELF-NORGE A/S
FRIGG - TCP 2
CONDEEP PLATFORM
CONCRETE SHAFT
NO. 5
1:100
UC 3337 - 1745 - 07 - 102

Fig. 29



ind	date	visu	coord	MODIFICATION

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microfiche	Nom	Date	Ech:
Dessiné :	DELFOLR	22.4.77	
Vérifié :			
Visé :			

PLUGGING OF HOLES

TYPICAL FITTI

ateliers et chantiers de bre

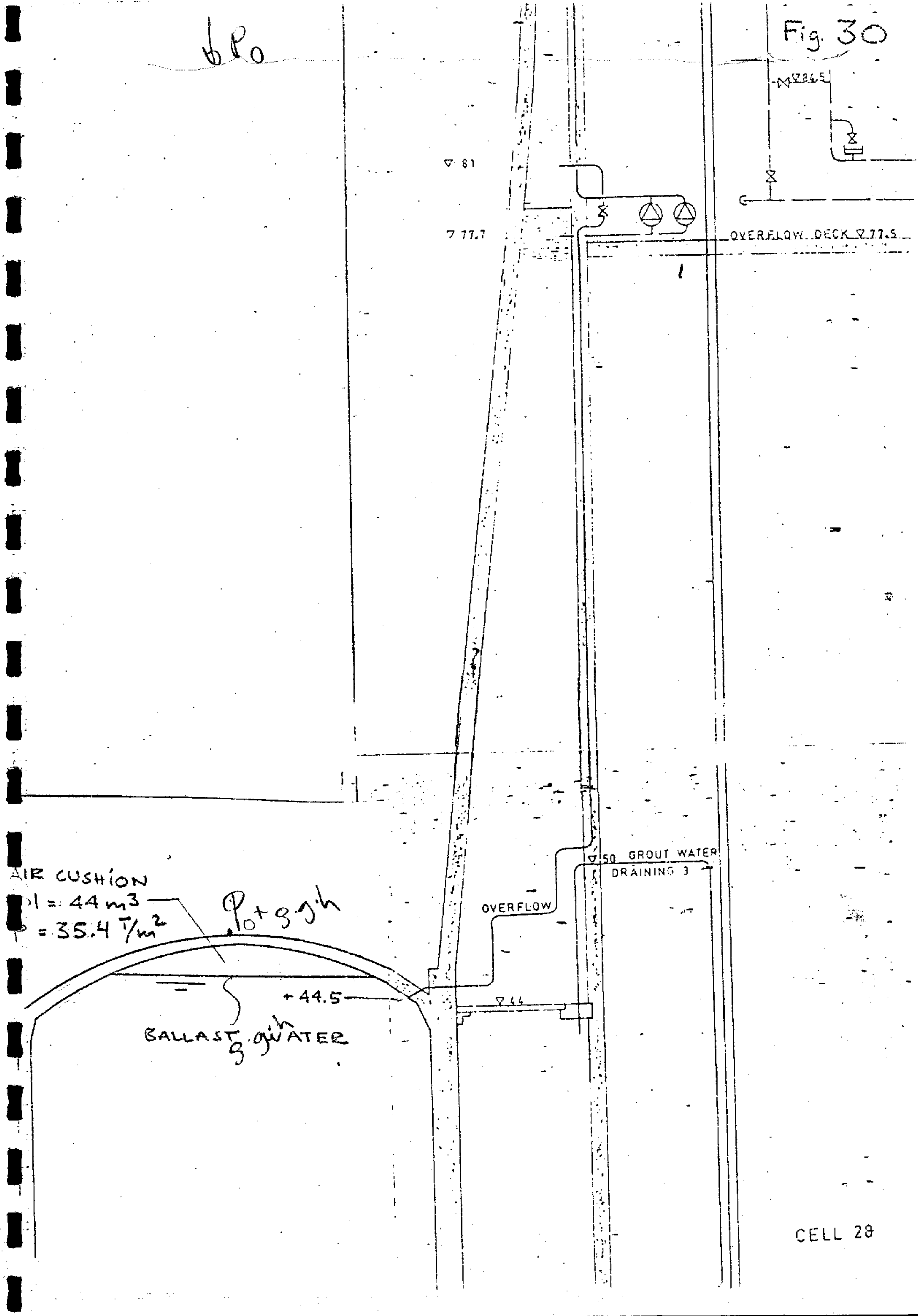
ELF NORGE
FRIGG TCP 2

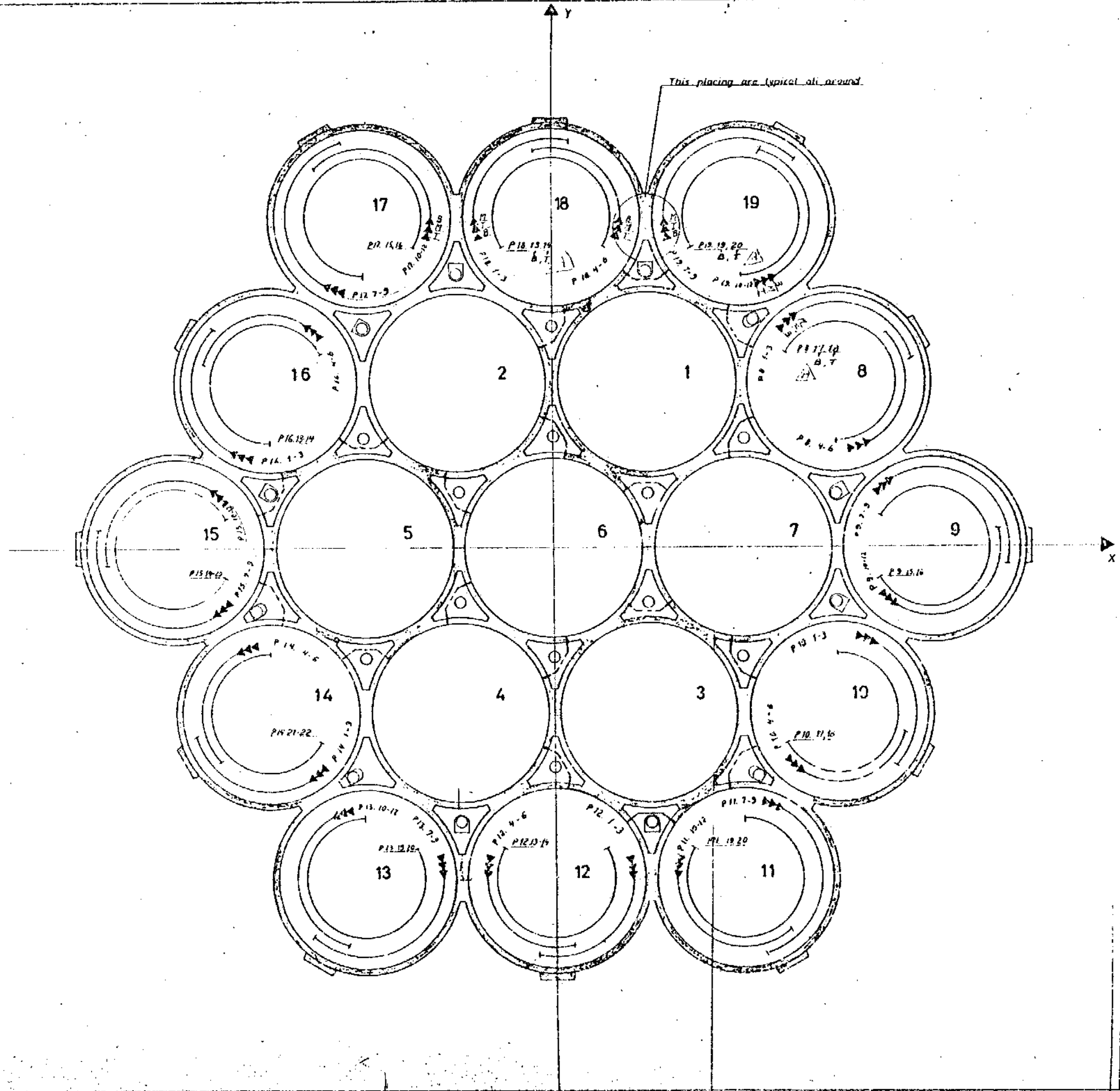
acb

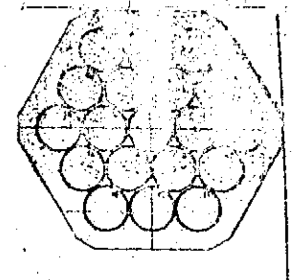
CEDEX N° 2 - 44040 - NANTES CEDEX / TEL

Cde N° 102 C 31 | 3 MRM 169 21

Fig. 30


∇ 81
∇ 77.7
OVERFLOW DECK ∇ 77.5
∇ 50 GROUT WATER
DRAINING 3
OVERFLOW
AIR CUSHION
= 44 m3
= 35.4 T/m2
+ 44.5
∇ 44
BALLAST WATER
CELL 28





REMARKS

CONCRETE COVER TO	
REINFORCEMENT	CM
CABLE.	MIN. 100CM +15 -0
EXTENDED INSPECTION	
CONCRETE GRADE:	C45
STEEL QUALITY	

- Cable : Freyssinet 12 T15 system
- ——— live anchorage model 294
- ———◄ : side mounted dead end anchorage model 294

B = bottom, M = middle, T = top: Means the elevation of this cables in proportion to each other

REFERENCES

PLAN, details, see dwg UC 3.3.2.6 - 1745 - 05 - 302, -303, -304, -305

Reinforcement at anchorage brackets see drwg. UC 3.3.2.6 - 1745 - 00 - 209

Rev index	Date	Revision	By		Endorsed
A	221178	SPECIFICATION OF CABLES	JW		

ELF-NORGE A/S

FRIGG - TCP 2

E-10

CONDEEP PLATFORM

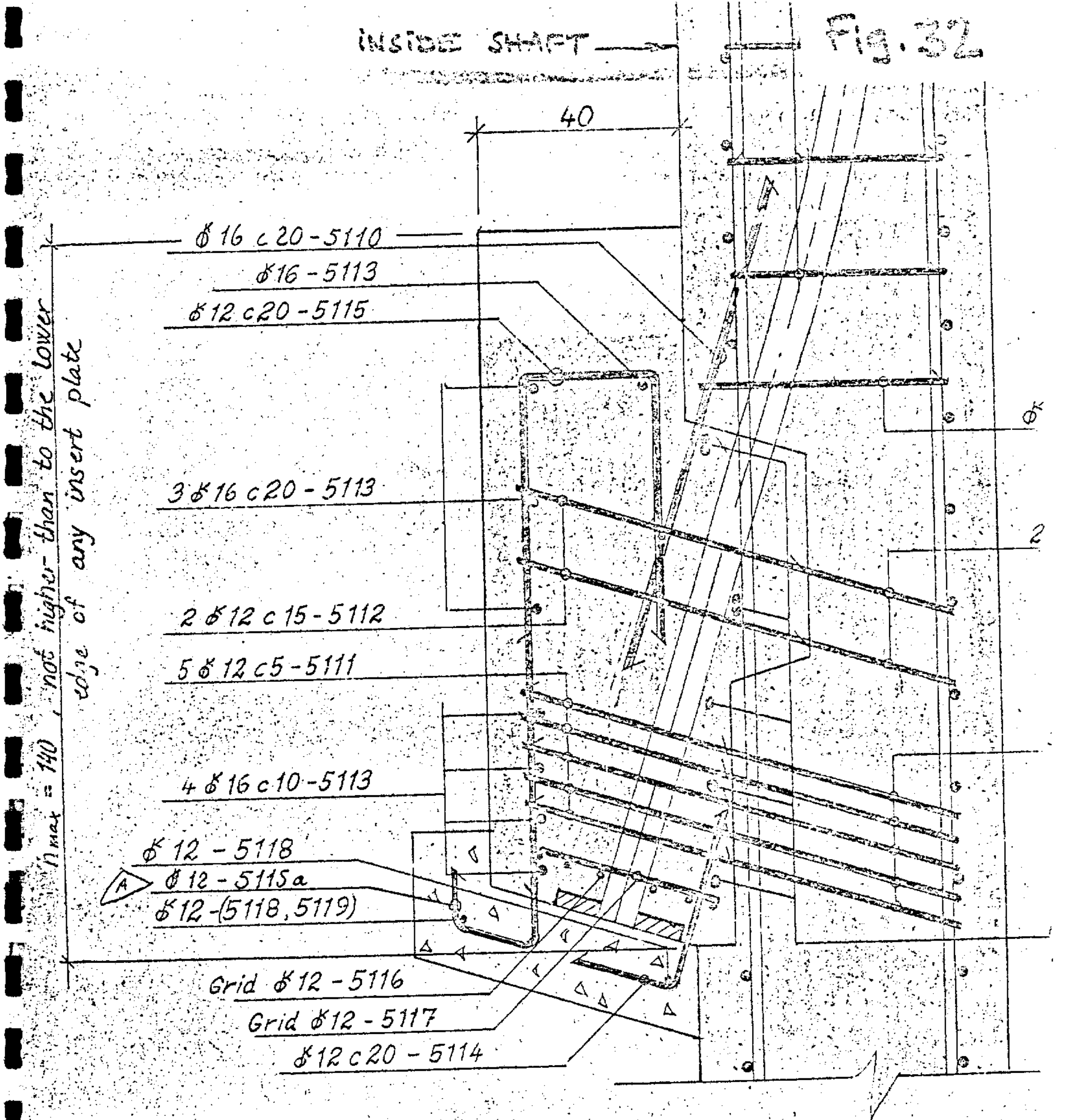
UPPER DOMES

PLAN OF HOOP CABLES

Scale 1:200

UC 3.3.2.6 - 1745 - 6

Fig. 32



o. 5115 to be cut at
ttom formwork, and
with an extra bar,
5115 a,
g. length = 50 cm

SECTION A-A
Main reinforcement in anchoring zone

LEVELS FOR ANCHORING OF CABLES

LEVEL	CABLE NOS					
51.50	1130	1230	1330	1430	1530	1630
55.00	1128	1228	1328	1428	1528	1628
58.50	1127	1227	1327	1427	1527	1627
62.00	1125	1225	1325	1425	1525	1625
65.50	1124	1224	1324	1424	1524	1624
69.00	1122	1222	1322	1422	1522	1622
72.50	1121	1221	1321	1421	1521	1621
76.00	1119	1219	1319	1419	1519	1619
79.50	1118	1218	1318	1418	1518	1618
83.00	1116	1216	1316	1416	1516	1616

DUCTS TO BE STOPPED AT LEVEL 46,02

LEVEL						
46,02	1102	1202	1302	1402	1502	1602
46,02	1108	1208	1308	1408	1508	1508
46,02	1114	1214	1314	1414	1514	1614

DUCTS TO BE STOPPED BELOW LEVEL 45,52

	1103	1203	1303	1403	1503	1603
	1106	1206	1306	1406	1506	1606
	1109	1209	1309	1409	1509	1609
	1112	1212	1312	1412	1512	1612
	1115	1215	1315	1415	1515	1615

SHAFT 4.
LEVELS FOR ANCHORAGE OF CABLES

Fig. 83

LEVELS FOR ANCHORING OF CABLES

LEVEL	CABLE NOS.					
51,50	3135	3235	3335	3435	3535	3635
52,50	3134	3234	3334	3434	3534	3634
53,50	3132	3232	3332	3432	3532	3632
54,50	3131	3231	3331	3431	3531	3631
56,50	3129	3229	3329	3429	3529	3629
59,00	3128	3228	3328	3428	3528	3628
62,00	3126	3226	3326	3426	3526	3626
65,00	3125	3225	3325	3425	3525	3625
68,00	3123	3223	3323	3423	3523	3623
70,00	3122	3222	3322	3422	3522	3622
72,00	3120	3220	3320	3420	3520	3620
74.00	3119	3219	3319	3419	3519	3619
76.00	3136	3236	3336	3436	3536	3636
80,00	3102	3202	3302	3402	3502	3602
82,00	3133	3233	3333	3433	3533	3633
85,00	3130	3230	3330	3430	3530	3630
86,50	3127	3227	3327	3427	3527	3627
88,00	3111	3211	3311	3411	3511	3611
89,50	3124	3224	3324	3424	3524	3624
91,00	3121	3221	3321	3421	3521	3621
92,50	3117	3217	3317	3417	3517	3617

DUCTS TO BE STOPPED BELOW LEVEL 45,52

3105	3205	3305	3405	3505	3605
3108	3208	3308	3408	3508	3608
3114	3214	3314	3414	3514	3614

SHAFT 3
LEVELS FOR ANCHORAGE OF CABLES.

Fig. 34

'ELS FOR ANCHORING
'ABLES

A

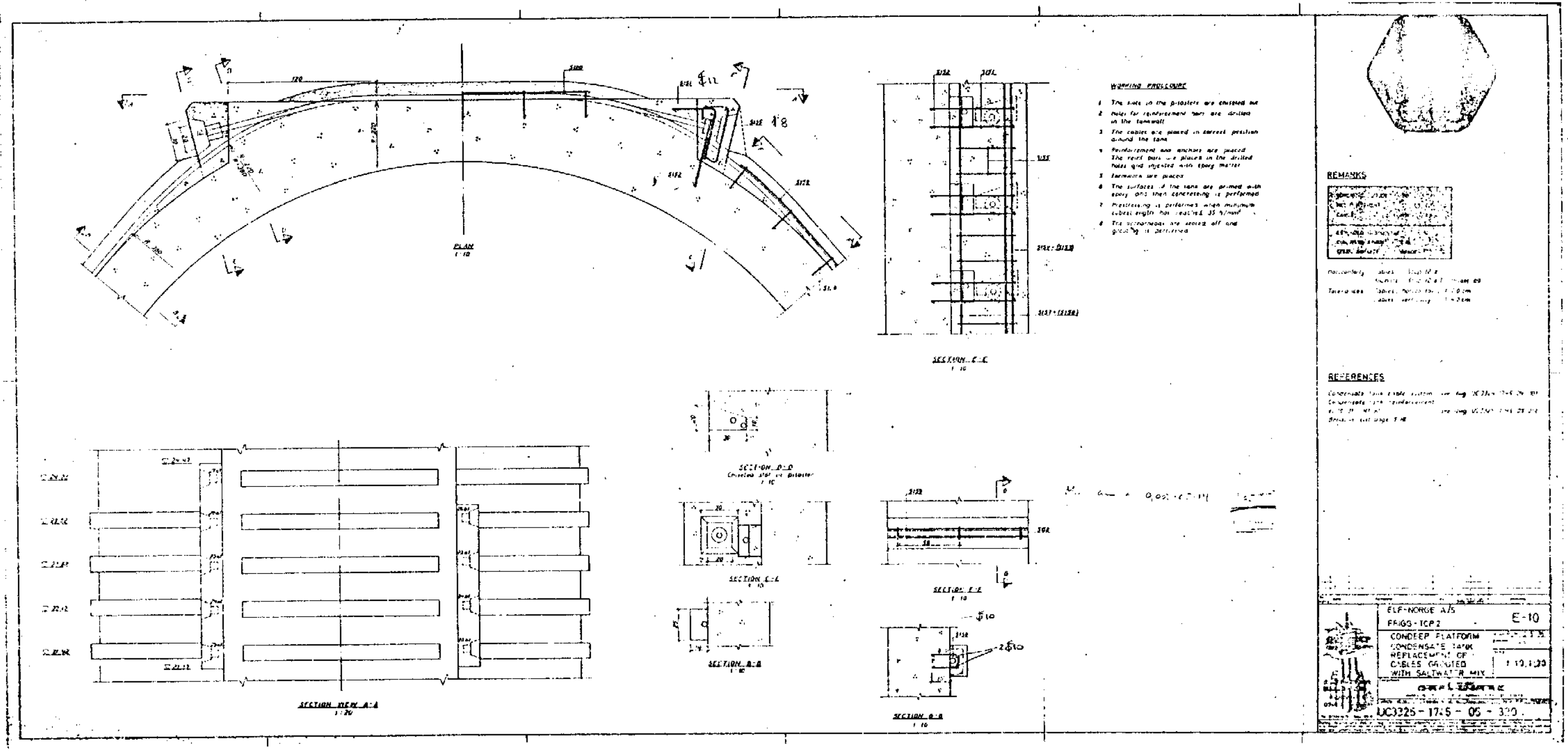
LEVEL	CABLE NOS					
52,00	5135	5235	5335	5435	5535	5635
53,00	5134	5234	5334	5434	5534	5634
54,00	5132	5232	5332	5432	5532	5632
55,00	5131	5231	5331	5431	5531	5631
56,00	5129	5229	5329	5429	5529	5629
57,00	5128	5228	5328	5428	5528	5628
58,00	5126	5226	5326	5426	5526	5626
59,75	5125	5225	5325	5425	5525	5625
61,25	5123	5223	5323	5423	5523	5623
62,75	5122	5222	5322	5422	5522	5622
64,25	5120	5220	5320	5420	5520	5620
65,75	5119	5219	5319	5419	5519	5619
67,25	5103	5203	5303	5403	5503	5603
69,00	5104	5204	5304	5404	5504	5604
71,00	5107	5207	5307	5407	5507	5607
77,00	5116	5216	5316	5416	5516	5616
81,00	5109	5209	5309	5409	5509	5609
84,00	5112	5212	5312	5412	5512	5612
87,00	5101	5201	5306	5401	5501	5601
90,00	5110	5210	5310	5410	5510	5610
93,00	5118	5218	5318	5418	5518	5618

'TS TO BE STOPPED BELOW
L 45,52

5127	5227	5327	5427	5527	5627
5115	5215	5315	5415	5515	5615
5133	5233	5333	5433	5533	5633

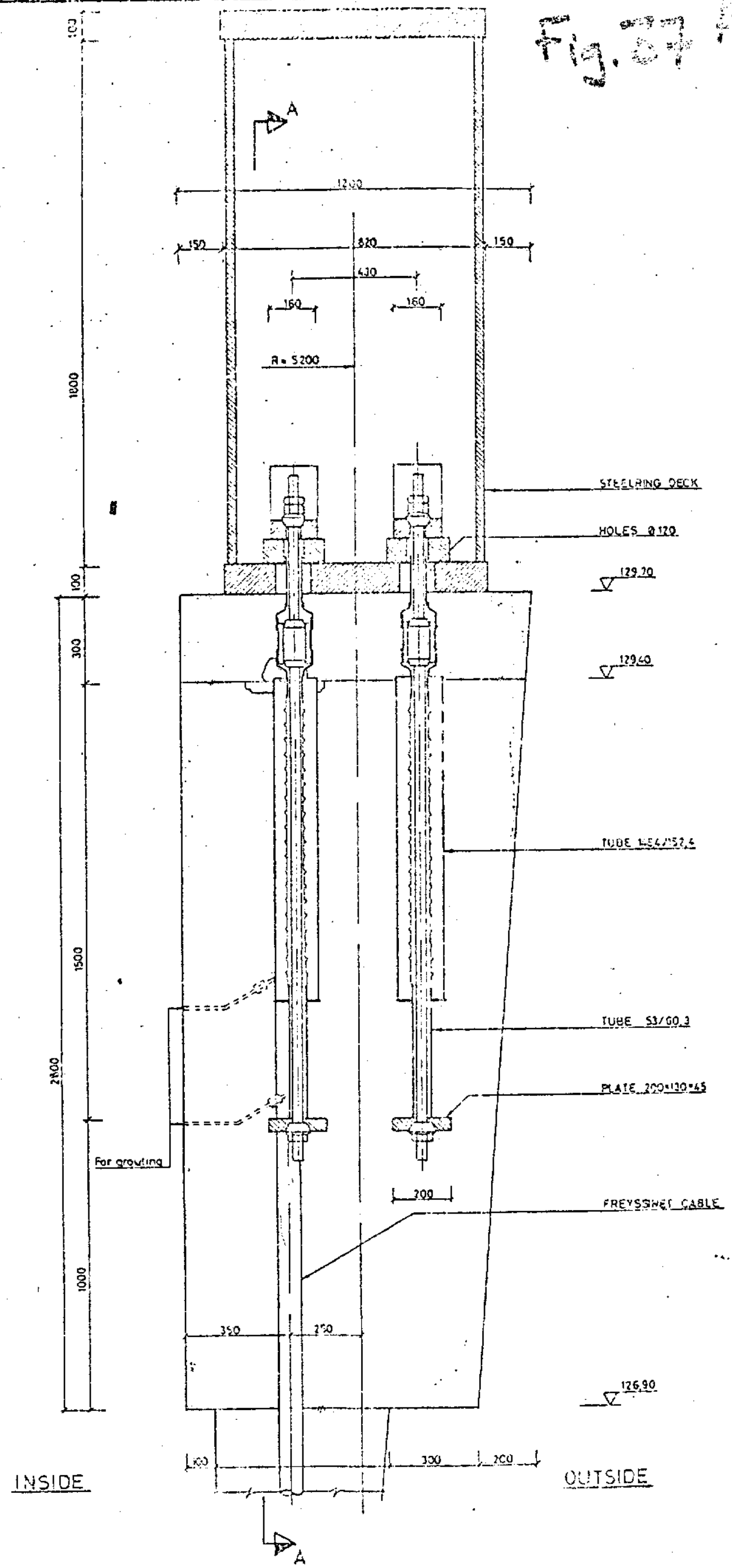
LEVELS FOR ANCHORING OF CABLES

SHEET 5



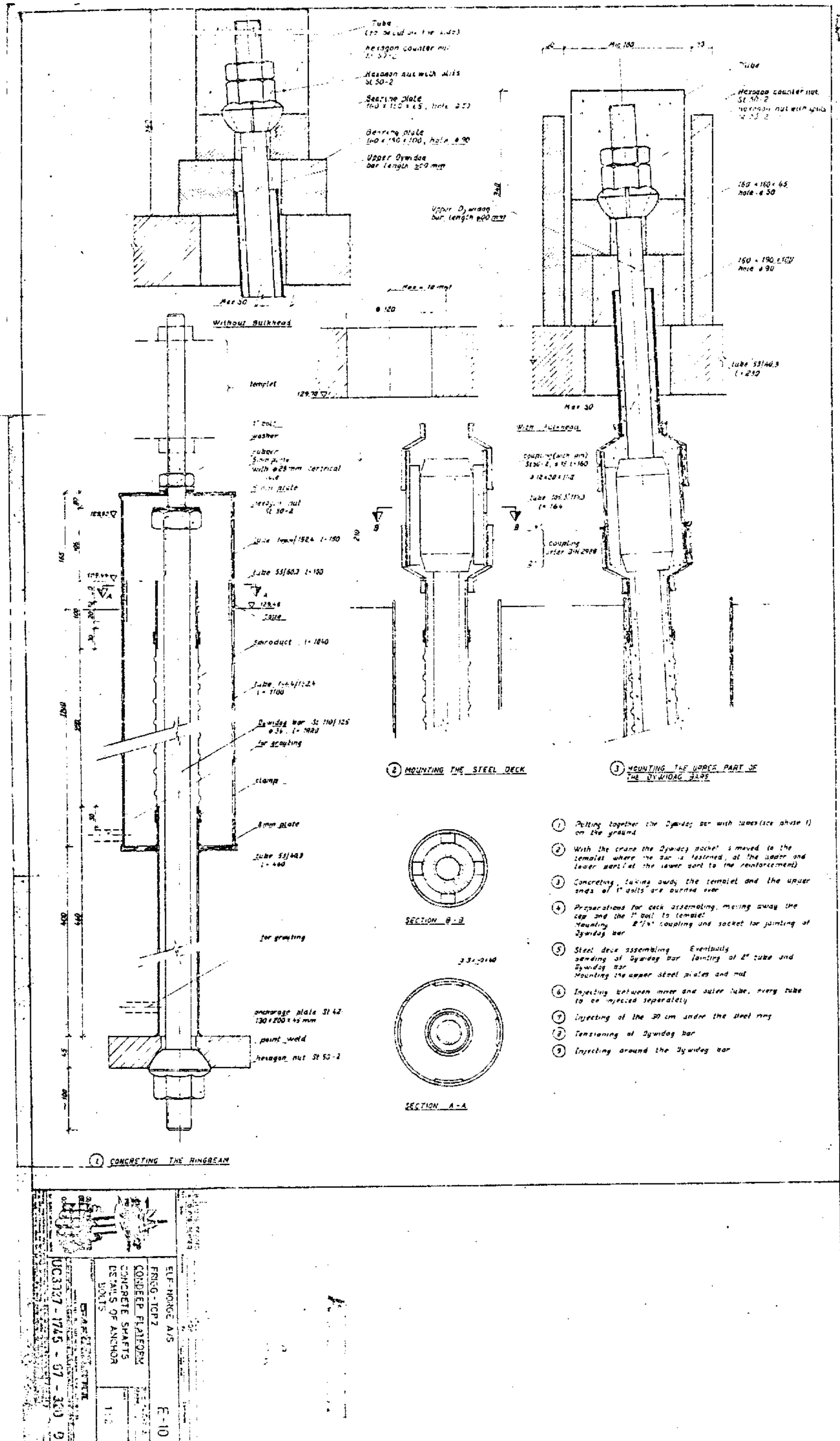
PLAN 1:10
SECTION C-C 1:10
WORKING PROCEDURE
1 The slots in the pilasters are chiseled out
2 Holes for reinforcement bars are drilled in the tankwall
3 The cables are placed in correct position around the tank
4 Reinforcement and anchors are placed. The reinf. bars are placed in the drilled holes and injected with epoxy mortar
5 Formwork are placed
6 The surfaces of the tank are primed with epoxy and then concreting is performed
7 Prestressing is performed when minimum cubestrength has reached 35 N/mm²
8 The anchorheads are sealed off and grouting is performed
REMARKS
REFERENCES
SECTION D-D
SECTION E-E
SECTION VIEW A-A 1:20
SECTION F-F
SECTION B-B
SECTION G-G
ELF-NORGE A/S
FRIGG-TCP 2
E-10
CONDEEP PLATFORM
CONDENSATE TANK
REPLACEMENT OF
CABLES GROUTED
WITH SALTWATER MIX
1:10,1:20
UC3325-1745-05-320

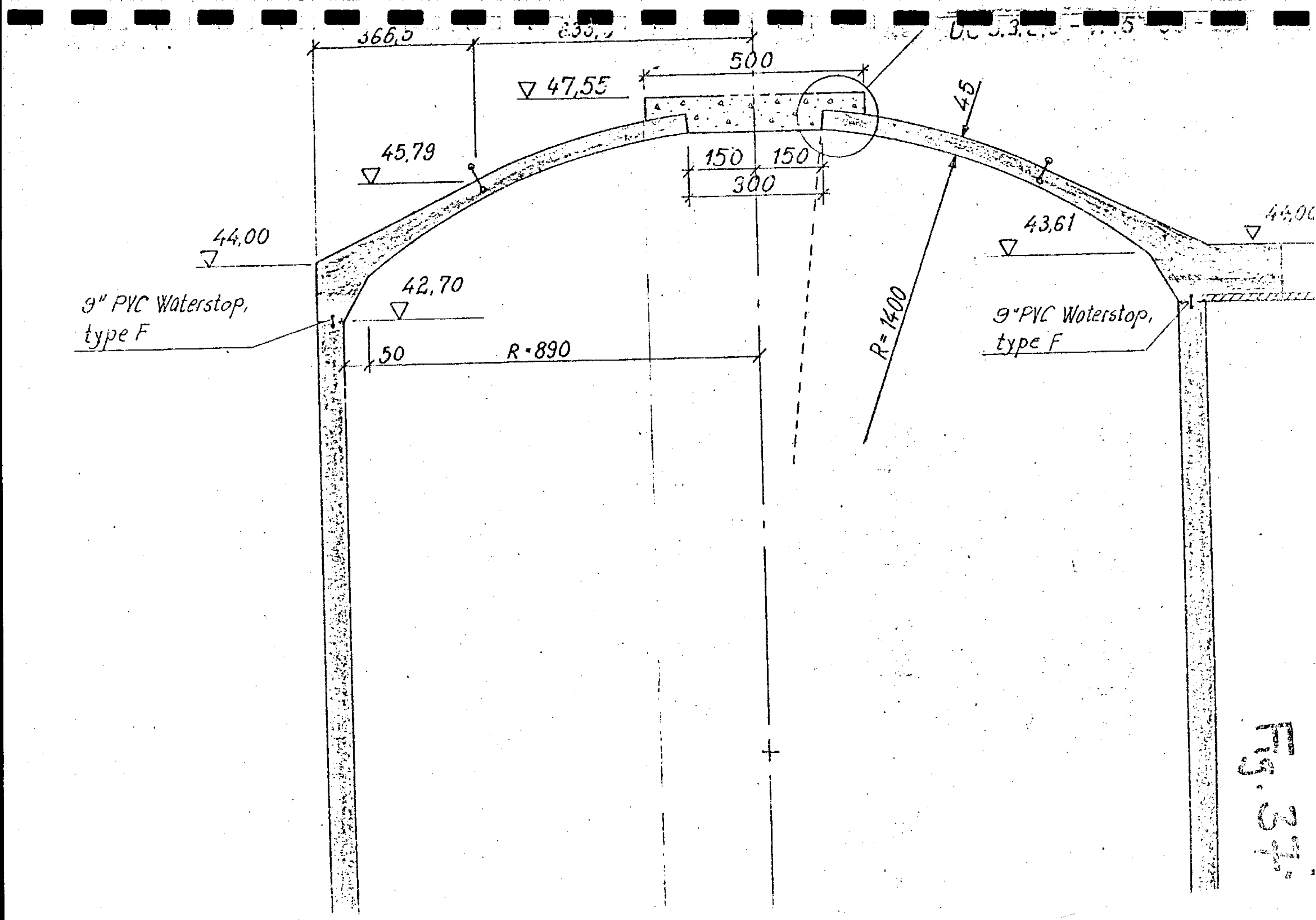
Fig. 37 A



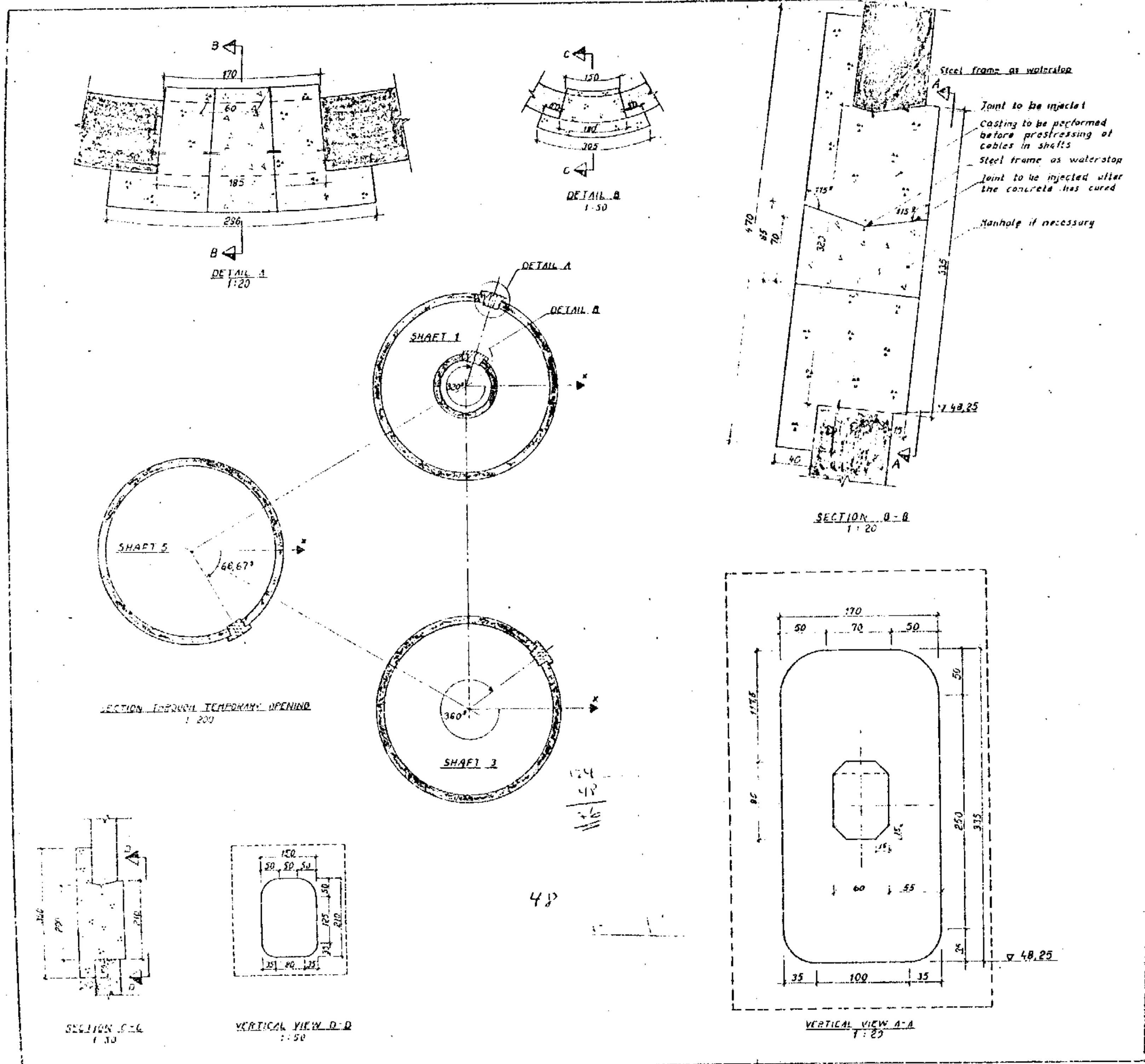
SHAFT 1 & 3

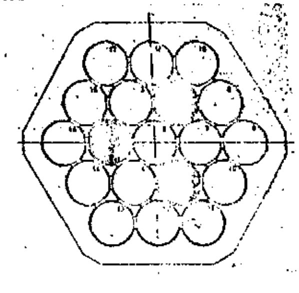
Fig. 3.5


Without Bulkhead
With Bulkhead
Bearing plate
Upper Dywidag bar length
Hexagon counter nut St 50-2
templet
washer
rubber
hexagon nut St 50-2
tube 55/60.3 l=100
Densoduct l=1840
Dywidag bar St 110/125 ø 36 l=1920
for grouting
clamp
8mm plate
tube 55/60.3 l=460
anchorage plate St 42 130×200×45 mm
point weld
hexagon nut St 50-2
coupling after DIN 2986
tube 55/40.3 l=230
1 CONCRETING THE RINGBEAM
2 MOUNTING THE STEEL DECK
3 MOUNTING THE UPPER PART OF THE DYWIDAG BARS
SECTION B-B
SECTION A-A
1 Putting together the Dywidag bar with tubes (see phase 1) on the ground
2 With the crane the Dywidag socket is moved to the templet where the bar is fastened, at the upper and lower part (at the lower part to the reinforcement)
3 Concreting, taking away the templet and the upper ends of 1" bolts are burned over
4 Preparations for deck assembling, moving away the cap and the 1" bolt to templet. Mounting 2"/4" coupling and socket for jointing of Dywidag bar
5 Steel deck assembling. Eventually bending of Dywidag bar. Jointing of 2" tube and Dywidag bar. Mounting the upper steel plates and nut
6 Injecting between inner and outer tube, every tube to be injected separately
7 Injecting of the 30 cm under the steel ring
8 Tensioning of Dywidag bar
9 Injecting around the Dywidag bar
ELF-NORGE A/S
FRIGG-TCP 2
CONDEEP PLATFORM
CONCRETE SHAFTS
DETAILS OF ANCHOR BOLTS
E-10
UC3127-1745-07-300 D



366,5
500
∇ 47,55
45,79
45
150
150
300
44,00
43,61
44,00
42,70
9" PVC Waterstop, type F
50
R=890
R=1400
9"PVC Waterstop, type F





REMARKS

CONCRETE COVER TO REINFORCEMENT		CM
CABLE:	MIN	CM
EXTENDED INSPECTION		
CONCRETE GRADE	C45	
STEEL QUALITY		

REFERENCES

- Formwork shafts, see dwg UC 3337 - 1745 - 07 - 101
- Reinforcement temp. openings, ——— " ——— - 236

ELF-NORGE A/S

FRIGG - TCP 2

E-10

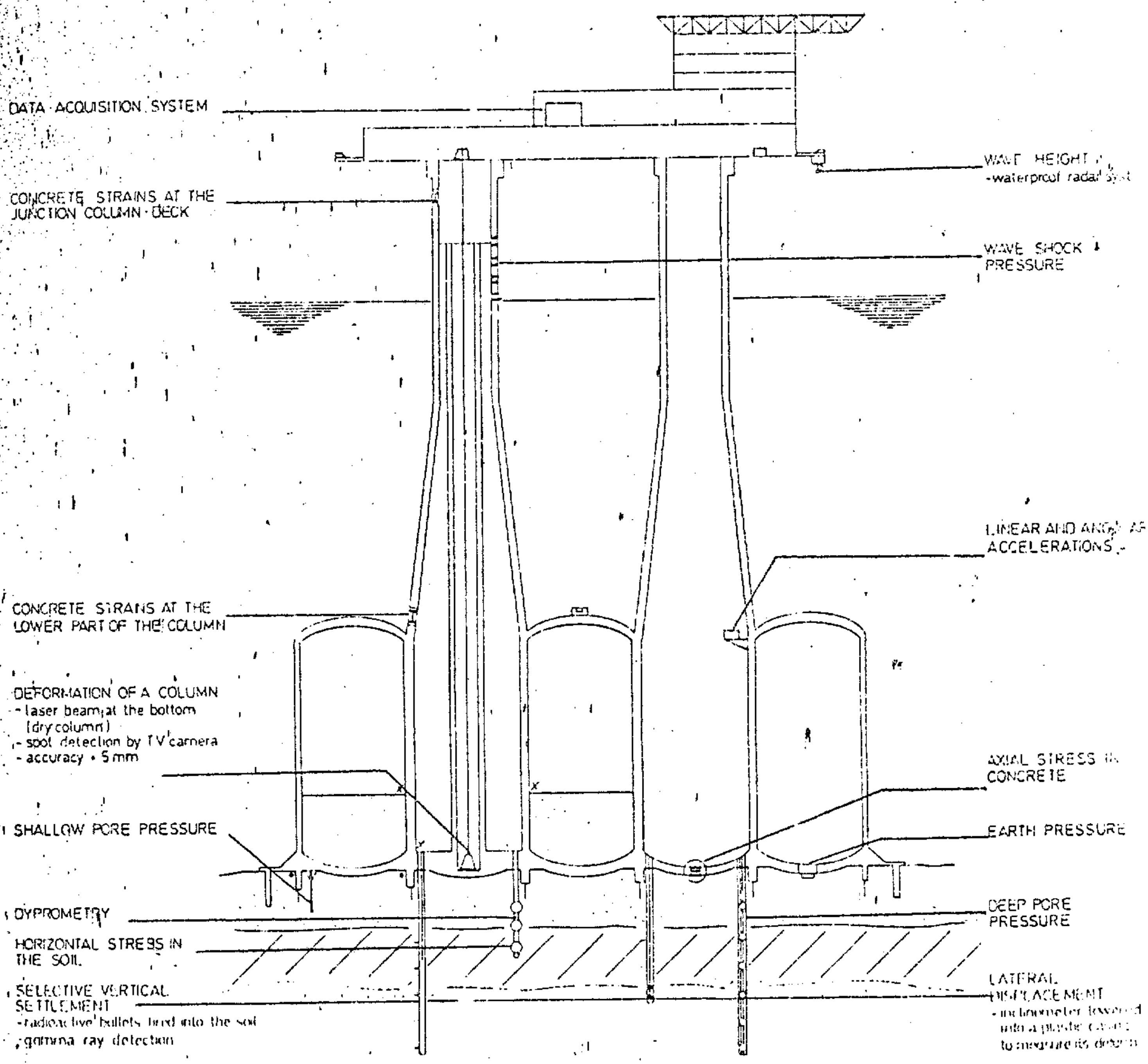
CONDEEP PLATFORM TEMPORARY OPENINGS IN SHAFT 1,3 & 5 AND BALLASTCYLINDER FORMWORK

1:20, 1:50, 1:200

UC3337 - 1745 - 07 - 105

Fig. 39

TCP 2: INSTRUMENTATION SUMMARY.



elf aquitaine norge a/s

SUMMARY

ENCLOSURE A

Norwegian Geotechnical Institute NGI

Norwegian Contractors
Hausmannsgt. 34

OSLO 1

26 SEPT 1977

Attn.: Siviling. Wolf

Oslo, 20th September, 1977
RKJ/sob

74810 Frigg Platform TCP 2
Future operation of anti-liquefaction system

1. GENERAL

We refer to our Operation Manual of 18th May 1977. The following comments may be added.

It may be difficult to give fixed criterias for taking action as potential danger may be caused by different constellations. Thus the functioning and the effect of the drainage system should be currently evaluated.

2. EFFECTS CAUSED BY DRAINAGE

When the drainage system is in operation, the following reactions will occur.

1) Skirt water pressure will be reduced.

2) Pore pressure will be reduced.

3) Effective stresses will increase in the subsoil and consequently increase settlement.

4) Transport of solids and percipitated materials in suspension may occur.

3. AIM

The aim is to establish an even suction under the whole base of the platform, but due to seepage, the reduction of pressure near the edge will be lower than under the centre.

To avoid an eccentric loading the skirt pressures should preferably be symmetrical around the centre.

4. OBSERVATIONS TO BE MADE

In order to observe the effect of the drainage system, measurements of skirt water pressure, pore pressure, settlement and tilt should be taken.

Contents of solids should also be controlled during the test period.

Possible piping is indicated by an increase in the water flow and an increase in the corresponding skirt pressure.

5. ANALYSIS OF WATER SAMPLES

The amount of solids and percipitated materials in suspension is to be determined by filtration.

The type of solids may be determined visually. If in doubt, X-ray defraction or atomic absorbtion spectrometry will have to be carried out.

6. ACCEPTABLE LIMITS FOR SUSPENDED MATERIALS

Valid to February 1978.

Maximum tolerable amount of materials in suspension:

From individual drains	:	0.2 grams/litre
From total flow	:	0.1 "

These limits applies to materials which are naturally present in the sea bed. For components from the grouting, specialists on grouting has to evaluate the tolerable amounts.

7. REVISION OF PROCEDURE FOR DETERMINING INDIVIDUAL FLOWS

To keep a nearly stationary flow and constant stress distribution, we would recommend that the water flow from individual groups of drains is determined by measuring the reduction obtained by shutting one group at a time.

Yours sincerely,
for the NORWEGIAN GEOTECHNICAL INSTITUTE

R. Jonsrud

Ragnar Jonsrud

Encl. 1. Activity log for the starting up of the anti-liquefaction system.
2. Values of skirt pressures.

Enclosure 2

elf aquitaine norge a/s

P.O. BOX 168
N. 4001 STAVANGER
TEL. (045) 41 011 TELEX 33174

98119 22.09.77

Det norske Veritas,
P.O. Box 300,

N-1322 HØVIK.

Industrial and Offshore Division.

Attn.: Mr. Warming, Jørgen.

YOUR REF.

OUR REF. 311 J Sc 77/0391/MPD/kh STAVANGER, 19th of September, 1977.

22 SEPT. 1977

Please find enclosed the procedures concerning rip rap operations. This work consists inthe antiscour protection of the corridor between platforms TP1 and TCP2 by laying 100/200mm rip rap round the footing of the above mentioned platforms.

The area to be covered is defined on sketch no. 1. The quantity of rip rap is around 7000m³ taking into account the 20m width to be protected, a covering thickness of 1m and a 1/5 slope.

OK OK but

This job shall be carried out by A.C.Z. Marine Engineering LTD during October 1977.

We remain at your disposal for any further informations,

Yours faithfully,

M.P. Delacroix

1) (graded) mixed materials with fines (tests ?)
2) results of tests ? (to be presented end of July)
3) 1. stage, what then ?
TP1 west side
TCP 2 north and east
4) Monitoring and surveying ?
DnV to receive documentation

1. - Specifications of Rip-rap

1. Destination

The rip-rap, subject of the present specifications, are destined to ensure the protection of platforms TP 1 and TCP 2 on the Frigg Field against erosion.

2. Granulometry

Crushed rip-rap of 100/200 mm.

2.1. Granulometry allowances

No rip-rap with a side greater than 200 mm shall be permitted.

No more than five per cent (5 %) rip-rap smaller than 100 mm shall be permitted.

2.2. Size allowances

No more than ten per cent (10 %) rip-rap having their largest side more than twice that of the smallest side shall be permitted.

3. Density

The density γ_s of the materials composing the rip-rap must not be less than 2.5 T/m3. It should not vary by more than 5 % from one rip-rap to another :

$$\frac{\Delta \gamma_s}{\gamma_s} < 5\ \%$$

4. Structure and stability of the rock

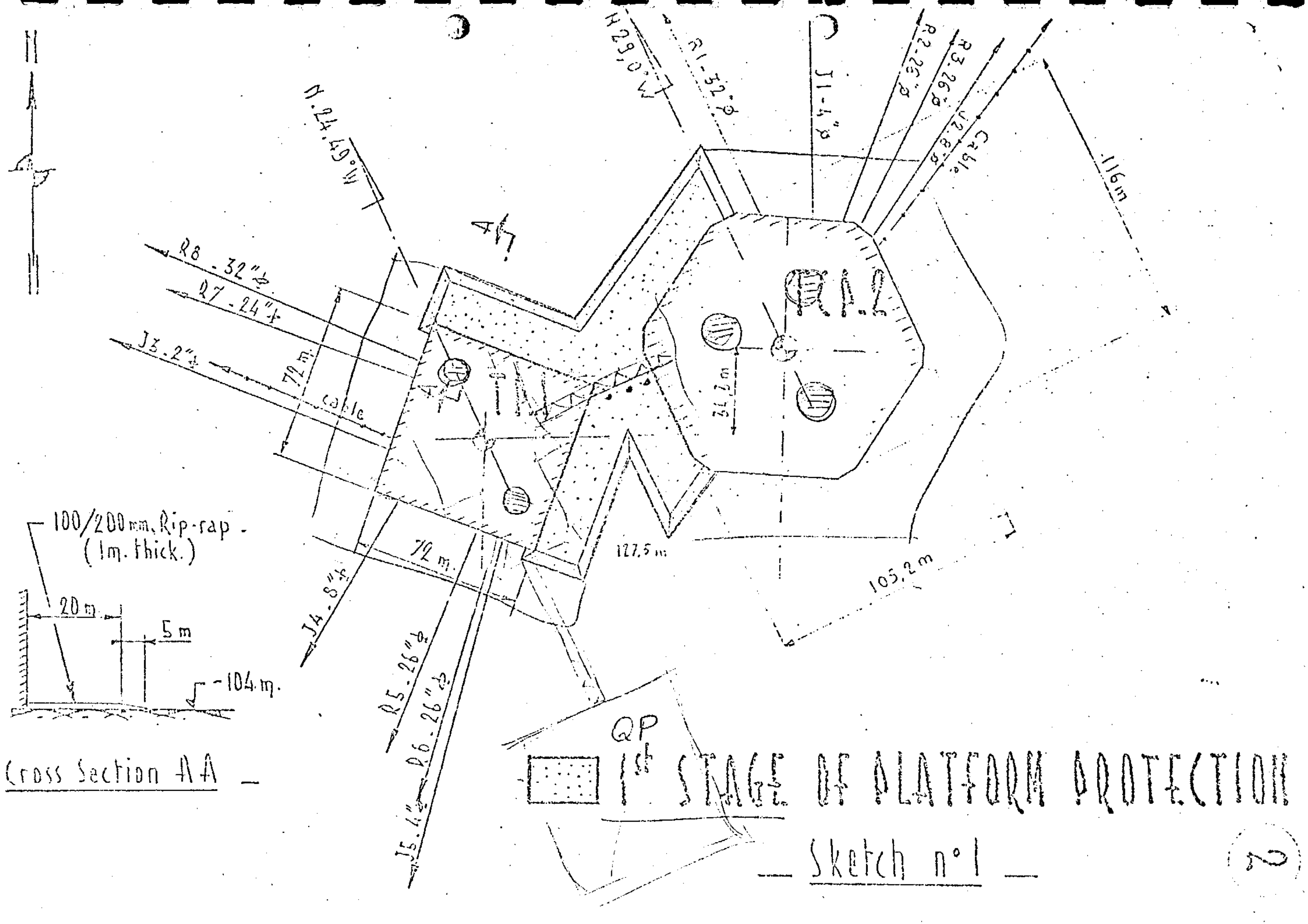
The rip-rap are derived from compact non lamellar rocks stable in sea water.

5. Quarry

The quarry from which the materials are extracted should be capable of supplying more than 10.000 m3 (ten thousand cubic meters) of rip-rap having the granulometry specified above.

The Contractor shall be responsable for obtaining permission to open the quarry, a duplicate of these documents shall be transmitted to the Company.

The Contractor shall supply the Company with samples of the rip-rap and a laboratory analysis report.



1st STAGE OF PLATFORM PROTECTION

Sketch n°1

2

INGENIØR CHR.F. GRØNER A.S.

Enclosure 3

ELF - NORGE A/S

FRIGG - TCP 2

CONCRETE DESIGN CRITERIA

New edition of 14th November 1974.

Høvik, 14.11.74
/ PTA

CONTENTS

1. GENERAL

The structural design of the FRIGG-TCP 2 CONDEEP PLATFORM shall confirm to the following design criteria:

A. The basic code shall be the Norwegian Code of Practice for Concrete Structures, Computations and Design, NS 3473.

B. As a supplement to the Norwegian Code, NS 3473, the TNO-SPECIFICATIONS paragraph 3.3.0 through 3.5.2.3 shall be used with the comments as stated under paragraph 3. in this document.

C. Special requirements from Det Norske Veritas for gravity offshore concrete structures.

2. CLARIFICATION

2.1. The Norwegian Code, NS 3473.

a. In the text there are some references to other Norwegian Codes:

a1. NS 3474 - Is translated into English and has for some time been available. See Appendix A.

a2. NS 3052, first edition, March 1970 - does not apply to offshore concrete structures and therefore shall be disregarded. The loadfactors to be used are defined in paragraph 4. in this document.

a3. References on page 10 are of no value for the use of the code.

a4. Paragraph 3.1.1 on page 13: The loads to be used in the calculation of this offshore structure have to be defined from special tests, measurements or other documentations.

a5. Paragraph 4.2 on page 18: See a2. on the preceding page.

a6. Paragraph 7.1.2 on page 41: See a2. on the preceding page.

a7. NS 481, Part 1: This code gives the standardized dimensions of plain hot rolled bars, tolerances of the diameter and the minimum required yield strength. See Appendix B.

a8. NS 482, Part 2: This code gives the same as in part 1, but for hot rolled deformed bars. See Appendix C.

a9. NS 3050: Has been translated into English. See Appendix D.

a10. NS 427A, Part 2, Sect. 5.4: Has been translated into English. See Appendix E.

a11. NS 481, Part 3: This code has to do with steel for prestressed concrete. See Appendix F. Designations and technical terms.

The corresponding English Code might be used.

b. The safety levels which are attained by using the NS 3473 and the loadfactors in paragraph 4. in this document are shown in Appendix G.

3. COMMENTS TO THE TNC - SPECIFICATIONS

a. Page 37: The idealized Smith-diagram to be in accordance with the test results from the actual reinforcement steel being used.

b. Page 38: The stress-strain curve of the actual prestressing steel to be used.

c. Page 39 and 40: The evalution of the design strength for concrete in compression and the stress-strain curve of concrete to be in accordance with NS 3473.

d. Paragraph 3.4.3.1: To be disregarded.

e. Paragraph 3.5.1.2: The load factors to be used together with the material properties as given in NS 3473 are defined in paragraph 4. in this document.

f. Paragraph 3.5.1.3: When deriving at the shear capacity of a cross-section the normal force should be taken into account if by documentation this can be verified.

The reduction of the shearforce some specified distance from a support is allowed if by documentation this can be verified.

g. Paragraph 3.5.1.5: The requirements of crack-width limitations shall be regarded as fullfilled by limiting the steelstresses in ordinary reinforced concrete as defined in paragraph 5. in this document.

4. LOADFACTORS TO BE USED WITH NS3473.

4.1 Ultimate limit state.

In the ULS checks, the following load factors are applied to the functional and environmental loads for the different combinations.

TABLE 2

LOAD	γ_f - Load factor							
	Functional						Environm.	Material safety factors γ_m to be in accordance with NS3473
Type of combination	D	L	F_t	F_p	P	T	E	
a	1.2	1.2	1.1	1.2	1)	2)	0	
b1	1.1	1.1	-	1.1	1)	2)	1.3	
b2	0.9	0.9	-	0.9	1)	2)	1.3	
c	1.2	1.2	-	1.2	1)	2)	1.3	

1) For direct loading effects on the concrete section, γ_f should be taken as the most unfavourable of the values 1.1 and 0.9. For indirect effects, such as moments in statically indeterminate systems due to prestress, γ_f can be taken equal to 1.0.

2) Where the effects due to differential settlements, creep, shrinkage, temperature may be significant, they are to be accounted for using $\gamma_f = 1.1$.

The loading combination listed in the table imply:

a) Functional loads.

b1) Functional loads maximum + extraordinary environmental.

b2) Functional load minimum (i.e. reduced dead load when it acts favourably) + extraordinary environmental loads.

c) Functional loads + "Ordinary" environmental loads.

Additional loading conditions to be checked:

1. Local soil pressure on lower dome. A load factor γ_f = 1.0 shall be applied, assuming that loads measured during installation.

2. The tensile capacity of the lower dome shall be checked for the applied suction forces during penetration. A load factor of γ_f = 1.2 shall be applied to the suction forces in loading combination a).

3. Grouting pressure. A load factor of γ_f = 1.0 shall be applied, assuming max. load on dome to grouting pressure is measured during installations.

4. The structure should be checked for misuse or accident (i.e. loss of hydrostatic pressure difference) applying a load factor γ_f = 1.0 on all loads. Only those loads likely to act simultaneously need to be considered.

5. LIMIT STATE OF CRACK-WIDTH.

5.1 Serviceability limit state.

The following limitations on reinforcement stresses are to be applied in the S.L.S. The purpose of the limitations on steel stresses in the S.L.S. is primarily to limit crack widths.

In S.L.S. creep and shrinkage of concrete and relaxation of reinforcement are to be taken into account.

Phase	Loading combin.	γ_f	Allowable stresses in SLS. N/mm^2	
			below - 20 m	above - 10 m
C	a)[1]	1.0	f_s = 200	f_s = 200
T and I	a)	1.0	f_s = 260	f_s = 260
0	a) and c)	1.0	f_s = 160	f_s = 100 x

x between - 20 m and - 10 m the allowable stresses may be changed linearly.

f_s = design strength of steel in ordinary reinforced concrete.

1) For short term loads during the construction phase 30% increase in stresses is allowed.

Overlevert i møte DNV
2.12.74 til

Høyer-Ellefsen v/ Grønnrød
Grøner v/ Andersen
Status Oljedirektorat v/ Haug.

Enclosure 4

DET NORSKE VERITAS

CLASSIFICATION AND REGISTRY OF SHIPPING
ESTABL. 1864

HEAD OFFICE

Til/To Råd. ing. Grøner
att. Siv. ing. Barset
Marieveien, Høvik

Oversendes uten følgeskriv/Forwarded without covering letter
Ikke godkjent vert trykksaksforsendelse/Not approved by G.P.O. as printed matter

- [x] Etter avtale / As arranged
- [ ] I henhold til Deres brev av / In accordance with your letter of
- [ ] Til orientering / For your information
- [ ] Til godkjennelse / For approval
- [ ] Returneres med takk for lånet / Returned with thanks
- [ ] Vennligst ring om dette / Please telephone in this regard
- [ ] Kan beholdes / May be retained
- [ ] Ønskes i retur / Please return
- [ ] ____________________
- [ ] ____________________

Svein Fjær

ELF-NORGE A/S - FRIGG TCP2

CONCRETE DESIGN CRITERIA

SPECIAL REQUIREMENTS FROM DnV

A. GENERAL

The intent of the present paper is to give additional requirements to the "Concrete Design Criteria" dated 14.11.74 issued by C. F. Grøner A/S. The paper can be regarded as the supplement C to the specifications A and B as recorded in chapter 1 of the Grøner criteria.

We assume that where discrepancy exists between the three specifications A, B and C, B is valid before A and C before A and B. ok

DnV's additional requirements most convinicntly can be related to the TNO-specifications. Therefore in the following paragraphs the requirements are given in terms of comments to the TNO criteria.

B. COMMENTS TO THE TNO-CRITERIA

3.3.2. 3.3.3. For definitions of loads reference, load condition and design principles is made to DnV Rules. ok

3.3.4.2. Foundation design is considered beyond the scope of the present criteria. ok

3.3.8. Steel design criteria is considered beyond the scope of the present criteria. ok

3.4.1.1. Steel strain should be limited to ε_{sy} + 5‰ Fatigue strength of steel bent to a radius less than 25 d is half the stress range for bars which has not been bent. ok

3.4.1.2. The stress-strain curve of the prestressing steel in question to be used.

3.4.2.1.1. The evaluation of the design strength for concrete in compression and the stress strain curve of concrete to be in accordance with NS 3473. The fatigue strength proposal is adequate provided static strength means static design capacity of the section. ok

3.4.3.1. Miners factor should be less than 0,2.

3.5.1.1. The load factors do not cover effects of structural imperfections with regard to structural stability. The safety factors with regard to soil is beyond the scope of the present paper.

3.5.1.2. The load factors to be used together with the material properties as given in 3473 are given below:

LOAD	Load factor									Material safety factor to be in accordance with
	Functional							Environm.		
Type Combinat.	D	L	F_t	F_p	P	T	To	W	S	
a	1.2	1.6[x]	1.1	1.2	1)	1.2	1.2	0	0	
b1	1.1	1.3	-	1.1	1)	1.2	1.2	1.2	1.2	NS 3473
b2	0.9	0.9[xx]	-	0.9	1)	1.2	1.2	1.3	1.3	

HUSK γ_f = 1,0 skal regnes på innvendig vanntrykk & ballast

x Maximum Live Load
xx Minimum Live Load
1) To be chosen in accordance with NS 3473

The loading combinations listen in table 2 implies:

a) Functional loads.
b1) Functional loads maximum + extraordinary environmental loads.
b2) Functional load minimum (i.e. reduced dead load when it acts favourably) + extraordinary environmental loads.

Additional loading conditions to be checked:

1. Local soil pressure on lower dome. A load factor of γ_f = 1.1 shall be applied, assuming that loads are based on analysis based on conservative soil parameters or on the most accurate pressure control during installation.

2. The tensile capacity of the lower dome shall be checked for the applied suction forces during penetration. A load factor γ_f = 1.2 shall be applied to the suction forces in loading combination a).

3. Grouting pressure. A load factor γ_f = 1.05 shall be applied, assuming max. load on dome due to grouting pressure are measured during installation.

4. The structure shall be checked for missuse or accident (i.e. loss of hydrostatic pressure difference) applying a load factor γ_f = 1.05 on all loads. Only those loads likely to be acting simultaneously need to be considered.

5. Load factors for loading conditions not covered in this document shall be agreed upon by DnV before applied.

6. Any load factor shall be given the value 1.0 if more unfavourable than the values given in the table.

The base of the towers shall be designed so that a possibl failure will develop in a ductile manner.

3.5.1.3. Design strength is to be taken in accordance with NS 3473. Shear capacity is to be taken in accordance with NS 3473. The rules developed for hollow cylindrical cross sections are not applicable. These type of sections are to be designed according to recognized methods for shell design.

3.5.1.5. Fatigue of concrete and steel is to be checked on the basis of the data given by TNO taking in account the aforementioned comments.

Fatigue in shear and bond should be checked by methods accepted by DnV.

Limit state of crack width is controlled by the requirements given in DnV rules Section 5 ch. D300 and E400.

Where principle tension stresses act at an angle more than 25° with any direction of reinforcement, special considerations are to be made.

3.5.1.6. The dynamic response should be kept under perceptibility F for operating conditions and D for extreme conditions.

3.5.1.8. The formula given are not satisfactory for a check of buckling and second order effects. Stability is to be investigated in accordance with principles given in NS 3473 ch. 5.5.

3.5.2.0. Minimum cover shall nowhere exceed the values given by more than 1.5 cm.

3.5.2.2. This point does not cancel the general requests for minimum reinforcement in NS 3473.

Fje/AAD

28.11.1974.

Enclosure 5
No. 076-45-75

STATFJORD PLATFORM A, BRENT D, FRIGG TCP 2

DnV's Concrete Design Criteria.

REFERAT FRA MØTE PÅ VMI 8.4.75.

Til stede:		
	Dahl	Dr. Olsen
	Erland	"
	Harstrup	"
	Børseth	Grøner
	Skåre	Høyer-Ellefsen
	Fjeld	DnV
	Røland	"
	Sigfridsson	"
	Sørensen	"

1. Hensikt.

Hensikten med møtet var å spesifisere bruken av lastfaktorene i DnV's Concrete Design Criteria.

2. Concrete Design Criteria.

Dahl uttalte at følgende kriterier vil bli benyttet:

Statfjord A	: DnV Concrete Design Criteria datert	23.10.74.
Frigg TCP 2	: " " " " "	28.11.74.
Brent D	: " " " " "	23.10.74.

Fjeld påpekte at Oljedirektoratet utarbeider nye kriterier og at spørsmålet om gyldigheten av DnV's kriterier for Statfjord A og Frigg TCP 2 vil bli tatt opp med dem.

Lastfaktorene for ULS i DnV kriterier brukes sammen med følgende retningslinjer:

2.1. Hydrostatisk trykk.

I plattformens operasjonstilstand regnes det kun lastfaktorer forskjellig fra 1.0, på differansen mellom innvendig og utvendig vanntrykk.

I tilstander frem til og med installasjonsfasen, regnes det uavhengige lastfaktorer på utvendig og innvendig vanntrykk.

Kriteriene er å forstå slik at lastfaktoren skal settes til 1.0 for et (eller begge) vanntrykk i de tilfeller dette er ugunstigere enn de verdier som er angitt i kriteriene.

2.2. Egenvekt.

Lastfaktoren skal settes til 1.0 i de tilfeller dette er ugunstigere enn de verdier som er angitt i kriteriene. Faktoren 1.0 brukes i slike tilfeller på hele betongkonstruksjonen.

2.3. Ballast.

Som for egenvekt.

2.4. Temperatureffekter.

Det skal regnes med de angitte lastfaktorer. De beregnede snittkrefter fra disse effekter kan imidlertid reduseres i relasjon til den stivhetsreduksjon p.g.a. oppsprekking som påviselig er tilstede i konstruksjonen ved den aktuelle lastkombinasjon.

En slik reduksjon kan også foretas i SLS.

2.5. Spennkraft.

Det vises i kriteriene til NS 3473. DnV vil vurdere nærmere om lastfaktoren skal settes til 0.9 (0.88) i de tilfeller dette er ugunstigere enn de der angitte faktorer.

Spennkraften reduseres med alle tap i tilfeller hvor dette er ugunstig. I motsatt fall medregnes kun de tap som med sikkerhet har inntruffet.

Oslo, 11.4.1975

KSØR/JT

214756 nova d
16192c verit n

Enclosure 6

roel/ahe/janb 11.5.76 telex no 7786

very urgent .

to: norwegian contractors
att.: mr. gjerde

copy to:
elf-norge, paris, att.: mr. bednarski/puidebat
elf-norge, aandalsnes, att.: mr. duvet
dnv, hamburg
dnv, essen, att.: mr. samdal

----

frigg field - condeep platform - tcp-2
prestressing bars for deck/shaft connection - dywidag st 110/125

---

further to meeting at dnv, oslo 11.5.76 between norcon and dnv, this is to inform you that the dywidag prestressing bars can be used with the following requirements from dnv:

1. the section between steel ringbeam and concrete shaft shall be in compresion even in the load combinations including maximum environmental loads, though without load factors.

2. with the assumption that design criteria for maximum tensile stress in the bars in uls is 0.8 times yield strength - according to ns 3473, all bars shall finally be stressed to 0.85 times yield strength as installed prior to grouting. locking stress assumed equal to 0.8 fy.

the stress in bars shall under no load condition (uls or sls)

the stress in bars shall under no load condition (uls or sls) exceed the stress level at prestressing.

3. magnetic particle testing of all bars for transverse surface cracks to be performed by manufacturer.

4. the quality of final grouting of bolts as proposed on groener dwg. uc. 3.3.3.7-1745-07-320 shall be document3ed by procedure tests.

5. complete documentation to be submitted regarding corrosion protection of bars in the period of 6 months from installation to grouting. it is to be documented that the temporary protection of ''self-healing'' fat does not have to be removed before grouting. documentation on performed corrosion tests on bars to be submitted to dnv.

6. prestressing bars will be supplied with test reports, certified by dnv, based on batches of max 50 tons/one heat.

7. a certain numbers of bars to be made accessible for routine checks by ultrasonic testing from topside.

in addition we recommend the bars to be tested by the manufacturer to 0.85 fy.

regards fjeld/eide/roeland

veritas o++++++

16192c verit n
214756 nove d

>16192b verit n

Enclosure 7

roel/ahe/janb 21.1.76 telex no 871

to: elf norge, paris, att.: mr. plouviez
from: det norske veritas, oslo

copy to:
norwegian petroleum directorate, stavanger
norwegian contractors, stabekk, att.: mr. eriksen
hoeyer-ellefsen, oslo, att.: mr. grorud
elf, aandalsnes, att.: dyvet

re.: condeep platform - design criteria, load combination-
loss of hydrostatic underpressure and extraordinary
environmental loads.
elf - norge a/s - frigg tcp 2

we refer to your telex no. 76/297 dated 19.1.76 and to our telex no. 9551 dated 22 12.75 to hoeyer-ellefsen, and repeat our point of view regarding the above load combination:

dnv does not require the platform to be designed for the loadcombination loss of hyrdostatic underpressure and extraordinary environmental loadsn provided it is verified that no major break-down of the structure will occur.

if this combination should occur, a half in production will be required, a thorough inspection will have to be carried out and any defects be repairedn if the platform is to be put into production again.

this point of view is shared by the norwegian petroleum directorate (npd).

in other words, if only a simplified calculation is submitted verifying sufficient capasity against a major break-down of the platform, the above actions will be required.

however, at this stage it appears that the designer has treated the above load combination on the same level as other critical load combinations with checks in uls with a general load factor of 1.05 and in sls with load factor of 1.0.

with this thorough design, dnv will not require a halt in production and inspection before resumption of production if such a load combination should occur.

regards fjeld/roeland

veritas o+++++++
16192b verit n
40017 nocon nm

Enclosure 8

FIXED OFFSHORE STRUCTURES

TECHNICAL NOTE.

OFFSHORE PLATFORMS - IMPACT LOADS FROM BOATS	Ref.: A6/5	
	Rev.: -	Date: 17.3.75

INTRODUCTION

Although the activity in the North Sea has lasted for a relatively short time, several platforms, both mobile and fixed, have been damaged due to impact loads from boats.

The question may arise if the platform, or special parts of them, should be protected in order to withstand a reasonable impact energy, and/or if special requirements should be put on the boats which are allowed to approach the platform.

PROPOSAL

Design loads

In order to obtain realistic load conditions two cases may be considered.

a) An operational load with an impact energy which the platform should withstand without damage, by use of fenders or by its own structural strength.
This load may for instance be caused by a supplyboat when approaching or leaving the platform.

b) An extreme load for which some damage may be allowed, but the platform as a whole should be constructed so as not to collapse. Such a situation may for instance occur if a supplyboat out of control is drifting against the platform. The impact velocity may be determined for each special location, also taking into account weather conditions and boat characteristics.

Main structure/special parts of the structure.

Special attention should be paid to the necessity for protection of parts of the structure or for the structure as a whole. Important members and gas/oil risers may need protection.

Information to be submitted

- Area of structure to be protected
- Actual impact energy, depending on boat size and impact velocity (for both load cases)
- Calculation of protection method, including type and size of bumper and installation method.

GUIDANCE

In order to pursue the design philosophy one should try to obtain the actual risk for impact loads on platforms and design according to this. Due to lack of data, no such probability method can be developed for some time. In order to solve the problem one has to agree on reasonable loadcases based on present knowledge and experience, that means to settle on a design boat size, strength and impact velocity.

a. Design boat size

Ships in general are not allowed to approach the platforms. If any accident occurs, it will most probably be caused by a supplyboat. An estimate of the size of future supplyboats indicates boats of about 2500 tons displacement.

b. Impact velocity

- Based on reasonable criteria a velocity of 0, 5 m/s may be established for the operational load case.
- The impact velocity in case of a boat out of control drifting against the platform may be determined by adding the effect on the boat from wind, current and waves, also taking into account the actual response of the boat in these load cases. The weather conditions should be those for which the supplyboat has to stop operating and move away.
  The impact velocity resulting from such a condition may be in the order of 1.5 - 2.0 m/s.

c. Impact energy.

When the boat dimensions and impact velocity is known, wellknown formulas may be applied for the impact energy also taking into account the hydrodynamic mass of the boat.

d. Sector to protect and height of protection

The sector to protect should be based on the intended approach direction of the supplyboats with a safety sector on each side.
The necessary height of the fendering system will depend upon factors such as wave crest and wave trough, mean tide elevations (fixed structure), relative motion platform/boat (mobile platforms), depth of fender beneath minimum waterline and height above maximum waterline.
For safety an extra length should be added at the top and bottom.

14/3/75
OPT/BG

Enclosure 9

FIXED OFFSHORE STRUCTURES

TECHNICAL NOTE.

GRAVITY STRUCTURES - SHOCK PRESSURE ON COLUMNS	Ref.: A6/1	
	Rev.: -	Date: 26/2-75

Definition

Shock pressure is defined as the impact pressure which arise when a breaking wave hits a relatively large structure.

Concern

Although the duration and exposed area of the impact pressure is limited, this load case is considered to be of great importance for the local strength of columns on gravity structures.

Requirements

- The possibility of braking waves for the actual area should be considered in order to determine a breaking waveheight (H_b) with the same level of probability to occur as the storm wave.
- The corresponding shock pressure intensity and distribution to be estimated
- A possible dynamic amplification to be taken into account.
- Calculation to be presented of the structures ability to withstand this load case.

0,25

Guidance

Investigations have recently been carried out about the probability for breaking waves in deep water. As breaking waves were defined waves with the relationship $H_b/T_b^2 > 0.267$ m/s (Ref. 1).
The results from this general investigation show that the most probable largest breaking wave height in a 100 year period is $H_{b100} \approx 1.4 \cdot H\,1/3$, where H 1/3 is the significant waveheight in the storm spectrum.

Significant wave ht $H_{1/3} \doteq H_{max}/1.9$

For TCP 2 $H_{1/3} = \frac{29}{1.9} = 15.3$ m

The corresponding wave period is as given from the above relationship. The magnitude of H_{b100} may of course vary from area to area, but the above figures may be used unless other documentation is provided.

The intensity and exposed area of the shock pressure will depend both on the structure and the breaking wave characteristic. Some information about this may be obtained from theoretical evaluation and in situ measurements on breakwaters and lighthouse. Unless more sophisticated calculations are provided, the basic equation for pressure,

$$P = C_s \cdot \gamma \cdot \frac{v^2}{2g}$$

may be used.

The shock pressure coefficient, C_s, should be chosen according to shape and dimensions of the exposed structure.

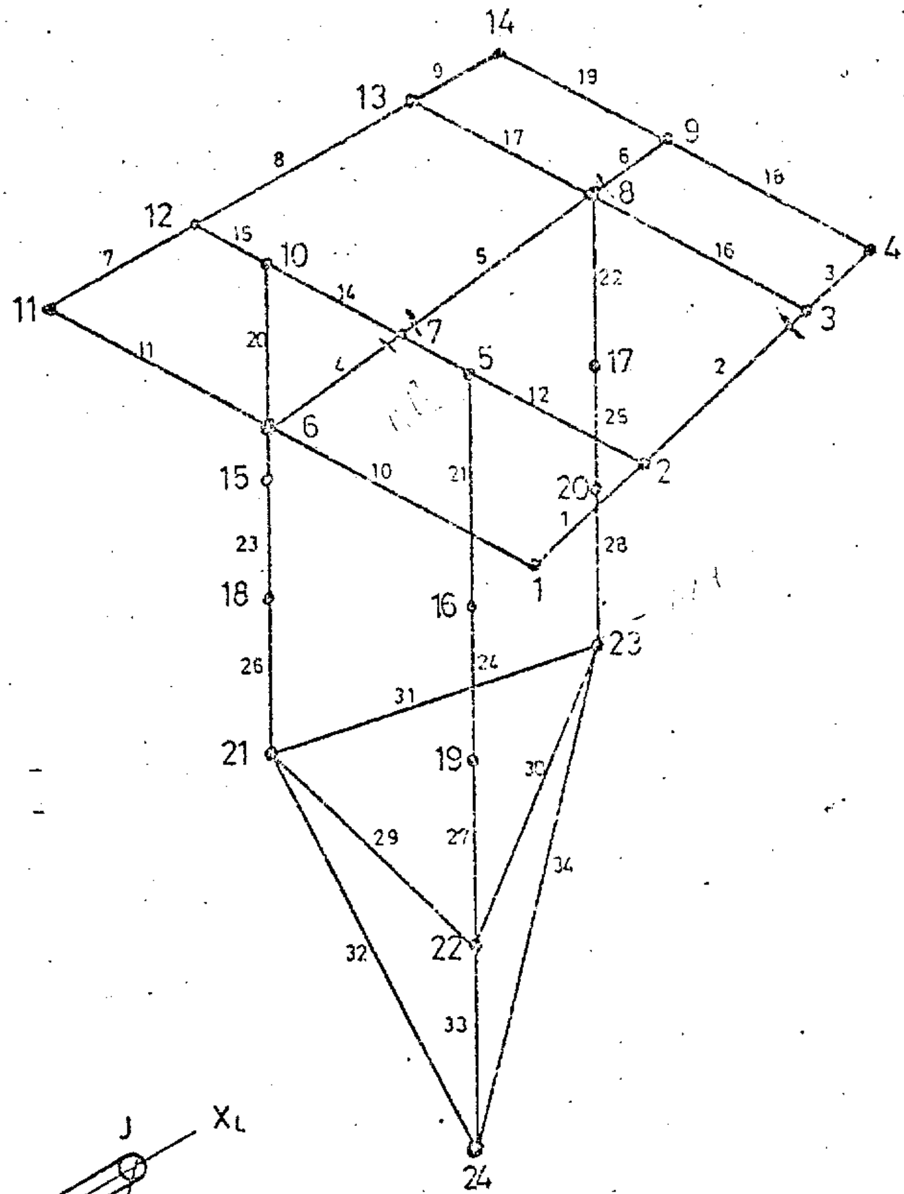
DnV is aware of the fact that this is a new problem for offshore deep water structures, and is consequently prepared to evaluate other and more sophisticated methods/approaches to solve it.

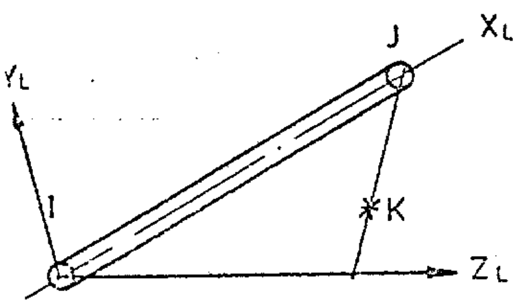
Ref. 1

Naht J.H. and Ramsey F.L: Probability Distribution of Breaking Wave Heights.
International Symposium on Ocean Wave Measurement and Analysis.
New Orleans, Louisiana, USA
Sept. 9-11-1974.

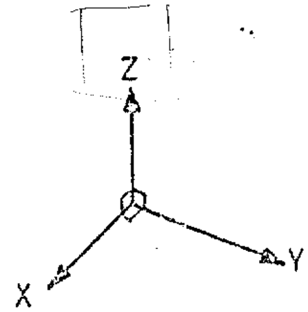
26/2/75
OPT/BG

Enclosure 10





Local coordinate system.
I_y — Cross-sectional moment of inertia about the local Z_L axis.
I_z — Cross sectional m of i about the local Y_L axis.



Global coordinate system

FIG. 2 FINITE ELEMENT MODEL

The model data are:

Nodal masses ($ts^2\ m^{-1}$)

1	115
2	249
3	211
4	86
5	105
6	133
7	240
8	266
9	107
10	96
11	99
12	219
13	212
14	95
15, 16, 17	836
18, 19, 20	910
21, 22, 23	10000
24	33000

Material properties:

Steel: $E = 21.5 \times 10^6\ t/m^2$, $G = 8.26 \times 10^6\ t/m^2$

Concrete: $E = 3.5 \times 10^6\ t/m^2$, $G = 1.4 \times 10^6\ t/m^2$

Soil : E : 2000 – 4000 t/m^2

Beam elements:

No.	Mat.	A m^2	Iy m^4	Iz m^4	Ix m^4
1, 3, 7, 9	steel	0.175	2,84	0.013	-
2, 8,	"	0.253	4.15	0.018	-
4	"	0.425	6.4	0.033	4.86
5	"	0.5	23.2	0.1	5.0
6	"	0.378	6.0	0.027	7.67
10, 11, 18,19	"	0.056	0.87	0.0008	-
12, 15	"	0.59	72.0	0.4	33.0
13, 14	"	0.864	63.0	0.4	7.4
16, 17	"	0.564	16.2	0.09	3.0
20, 21	concrete	14.1	174.0	174.0	348.0
22	"	17.0	230.0	230.0	460.0
23 - 25	"	19.2	413.0	413.0	826.0
26 - 28	"	30.4	1186.0	1186.0	2372.0
29 - 34	"	10^6	10^6	10^6	2×10^6

The nodal massed are calculated by adding the relevant platform dry weight to the additional hydrodynamic weight. The caisson mass was thus calculated to be:

Concrete bottom slab:

$\frac{2.5}{9.81} \times 1.75 \times \pi \times 53.5^2 \qquad = 4\,000\ tm^{-1}s^2$

Concrete walls

$\frac{2.5}{9.81} \times 19 \times \pi \times 20 \times 0.6 \times 38 \qquad = 6\,800$ "

Top shells

$\frac{2.5}{9.81} \times 16 \times \pi \times 10^2 \times 0.45 \qquad = 600$ "

Sand ballast

$\frac{2.0}{9.81} \times 16 \times \pi \times 9.4^2 \times 7 \qquad = 6\,300$ "

Water mass

$\frac{1.03}{9.81} \times 19 \times \pi \times 9.4^2 \times 28 \qquad = 15\,500$ "

Hydrodynamic mass

$\frac{1.03}{9.81} \times 19 \times \pi \times 10^2 \times 42 \qquad = 26\,300$ "

(Number of cells)

$59\,500\ tm^{-1}s^2$

The bottom slab and sand ballast is lumped at node 24 together with half the concrete wall mass, half the hydrodynamic mass and a proportionate amount of the water mass. The rest is divided between nodes 21-23, together with the contribution from the shaft bases.

$$m_{24} = 4\,000 + \frac{6\,800}{2} + \frac{15\,500}{2.5} + \frac{26\,300}{2} = 33\,000\ tm^{-1}s^2$$

The shaft stiffness is calculated by using mean values of stiffness.

Thus for element 23

$$I = \frac{\quad}{2}\left(0.53 \times \left(\frac{14.7}{2}\right)^3 + 0.45 \left(\frac{9.95}{2}\right)^3\right) \qquad 413\ m^4$$

Soil data:

Based on the most recent site soil data, NGI has estimated the soil shear modulus to be (4),

$$\underline{G = 2000 \ t/m^2}$$

The radiys of the equivalent base circel is 53.5 m, and the influence of the soil on platform vibrations is then calculated according to (3) which includes soil stiffness and damping coefficents based on half space theory. To account for a possible return of radiated energy due to soil layering the geometrical damping was reduced by 50 %.

To investigate the effect of a stiffer soil results are also presented for a soil shear modulus of,

$$\underline{\quad = 4\ 000 \ t/m^2}$$

Additonal damping.

Additional damping, representing 2% of critical damping (based on the mass matrix), has been introduced to represent internal damping effects.

[illegible]

Revised May 9, 1975

Enclosure [illegible]

CONCRETE CONSTRUCTION - TOLERANCES

CONDEEP PLATFORM

FRIGG TCP 2

1.	Foundation for steel skirts, vertically	± 3 cm
2.	Steel skirt	
	a) Top of steel skirt, on radius	± 2.0 cm
	b) Maximum slope to vertical	1 : 100
3.	Concrete skirt	
	a) On diameter	± 5 cm
	b) Wall thickness	+ 2 cm - 1 cm
4.	Domes	
	a) On diameter horizontal	± 5 cm
	b) On perfect shape	± 10 cm
	c) On thickness	+ 10 cm - zero
5.	Slipform, cell walls	
	a) Horizontal diameter of true circle, tolerance on installation of slipform included	± 5 cm
	b) Overall deviation from true circle, tolerance on installation of slipform included	± 5 cm
	c) Wall thickness	+ 2 cm - 1 cm
	d) Deviation of actual center from theoretical center	10 cm

6. Slipform, shafts

a) Horizontal diameter of true circle, tolerance on installation of slipform included ± 5 cm

b) Overall deviation from true circle, tol. on installation included (conical part) ± 10 cm

c) Overall deviation from true circle, tol. on installation included (cylindrical part) ± 5 cm

d) Wall thickness + 3 cm / - 1 cm

e) Distance between shafts center to center ± 15 cm

f) Deviation of actual centerline of each shaft from theoretical centerline 10 cm

7. Recesses and openings in slipformed walls

Placement, horizontal and vertical ± 10 cm

8. Recesses and openings, slipformed walls excluded. Placement: ± 10 cm

9. Weldplates and other inserts in slipformed walls will be recessed about 1.5 cm from concrete surface

10. Reinforcement - concrete cover

Reinforcement against fixed forms and cell walls slipform:

Below - 20 MLW (middle low water level): 7.5 +/- 1.0
Above - 20 MLW 8.5 +/- 1.0

11. Prestressing cables - concrete cover

A Cable ducts and anchors

Cantilevered slab: Cover min. 10 cm.
Live anchor: +/- 2.5 cm acc. to loc. on drawings.
Dead anchor: +/- 7.5 cm acc. to loc. on drawings.

Upper domes: Cover min. 10 cm.
Horisontal: +/- 5.0 cm acc. to loc. on drawings.
Vertical: +/- 10.0 cm. " " " " "
The theoretical circle radius R as shown on the drawings shall be maintained within the limits R +/- 5% of t (t = wall thickness).

Shafts: Cover min. 10 cm.
Horisontal radial: +/- 5.0 cm acc. to loc. on drwgs.
" tangential: +/-10.0 cm " " " " "

B <u>Prestressing cables</u>

40 mm or 10% of the distance to the nearest concrete face whichever is the smaller, on the theoretical position of individual cables or cable groups.

338828 13

C14

Enclosure 12

iod/roel/ahe/janb 28.10.77 telex no 101669

to: norwegian contractors, oslo, att.: mr. wolff

copy to:
elf stavanger, att.: marchand/tremon/wautelet/oedegaard
elf tcp2, frigg , att.: davis/digoix/douchet/marchand
ing. chr. f. groener, oslo, att.: boerseth
norwegian petroleum directorate, control section, stavanger

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condeep platform - frigg tcp 2
emptying of shaft no. 5

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we refer to your telex no. 2127 dated 21.10.77 with a request for dnv acceptance for emtying shaft no. 5 on the same conditions as for emtying shaft no. 3.

we refer also our telex no. 21722 dated 28.2.77 and telex no. 60016 dated 1.6.77 with our acceptance of emptying shaft no. 3 from evaluation of strength of structure.

as shafts no. 3 and 5 have identical reinforcement, emptying of shaft no. 5 is accepted on the following conditions:

1. the numberof emptying operations should be limited as much as possible.

2. the general draw-down in platform is to be between 25.0 m and 35.0 m.

3. shafts no. 3 and 5 are not to be emptied simultaneously.

4. the detailed procedure for emtying of shafts shall be included in the platform operation manual, taking into account par. 1, 2 and 3.

GRØNER NOTEBY

JOB CONDEEP
ELF-NORGE A.S - FRIGG TCP 2
CONCRETE QUALITY CONTROL SUMMARY

Enclosure 13

RE

REPORT	DATE	STRUCTURAL MEMBER	CEMENT Kg/m³	W/C	ADMIXTURES lt per m³	SLUMP cm	AIR %	TEMPERATURE °C CONCR	TEMPERATURE °C AIR	COMPRESSIVE STRENGTH MPa 15cm CUBES σ_1	σ_7	σ_{28}	σ_{56}	σ_{90}
E-1	24.4	C. Skirt 9,10,11	460	0,39	6LP	12	-	18	3	45,8	57,2	57.0	61.5	57.5
2	"	" " "	480	0,39	4LP 2R	10	1,7	18	10	44,4	49.1	56.1	63.7	56.3
3	"	" " "	480	0,39	4LP 2R	13	-	18	8	41,7	50,0	54,0	59,2	61,5
4	25.4	" " "	480	0,39	4LP 2R	11	-	18	10	44,4	48.6	57.2	58,3	64,1
5	"	" " "	480	0,39	4LP 2R	10	1,6	18	13	48.6	50.4	59.4	59.2	57.0
6	29.4	" " 6	460	0,38	4LP 2R	10	-	12	7	46.7	50.4	58.7	59.2	61.9
7	"	" " "	460	0,39	4LP 2R	10	-	13	12	47.2	52.8	60.4	63.2	59.0
8	7.5	" " 8,18,19	460	0,40	4LP 2R	12	-	18	15	43.5	52.3	53.5	63.2	65.6
9	8.5	" " "	460	0,40	4LP 2R	12	-	17	7	48.1	52.3	58.8	64.1	65.2
10	8.5	" " "	460	0,39	4LP 2R	10	-	17	9	48.1	50.9	60.7	64.9	68.0
11	8.5	" " "	460	0,39	4LP 2R	10	2,0	20	20	45.7	49.5	57.8	60.1	63.3
12	"	" " "	460	0,40	4LP 2R	11	-	18	15	45.8	48.5	57.9	60.5	62.4
13	"	" " "	460	0,40	4LP 2R	12	-	17	9	49.3	48.6	59.2	59.2	61.6
14	9.6	" " 17,16	420	0,39	6LP 2R	15	-		13	43.0	50.9	56.7	61.7	60.5
15	10.6	" " "	420	0,39	6LP 2R	12	2,5	15	11	40.3	46.7	51.9	56.0	59.6
16	"	" " "	420	0,39	6LP 2R	14	-	14	11	42.1	48.6	55.1	61.5	63.7
17	"	" " "	420	0,39	6LP 2R	11	-		13	40.8	44.8	53.2	55.4	61.0
18	"	Mort. for tie h.			EXM							45.8		
19	18.6	C. Skirt 12,13	420	0,40	6LP 2R	14	-	17	15	38.5	49.1	59.0	60.5	64.9
20	"	" " "	420	0,39	6LP 2R	13	-	20	18	41.2	47.5	58.1	58.7	63.2
21	"	" " "	420	0,39	6LP 2R	13	-	19	16	40.8	43.9	58.3	60.5	64.1
22	19.6	" " "	420	0,39	6LP 2R	11	-	19	15	43.9	49.1	57.2	61.5	62.8
23	30.5	" " 14,15	420	0,39	6LP 2R	13	-	19	19	45.8	49.5	56.4	61.5	63.7
24	"	" " "	420	0,39	6LP 2R	12	-	19	20	44.8	50.0	59.1	61.5	67.5
25	"	" " "	420	0,39	6LP 2R	12	-	12	6	41.7	45.3	54.9	68.1	61.9
26	"	" " "	420	0,39	6LP 2R	12	-	18	13	41.7	46.7	55.8	53.6	62.8
								Mean Value		44,2	48,2	57,3	60,6	63,3
								St.Deviation		3,0	2,3	2,2	2,2	2,3
E-27	28.7	Anchorage, Innh.	490	0,38	1LP	10	-	20	16		42.0	50.8		
28	"	" "	490	0,38	1LP	9	-	20	16		41.3	50.9		
E-29	30.7	Lower Dome 19	420	0,40	6LP 2R	12	-	12	20		45.8	54.2	60.5	
30	"	" " "	420	0,40	6LP 2R	15	-	11	17		46.6	56.0	60.5	
31	31.7	" " "	420	0,39	6LP 2R	12	-	10	15		49.0	58.7	61.0	
32	"	" " "	420	0,40	6LP 2R	15	-	10	15		46.7	57.4	61.5	
33	"	" " "	420	0,40	6LP 2R	17,5	-	12,5	12		48.6	57.8	60.1	
34	"	" " "	480	0,40	6LP 2R	14,5	-	12	12		46.6	55.1	59.2	
35	"	" " "	420	0,40	6LP 2R	12	-	12,5	13		46.7	56.7	62.4	
36	"	" " "	420	0,40	6LP 2R	14	-	9	11		44.5	54.2	57.8	
37	1.8	" " "	420	0,40	6LP 2R	15	-	8	11		44.8	54.2	57.8	
38	"	" " "	420	0,40	6LP 2R	16	-	9	10		44.4	52.6	57.8	
39	"	" " "	420	0,40	6LP 2R	16	-	9	11		46.7	56.3	58.7	
40	1.8	" " "	420	0,40	6LP 2R	11	-	9	13		50.4	60.1	62.4	
41	"	" " "	420	0,40	6LP 2R	14	-	9,5	16		44.3	53.5	56.9	
42	"	" " "	420	0,40	6LP 2R	15	-	9	17		40.3	50.0	51.9	
43	"	" " "	420	0,40	6LP 2R	13	-	9,5	17		41.4	49.6	52.3	
44	"	" " "	420	0,40	6LP 2R	16	-	9	15		43.9	54.7	56.0	
45	"	" " "	420	0,40	6LP 2R	16	-	8	13		43.9	52.8	57.4	

GRØNER NOTEBY

JOB CONDEEP
ELF – NORGE A.S – FRIGG TCP 2
CONCRETE QUALITY CONTROL SUMMARY

RE:

REPORT	DATE	STRUCTURAL MEMBER	CEMENT kg/m³	W/C	ADMIXTURES lt. PER 1 m³	SLUMP cm	AIR %	TEMPERATURE °C CONCR	TEMPERATURE °C AIR	COMPRESSIVE STRENGTH MPa 15cm CUBES σ_3	σ_7	σ_{28}	σ_{56}	σ_{90}
E-46	2.8	Lower Dome 19	420	0,40	6LP 2R	15	-	6,5	13		47.7	53.8	58.3	
47	"	" " "	480	0,40	6LP 2R	17	-	9,5	14		42.6	50.7	50.9	
48	"	" " "	420	0,40	6LP 2R	10	-	9	14		43.9	52.4	56.0	
49	"	" " "	420	0,40	6LP 2R	11	-	9,5	16		45.9	54.4	56.7	
							Mean Value				45.5	54.5	58.0	
							St. Deviation				2.5	2.7	3.2	
E-50	5,8	" " 9	420	0,40	6LP 2R	16	2,3	10	[illegible]		47.6	54.4	59.3	
51	"	" " "	420	0,41	6LP 2R	18	-	12	20		47.1	50.7	54.6	
52	"	" " "	420	0,40	6LP 2R	17	-	10	23		48.8	57.2	59.6	
53	"	" " "	480	0,40	6LP 2R	17	-	11	20		48.8	56.5	60.1	
54	"	" " "	480	0,40	6LP 2R	18	-	10	20		46.6	54.0	56.4	
55	6.8	" " "	420	0,40	6LP 2R	12	-	6,5	17		47.6	55.6	59.6	
56	6.8	" " "	420	0,40	6LP 2R	13	-	11	24		47.2	54.4	59.2	
57	"	" " "	420	0,41	6LP 2R	16		11	25		47.4	53.5	55.6	
58	"	" " "	420	0,40	6LP 2R	17	-	10	25		46.8	56.5	59.7	
59	"	" " "	420	0,40	6LP 2R	16	-	10	21		50.2	57.4	58.7	
60	"	" " "	420	0,40	6LP 2R	16	-	11	19		47.4	53.3	56.9	
61	7.8	" " "	420	0,40	6LP 2R	12	-	11	17		49.6	55.4	60.5	
62	"	" " "	420	0,40	6LP 2R	12	-	10,5	16		47.7	55.1	58.7	
63	"	" " "	420	0,40	6LP 2R	11	-	11	17		47.8	52.1	60.5	
64	"	" " "	420	0,39	6LP 2R	10	-	10,5	18		47.7	56.5	59.6	
65	"	" " "	420	0,40	6LP 2R	14	-		25		51.3	58.1	62.4	
66	"	" " "	420	0,40	6LP 2R	15	-		25		50.0	57.4	62.9	
67	"	" " "	420	0,40	6LP 2R	15	-	12	25		50.5	56,5	61,0	
68	"	Achorage, Bolts.			EXM				24		27.4			
69	"	Lower Dome 9	420	0,40	6LP 2R	15	-	11	20		51.4	59.4	64.1	
70	"	" " "	420	0,40	6LP 2R	15	-	10	18,5		47.5	55.8	61.9	
							Mean Value				48.3	55.5	59.6	
							St. Deviation				2.1	2.1	2.4	
E-71	8.8	Rad.Skirt 14-6	420	0,40	6LP 2R	14	-	29	22		47.8	55.8	50.1	
72	12.8	Lower Dome 17	420	0,42	6LP 2R	13	-	12,5	17		47.6	55.6	56.9	
73	"	" " "	420	0,41	6LP 2R	10	-	11	17		47.6	54.9	60.1	
74	"	" " "	420	0,43	6LP 2R	16	-		17		47.6	54.9	62.4	
75	13.8	" " "	420	0,42	6LP 2R	16,5	-	10	14		50.4	58.8	63.6	
76	"	" " "	420	0,42	6LP 2R	13	-	10	20		52.8	50.8	64.1	
77	"	" " "	420	0,42	6LP 2R	15	-	11	20		44.8	57.8	58.7	
78	"	" " "	420	0,43	6LP 2R	16	-	12	20		47.6	53.9	58.7	
79	"	" " "	420	0,41	6LP 2R	14	-	10	17		49.1	59.0	62.4	
80	"	" " "	420	0,42	6LP 2R	17	-	10	15		46.3	56.9	60.5	
81	14.8	" " "	420	0,42	6LP 2R	16	-	11	14		50.4	57.4	61.5	
82	"	" " "	420	0,42	6LP 2R	17	-	11	13		50.4	57.6	63.2	
83	"	" " "	420	0,41	6LP 2R	13	-	13	17		50.0	58.3	63.7	
84	14.8	" " "	420	0,42	6LP 2R	16	-	12	17		46.7	55.8	56.9	
85	"	" " "	420	0,41	6LP 2R	14	-	12	18		50.0	58.5	64.1	
86	"	" " "	420	0,42	6LP 2R	16	-	12	19		45.3	54.2	59.6	
87	"	" " "	420	0,41	6LP 2R	12	-	11	15	40.3	46.7	56.0	60.5	
88	"	" " "	420	0,42	6LP 2R	12	-	12	14	40.8	48.6	56.0	61.5	

DATE	JOB NO	DWG NO	RVD.
19/1 1976	13468	2	

GRØNER NOTEBY

JOB: CONDEEP
ELF-NORGE A.S - FRIGG TCP 2
CONCRETE QUALITY CONTROL. SUMMARY

RE:

REPORT	DATE	STRUCTURAL MEMBER	CEMENT kg/m³	w/c	ADMIXTURES lt PER m³	SLUMP cm	AIR %	TEMPERATURE °C CONCR	TEMPERATURE °C AIR	COMPRESSIVE STRENGTH MPa 15cm CUBES σ1	σ7	σ28	σ56	σ90
E-89	14.8	Lower Dome 17	420	0,41	6LP 2R	11	-	11,5	12,5	42.8	49.5	58.5	61.5	
90	15.8	" " "	420	0,41	6LP 2R	10	-	20	12	44.8	47.6	56.9	62.4	
						Mean Value				42.7	48.4	56.9	61.2	
						St. Deviation				2.1	2.0	1.8	2.3	
F-91	19.8	Lower Dome 8	420	0,43	6LP 2R	14	-	7	14		46.3	56.7	59.2	
92	20.8	" " "	420	0,43	6LP 2R	15	-	6	13		44.8	55.1	58.7	
93	"	" " "	420	0,43	6LP 2R	12	-	6	12		49.5	58.5	64.1	
94	"	" " "	480	0,39	6LP 2R	14	-	8	19		48.1	57.4	61.5	
95	"	" " "	420	0,42	6LP 2R	9	-	8	19		49.5	57.6	61.5	
96	"	" " "	420	0,42	6LP 2R	17	-	8	19		50.4	56.5	59.6	
97	"	" " "	420	0,41	6LP 2R	12	-	8	18	44.6	48.6	58.8	63.2	
98	"	" " "	420	0,42	6LP 2R	15	-	12	17		45.3	53.5	56.4	
99	"	" " "	420	0,42	6LP 2R	14	-	13	15		45.3	54.2	55.6	
100	"	" " "	420	0,42	6LP 2R	14	-	12,5	14		47.6	55.6	58.7	
101	21.8	" " "	420	0,42	6LP 2R	15	-	11	14	43.0	47.6	55.6	61.5	
102	"	" " "	420	0,42	6LP 2R	14	-	12	13		48.1	57.6	60.5	
103	"	" " "	420	0,42	6LP 2R	14	-	10	16		46.3	54.6	58.7	
104	"	" " "	420	0,42	6LP 2R	15	-	10	16		47.6	55.8	60.1	
105	"	" " "	420	0,42	6LP 2R	12	-	12	16	46.3	50.0	59.0	62.4	
106	"	" " "	420	0,42	6LP 2R	15	-	11,5	16		49.1	55.3	60.5	
107	"	" " "	420	0,42	6LP 2R	13	-	11,5	16		49.5	57.6	62.4	
108	"	" " "	420	0,42	6LP 2R	16	-	10,5	15		45.8	53.7	57.4	
109	22.8	" " "	420	0,42	6LP 2R	15	-	9	12	40.8	45.8	52.3	53.7	
110	"	" " "	420	0,41	6LP 2R	14	-	11,5	16		50.4	57.2	59.2	
111	"	" " "	420	0,41	6LP 2R	12	-	15	16		50.9	60.3	64.1	
							Mean Value			43.7	47.9	56.4	60.0	
							St. Deviation			2.3	1.9	2.0	2.7	
E-112	26.8	Lower Dome 18	420	0,43	6LP 2R	12	-	8,5	15	41.2	45.7	55.4	59.6	
113	"	" " "	420	0,43	6LP 2R	13	-	10	14	42.1	46.7	55.3	61.5	
114	"	" " "	420	0,43	6LP 2R	14	-	10	14		49.5	55.5	59.2	
115	"	" " "	420	0,43	6LP 2R	11	-	11	14		48.6	56.3	60.5	
116	"	" " "	420	0,43	6LP 2R	13	-	12	14		49.5	58.1	61.0	
117	27.8	" " "	420	0,42	6LP 2R	15	-	10	12		44.4	51.4	55.1	
118	"	" " "	420	0,42	6LP 2R	15	-	9,5	12		44.4	52.3	54.6	
119	"	" " "	420	0,42	6LP 2R	16	-	10	13		46.7	53.0	56.4	
120	"	" " "	420	0,42	6LP 2R	16	-	10	13		46.7	52.6	57.4	
121	"	" " "	420	0,42	6LP 2R	16	-	9	15	39.6	44.4	51.9	57.4	
122	"	" " "	420	0,42	6LP 2R	13	-	10	16		48.1	54.9	61.0	
123	"	" " "	420	0,42	6LP 2R	10	-	11	16		49.1	56.6	59.6	
124	"	" " "	420	0,42	6LP 2R	13	-	11	16		54.6	54.9	58.7	
125	"	" " "	420	0,43	6LP 2R	15	-	12	15		46.2	54.0	57.4	
126	"	" " "	420	0,43	6LP 2R	13	-	11	14		47.6	57.2	61.5	
127	"	" " "	420	0,43	6LP 2R	12	-	11	13		49.1	58.5	61.9	
128	"	" " "	420	0,43	6LP 2R	14	-	11	13		46.7	54.7	59.6	
129	"	" " "	420	0,41	6LP 2R	13	-	11	12,5		48.6	55.4	60.5	
							Mean Value			41.0	47.5	54.9	59.1	
							St. Deviation				2.4	2.1	2.6	

DATE	JOB NO	DWG NO	RVC
19/1 1976	13468	3	

GRØNER NOTEBY

JOB: CONDEEP
ELF-NORGE A.S - FRIGG TCP 2
CONCRETE QUALITY CONTROL SUMMARY

RE:

REPORT	DATE	STRUCTURAL MEMBER	CEMENT kg/m³	W/C	ADMIXTURES 1t PER m³	SLUMP cm	AIR %	TEMPERATURE °C CONCR	TEMPERATURE °C AIR	COMPRESSIVE STRENGTH MPa 15cm CUBES σ_3	σ_7	σ_{28}	σ_{56}	σ_{90}
E-130	26.8	Lower Dome 7	420	0,42	6LP 2R	12	-	10	15		49.1	56.4	61.0	
131	"	" " "	420	0,42	6LP 2R	15	-	10	14		49.1	55.5	58.7	
132	"	" " "	420	0,42	6LP 2R	12	-	13	13		50.0	57.6	63.7	
133	"	" " "	420	0,42	6LP 2R	15	-	13	12		50.0	56.9	59.2	
134	29.8	" " "	420	0,43	6LP 2R	11	-	12	10		47.6	55.1	58.3	
135	"	" " "	420	0,43	6LP 2R	13	-	11,5	10		45.8	55.6	60.1	
136	"	" " "	420	0,43	6LP 2R	13	-	12,5	10		45.3	54.4	58.3	
137	29.8	" " "	420	0,42	6LP 2R	15	-	10	14		45.8	54.2	58.7	
138	"	" " "	420	0,42	6LP 2R	10	-	11,5	14		48.1	56.9	61.0	
139	"	" " "	420	0,42	6LP 2R	14	-	11	14	43.1	49.1	55.6	61.0	
140	"	" " "	420	0,43	6LP 2R	13	-	11	12		48.1	53.5	59.6	
141	"	" " "	420	0,43	6LP 2R	13	-	11	12		49.5	54.9	61.0	
							Mean Value			43.1	48.1	55.6	60.1	
							St. Deviation			-	1.7	1.2	1.7	
142	4.9	Lower Dome 6	420	0,44	6LP 2R	18	-	8,5	12		43.9	55.3	56.0	
143	"	" " "	420	0,41	6LP 2R	11	-	9	13		47.2	56.7	59.6	
144	"	" " "	420	0,42	6LP 2R	12	-	9	14		48,6	58.7	60.5	
145	"	" " "	420	0,41	6LP 2R	15	-	8	13		51,4	57.6	53.2	
146	"	" " "	420	0,41	6LP 2R	14	-	8	13		44,8	55.3	56.0	
147	"	" " "	420	0,41	6LP 2R	10	-	8	12	44.0	46.3	56.2	58.7	
148	5.9	" " "	420	0,42	6LP 2R	12	-	9	12		47.2	56.9	56.9	
149	"	" " "	420	0,42	6LP 2R	13	-	9			47,6	54.7	58.3	
150	"	" " "	420	0,42	6LP 2R	13	-	10	11		47.2	55.4	60.5	
151	"	" " "	420	0,42	6LP 2R	11	-	10	12		49.1	57.0	61.5	
152	"	" " "	420	0,42	6LP 2R	9	-	10	12		51.4	57.4	61.5	
153	"	" " "	420	0,42	6LP 2R	10	-	10	12		48.6	56.5	57.8	
	"						Mean Value			44.0	47.8	56.5	58.4	
							St. Deviation				2.3	1.2	2.5	
154	5.9	Starcell 13	420	0,41	6LP 2R	14	-	15	10		53.2	60.6	63.2	
155	9.9	Lower Dome 2	420	0,40	6LP 2R	16	-	10	14		44.4	58.7	64.9	
156	"	" " "	420	0,41	6LP 2R	14	-	9	14		49.5	58.1	62.8	
157	"	" " "	420	0,40	6LP 2R	14	-	10	16		50.4	57.2	63.7	
158	"	" " "	420	0,41	6LP 2R	15	-	10	13		50.4	58.3	61.5	
159	"	" " "	420	0,41	6LP 2R	14	-	10	12		49.5	57.6	63,2	
160	"	" " "	420	0,40	6LP 2R	13	-	11	12		49.5	57.4	62.8	
161	"	" " "	420	0,41	6LP 2R	13	-	11	11		49.5	57.4	61.9	
162	10.9	" " "	420	0,41	6LP 2R	14	-	9	11		47,6	55.6	59.2	
163	"	" " "	420	0,41	6LP 2R	15	-	8	10		49.5	59.0	60.5	
164	"	" " "	420	0,41	6LP 2R	12	-	9	10		52.3	61.0	64.9	
165	"	" " "	420	0,40	6LP 2R	11	-	9	10		51.9	61.3	62.8	
166	"	" " "	420	0,40	6LP 2R	10	-	11	12		53.2	59,4	63.2	
							Mean Value				49,8	58,4	62.6	
							St. Deviation				2,3	1.6	1.7	

DATE	JOB NO	DWG NO	RVD
19/1 1976	13468	4	

GRØNER NOTEBY

JOB: CONDEEP
ELF-NORGE A.S - FRIGG TCP 2
CONCRETE QUALITY CONTROL SUMMARY

RE

REPORT	DATE	STRUCTURAL MEMBER	CEMENT Kg/m³	w/c	ADMIXTURES lt PER m³	SLUMP cm	AIR %	TEMPERATURE °C CONCR	TEMPERATURE °C AIR	COMPRESSIVE STRENGTH MPa, 15cm CUBES σ_3	σ_7	σ_{28}	σ_{56}	σ_{90}
E-167	11.9	Lower Dome 3	420	0,41	6LP 2R	15	-	8	13	46.1	50.0	59.7	60.1	
168	"	" " "	420	0,41	6LP 2R	14	-	9	13		56.9	62.9	70.7	
169	"	" " "	420	0,41	6LP 2R	14		9	15		49,5	59.0	63.2	
170	"	" " "	420	0,41	6LP 2R	15	-	6	13	43.7	52.3	58.8	65.0	
171	"	" " "	420	0,41	6LP 2R	13	-	9	13		47,6	59,2	62.4	
172	"	" " "	420	0,41	6LP 2R	13	-	10	11		47.6	56,3	58,7	
173	"	" " "	420	0,41	6LP 2R	12	-	10	11		49.1	57.4	60.5	
174	12.9	" " "	420	0,42	6LP 2R	16	-	10	9		45,8	53.5	59.2	
175	"	" " "	420	0,41	6LP 2R	11	-	10	13		50.0	57.8	62.4	
176	"	" " "	420	0,41	6LP 2R	11	-	10	13		51.9	62.2	65.4	
177	12.9	Cable Anc.								5.2	6.0	6.5		
178	12.9	Lower Dome 3	420	0,41	6LP 2R	13	-	8	15		47.2	57.6	61.0	
179	"	" " "	420	0,41	6LP 2R	13	-	8	14		47.6	56.7	61.5	
							Mean Value			44.9	49.6	58.4	62.5	
							St. Deviation				3.0	2.5	3.3	
180	16.9	Lower Dome 1	420	0,42	6LP 2R	13	-	12	15		49.1	61.0	63.2	
181	17.9	" " "	420	0,43	6LP 2R	14	-	10	13		50.4	57.4	61.0	
182	"	" " "	420	0,41	6LP 2R	12	-	9	13		56.0	62.6	69.2	
183	"	" " "	420	0,41	6LP 2R	14	-	10	13	45,3	52,3	58,3	61,5	
184	"	" " "	420	0,41	6LP 2R	15	-	10	14		53.7	62.6	65.4	
185	"	" " "	420	0,41	6LP 2R	12	-	12,5	16		47.2	55.4	59.2	
186	"	" " "	420	0,39	6LP 2R	7	-	12	16		53.7	62.2	67.5	
187	"	" " "	420	0,39	6LP 2R	8	-	13	15		54.6	64.8	70.9	
188	"	" " "	420	0,40	6LP 2R	11	-	13	14		48.6	59.4	63.5	
189	"	" " "	420	0,41	6LP 2R	12	-	13	13		51.4	59.4	64.9	
190		Not existing												
191		" "												
192	18.9	Lower Dome 1	420	0,40	6LP 2R	14	-	12	13		52.3	61,0	63,2	
193	"	" " "	420	0,40	6LP 2R	14	-	11	13		54.2	63.9	66.7	
194	"	" " "	420	0,40	6LP 2R	15	-	10	12		55.1	63.7	68.5	
195	"	" " "	420	0,40	6LP 2R	11	-	10	11		54.6	61.2	55.8	
196	"	" " "	420	0,40	6LP 2R	13		10	11	47.2	51.9	57.3	66.7	
197	"	" " "	420	0,41	6LP 2R	17	-	10	11		52.3	63.2	67.5	
198	"	" " "	420	0,40	6LP 2R	16	-	11	11		51.9	61.0	64.5	
199	"	" " "	420	0,40	6LP 2R	11	-	10	11		51,9	60.1	(56,4)	
							Mean Value			46.3	52.3	60.8	65.3	
							St. Deviation				2.4	2.6	3.1	
200	23.9	Lower Dome 10,11	420	0,40	6LP 2R	10	-	16	12		51.9	61.7	66.7	
201	"	" " "	420	0,40	6LP 2R	13	-	15	14		53.7	62.8	67.1	
202	"	" " "	420	0,40	6LP 2R	13	-	14	16	45.8	54.2	62.7	66.3	
203	"	" " "	420	0,40	6LP 2R	9	-	15			55.1	63.5	67.5	
204	"	" " "	420	0,40	6LP 2R	12	-	14	12		53.7	61.9	64.9	
205	"	" " "	420	0,40	6LP 2R	9	-	14	9	43,7	51,4	60,3	63,7	

DATE	JOB NO	DWG NO	REV
19/1 1976	13468	5	

GRØNER NOTEBY

JOB CONDEEP
ELF-NORGE A.S - FRIGG TCP 2
CONCRETE QUALITY CONTROL. SUMMARY

RE:

REPORT	DATE	STRUCTURAL MEMBER	CEMENT kg/m³	w/c	ADMIXTURES 1t PER 1m³	SLUMP cm	AIR %	TEMPERATURE °C CONCR	TEMPERATURE °C AIR	COMPRESSIVE STRENGTH MPa 15cm CUBES σ_3	σ_7	σ_{28}	σ_{56}	σ_{90}
E-205	23,9	Lower Dome 10,11	420	0,40	6LP 2R	9	-	14	9	43.7	51.4	60.3	63.7	
206	″	″ ″ ″	420	0,40	6LP 2R	15	-	14	9		50.9	60.1	64.1	
207	″	″ ″ ″	420	0,40	6LP 2R	14	-	12	9		51.9	62.6	64.1	
208	″	″ ″ ″	420	0,40	6LP 2R	17	-	13	8		48.1	59.2	60.5	
209	24.9	″ ″ ″	420	0,40	6LP 2R	13	-	11	8		49.5	58.3	60.1	
210	″	″ ″ ″	420	0,40	6LP 2R	14	-	11	7,5		47.2	56.7	59.2	
211	″	″ ″ ″	420	0,40	6LP 2R	15	-	10	9		50.4	58.5	62.8	
212	″	″ ″ ″	420	0,40	6LP 2R	11	-	11	10		53.7	63.0	64.9	
213	″	″ ″ ″	420	0,40	6LP 2R	14	-	12	12		50.4	63.3	66.3	
214	″	″ ″ ″	420	0,40	6LP 2R	12	-	14	12		56.9	62.3	69.7	
215	″	″ ″ ″	420	0,40	6LP 2R	17	-	14	12		52.3	59.2	64.1	
216	″	″ ″ ″	420	0,40	6LP 2R	16	-	15	12	44.8	53.2	62.2	66.3	
217	″	″ ″ ″	420	0,42	6LP 2R	20	-	11	9		46.7	56.7	61.9	
218	″	″ ″ ″	420	0,41	6LP 2R	17	-	12	9	40.3	49.5	59.2	61.0	
219	″	″ ″ ″	420	0,40	6LP 2R	15	11	11	8		50.4	58.3	66.3	
220	″	″ ″ ″	420	0,40	6LP 2R	16	-	12	8		50.0	59.2	63.2	
221	″	″ ″ ″	420	0,40	6LP 2R	14	-	10	7		50.9	63.2	66.7	
222	25.9	″ ″ ″	420	0,41	6LP 2R	13	-	9	8		53.7	63.7	65.4	
223	″	″ ″ ″	420	0,40	6LP 2R	13	-	9	9		56.4	64.5	65.8	
224	″	″ ″ ″	420	0,40	6LP 2R	14	-	12	11		52.8	62.8	63.2	
225	″	″ ″ ″	420	0,40	6LP 2R	13	-	13	14		49,5	58,1	61,0	
226	″	″ ″ ″	420	0,40	6LP 2R	13	-	14	16		51.9	61.5	65.8	
227	″	″ ″ ″	420	0,40	6LP 2R	14	-	14	16	42.6	50.9	59.2	64.5	
228	″	″ ″ ″	420	0,40	6LP 2R	12	-	14,5	14		51.4	60.1	65.8	
229	″	″ ″ ″	420	0,40	6LP 2R	14	-	14,5	13,5	41.0	48.6	56.3	61.5	
230	″	″ ″ ″	420	0,40	6LP 2R	12	-	14	13,5		50.0	59.2	61.0	
231	″	″ ″ ″	420	0,40	6LP 2R	14	-	15	13,5		46.7	56.5	60.5	
232	″	″ ″ ″	420	0,40	6LP 2R	14	-	16	14		49.1	58.3	62.8	
233	″	″ ″ ″	420	0,40	6LP 2R	9	-	14	14		49.5	59.5	61.5	
234	26.9	″ ″ ″	420	0,40	6LP 2R	13	-	12	15		49.5	60.4	64.1	
235	″	″ ″ ″	420	0,40	6LP 2R	12	-	12	16		50.9	59.4	61.0	
							Mean Value			43.0	51.2	60.4	63.9	
							St. Deviation			2.2	2.5	2.3	2.5	
236	29.9	Cell no.20	500	0,40	3LP	11	-	14			44.4	50.5	55.5	
237	″	″ ″ ″	480	0,40	3LP	12	-	16			51.4	55.8	61.5	
238	″	″ ″ ″	480	0,40	3LP	8,5	-	16	11		50.4	56.5	53.2	
240	″	″ ″ ″	480	0,40	3LP	7,5	-	14	11		49.5	56.3	60.1	
241	″	″ ″ ″	480	0,40	4LP	7,5	-	15	12		50.0	54.8	62.4	
242	″	″ ″ ″	480	0,40	4LP	8	-	14	12		51.9	58.7	66.7	
243	30.9	″ ″ ″	480	0,40	4LP	11	-	14	12		50.0	56.3		
244	″	″ ″ ″	480	0,40	4LP	10	-	13	12		50.4	56.3		
247	″	″ ″ ″	480	0,40	4LP	13	-	16	15		52.8	58.4	60.1	
248	″	″ ″ ″	480	0,40	4LP	12	-	16	15		46.7	52.6	57.4	
249	″	″ ″ ″	480	0,39	4LP	10	-	15	14		47.6	53.5	60.6	
252	″	″ ″ ″	480	0,39	5LP	12	-	16	14		50.0	55,1	54,1	

DATE	JOB NO	DWG NO.	REV
19/1 1976	13468	6	

GRØNER NOTEBY

JOB: CONDEEP
ELF – NORGE A.S – FRIGG TCP 2
CONCRETE QUALITY CONTROL SUMMARY

RE

REPORT	DATE	STRUCTURAL MEMBER	CEMENT kg/m³	w/c	ADMIXTURES lt per m³	SLUMP cm	AIR %	TEMPERATURE °C CONCR	TEMPERATURE °C AIR	COMPRESSIVE STRENGTH MPa, 15cm CUBES σ_1	σ_7	σ_{28}	σ_{56}	σ_{90}
E-253	30/9	Cell no. 20	480	0,39	5LP	11		15	14		49.1	53.5	61.9	
254	1/10	" " "	480	0,40	5LP	9		17	15		46.3	54.4		
255	"	" " "	480	0,40	5LP	8,5		16	15		49.1	56.1		
256	"	" " "	480	0,40	4LP	11		17,5	17,5		47.6	55.5	56.4	
258	"	" " "	480	0,40	4LP	10		20	20		49.5	56,3	60,1	
259	"	" " "	480	0,40	4LP	10		20	20		50,0	56,7	60,5	
260	"	" " "	480	0,40	4LP	13		19	12		48.6	55.6	59.2	
261	"	" " "	480	0,40	4LP	13		19	19		50.9	57.7	60.5	
263	"	" " "	480	0,40	3LP	15		16	12		44.8	51.6	54.2	
264	"	" " "	480	0,40	3LP	14		16	12		46.7	52.6	54.6	
265	"	" " "	460	0,40	3LP	8		16	11		49.5	54.4	58.7	
268	2/10	" " "	480	0,40	3LP	9		16	13		47.2	53.0	58.3	
269	"	" " "	480	0,40	3LP	9		16	13		48.6	51.9	58.7	
270	"	" " "	460	0,40	3LP	14		15,5	15		45.6	52.4	56.9	
271	"	" " "	480	0,40	3LP	14		15,5	15		44.8	51.4	56.9	
272	"	" " "	480	0,40	3LP	7,5		14	[illegible]		49.1	54.7	58.7	
273	"	" " "	480	0,40	3LP	8		14	13,5		46.6	54.2	57.4	
274	3/10	" " "	420	0,41	3LP	12		14	13		42.9	49.1	52.8	
275	"	" " "	420	0,41	3LP	11		15	13		43.0	50.7	51.4	
276	"	" " "	480	0,40	3LP	14		15	10		44.8	53.5	54.2	
277	"	" " "	480	0,40	3LP	13		15	10		45.8	52.1	54.2	
278	"	" " "	480	0,40	3LP	8		15	12		46.6	54.2	58.7	
279	"	" " "	480	0,40	3LP	8,5		14	12		48.6	53.0	57.4	
280	"	" " "	480	0,40	3LP	9		16	13		45.3	52.8	55.4	
281	"	" " "	480	0,40	3LP	8		15	13		45.3	52.6	56.4	
							Mean Value				48.0	54.2	58.4	
							St. Deviation				2.5	2.3	3.4	
239	29/9	Lower Dome 4+5	420	0,41	6LP 2R	9,5		13	11		51.4	58.5	62.8	
245	30/9	" " "	420	0,41	6LP 2R	11		11	12		49.5	58.8	62.6	
246	"	" " "	420	0,41	6LP 2R	16		11	14		43.0	51.7	55.6	
250	"	" " "	420	0,40	6LP 2R	12		10	14		47.6	55.1	61.9	
251	"	" " "	420	0,42	6LP 2R	13		12	13		49.5	55.3	63.2	
257	1/10	" " "	420	0,40	6LP 2R	10		13	18	42.2	50.0	58.8	61.0	
262	"	" " "	420	0,41	6LP 2R	15		11	15		52.3	59.4	63.7	
265	"	" " "	420	0,40	3LP	8		16	11		49.5	54.9	58.7	
266	2/10	" " "	420	0,41	6LP	15		10	11		49.1	57.2	61.0	
267	"	" " "	420	0,41	6LP 2P	18		9	12	42.8	50.0	57.8	61.9	
							Mean Value			42.6	49.2	57.0	61.5	
							St. Deviation				2.7	2.5	2.4	

DATE	JOB NO	DWG NO.
19/1 1975	13468	7

GRØNER NOTEBY

JOB CONDEEP
ELF-NORGE A.S - FRIGG TCP 2
CONCRETE QUALITY CONTROL SUMMARY

RE:

REPORT	DATE	STRUCTURAL MEMBER	CEMENT kg/m³	W/C	ADMIXTURES lt per m³	SLUMP cm	AIR %	TEMPERATURE °C CONCR	TEMPERATURE °C AIR	COMPRESSIVE STRENGTH MPa 15cm CUBES σ_3	σ_7	σ_{28}	σ_{55}	σ_{90}
E-282	6/10	L. Dome 15+16	420	0,43	6LP 2R	16		13,5	8		13.6	58.5	62.8	
283	"	" " "	420	0,43	6LP 2R	16		13,5	7		48.6	58.3	63.7	
284	"	" " "	420	0,43	6LP 2R	16		6	7		48.6	58.3	64.1	
285	7/10	" " "	420	0,41	6LP 2R	13		8	8		54.2	59.0	64.9	
286	"	" " "	420	0,41	6LP 2R	13		9	7		53.7	60.1	64.9	
287	"	" " "	420	0,41	6LP 2R	13		9	11		49.5	56.7	64.1	
288	7/10	" " "	420	0,41	6LP 2R	12		10	11		50.4	57.2	61.0	
289	"	" " "	420	0,42	6LP 2R	18		7,5	7		49.1	56.7	62.4	
290	"	" " "	420	0,41	6LP 2R	10		8	6	46.7	49.5	59.0	63.2	
291	8/10	" " "	420	0,41	6LP 2R	14		8	8		50.0	58.7	63.7	
292	"	" " "	420	0,40	6LP 2R	12		8	9		46.7	58.5	63.2	
293	"	" " "	420	0,41	6LP 2R	12		9,5	7		46.7	57.4	61.0	
294	8/10	" " "	420	0,41	6LP 2R	15		8	6		49.1	58.5	61.9	
295	9/10	" " "	420	0,41	6LP 2R	10		9	7		50.4	57.2	64.1	
							Mean Value			46,7	49.7	58.2	63.1	
							St. Deviation			-	2.1	1.0	1.3	
296	9/10	L. Dome no. 12	420	0,41	6LP 2R	15		6	6		45.8	54.9	60.5	
297	10/10	" " "	420	0,40	6LP 2R	11		6	4		48.6	56.9	59.2	
298	"	" " "	420	0,40	6LP 2R	12		7	4		48.1	57.1	61.5	
299	"	" " "	420	0,40	6LP 2R	12		8	7		49.1	57.2	58.7	
300	"	" " "	420	0,40	6LP 2R	12		7	7		48.6	57.2	59.6	
301	"	" " "	420	0,41	6LP 2R	12		9	5		56.4	56.5	61.0	
302	"	" " "	420	0,41	6LP 2R	12		7	5	40.6	49.1	56.9	62.4	
							Mean Value			40.6	49.4	56.7	60.4	
							St. Deviation			-	3.3	0.8	1.3	
303	12/10	L. Dome 13+14	420	0,41	6LP 2R	9		8	8		50.4	59.6	62.4	
304	"	" " "	420	0,45	6LP 2R	10		9,5	5		47.6	54.4	60.5	
305	"	" " "	420	0,41	6LP 2R	10		9	4		46.7	53.2	59.2	
306	"	" " "	420	0,41	6LP 2R	16					48.1	56.0	62.4	
307	13/10	" " "	420	0,41	6LP 2R	12		8	5		44.8	53.0	56.0	
308	"	" " "	420	0,42	6LP 2R	16		5	7		49.1	57.6	60.5	
309	"	" " "	420	0,40	6LP 2R	10		7	4		44.8	55.3	56.9	
310	"	" " "	420	0,41	6LP 2R	11		8	4		47.2	54.4	59.6	
311	"	" " "	420	0,40	6LP 2R	11		7	3		45.3	54.4	61.5	
312	14/10	" " "	420	0,41	6LP 2R	15		7,5	3		41.2	50.9	54.6	
313	"	" " "	420	0,40	6LP 2R	6		7	7		51.9	59.9	64.1	
314	"	" " "	420	0,41	6LP 2R	14		7	7		43.9	52.1	54.2	
315	"	" " "	420	0,40	6LP 2R	9,5		8,5	8	41.5	46.7	56.0	58.7	
316	"	" " "	420	0,40	6LP 2R	9		8	6		48.6	57.8	58.7	
							Mean Value			41.5	46.9	55.3	59.2	
							St. Deviation			-	2.8	2.7	3.0	

DATE	JOB NO	DWG NO.	REV.
19.1 1976	13468	3	

GRØNER NOTEBY

JOB: CONDEEP
ELF-NORGE A.S - FRIGG TCP 2
CONCRETE QUALITY CONTROL SUMMARY

RE

REPORT	DATE	STRUCTURAL MEMBER	CEMENT kg/m3	W/C	ADMIXTURES lt per m3	SLUMP cm	AIR %	TEMPERATURE °C CONCRETE	TEMPERATURE °C AIR	COMPRESSIVE STRENGTH MPa (15 cm CUBES) σ_1	σ_7	σ_{28}	σ_{56}	σ_{90}
E-317	16/10	R.Sup.1.1-1.4	480	0,40	6LP 2R	10		14	10	43.3	50.4	59.0	62.8	
318	18/10	Cell 21,L-+6,07	480	0,40	4LP	9		13	8	41.7	47.2	53.5	57.4	
319	20/10	R.Sup. 2	480	0,40	4LP	15		10	5		45.8	52.3	56.4	
320	22/10	" " 6,3 - 1	480	0,41	4LP	17		10	6		43.9	51.4	54.6	
321	28/10	" " 4.1-4.3	480	0,40	4LP	14		14	8		32.7	50.4	55.1	
322	29/10	" " 7.1 - 7.2	480	0,40	4LP	14		15	9		43.9	52.4	59.5	
323	30/10	" " 3.1-3.3	480	0,40	4LP	12		15	11		42.1	48.6	53.2	
324	31/10	C. Walls L.6,15	500	0,40	6LP 0,5R	12		15	11		45.3	53.3	58.7	
325	"	" "	500	0,40	6LP 0,5R	13		15	11		44.8	56.0	57.8	
326	"	" "6,20	500	0,40	6LP 0,5R	18		16	11		46.3	55.1	57.8	
327	"	" "6,25	500	0,40	6LP 0,5R	16		17	11		44.4	53.0	59.2	
328	"	" "6,50	500	0,40	6LP 0,5R	15		16	12		43.9	49.8	57.8	
329	"	" "	500	0,39	6LP 0,5R	14		16	11		46.3	53.3	56.7	
330	"	" "6,65	500	0,39	6LP 0,5R	13		15	11		49.5	55.8	57.4	
331	"	" "	500	0,40	6LP 0,5R	14		16	10		47.2	53.0	56.7	
332	"	" "	500	0,40	6LP 0,5R	16		16	10		46.7	58.3	60.5	
333	1/11	" "6,75	500	0,39	6LP 0,5R	12		17	8		50.9	59.2	62.1	
334	"	" "6,85	500	0,40	6LP 0,5R	14		15	7		51.4	58.1		
335	"	" "6,90	480	0,39	6LP	10		17	8		50.4	57.6	58.1	
336	"	" "7,25	480	0,40	6LP	14		15	10		47.6	54.9	59.2	
337	"	" "7,30	480	0,40	5LP	12		16	11		46.7	55.6	57.4	
338	"	" "7,40	480	0,40	5LP	10		14	12		49.5	56.2	53.2	
339	"	" "7,48	480	0,40	5LP	9		15	12		47.6	54.0	56.0	
340	"	" "7,60	480	0,40	5LP	12		15	12		45.3	54.0	57.8	
341	"	" "7,75	480	0,40	4LP	12		16	11		47.6	56.7	58.7	
342	"	" "7,85	480	0,40	4LP	13		16	11		50.0	57.4	57.8	
343	"	" "7,90	480	0,40	4LP	12		16	11		49.5	55.9	59.6	
344	"	" "7,95	480	0,41	4LP	18		14	10		45.3	51.9	56.4	
345	"	" "8,00	430	0,40	4LP	13		15	10		50.0	57.2	62.4	
346	2/11	" " "	480	0,40	4LP	13		16	10		49.5	57.0	58.7	
347	"	" "8,30	480	0,40	4LP	13		16	9		47.6	52.8	57.8	
348	"	" "8,45	480	0,40	4LP	11		16	9		48.1	53.7	56.0	
349	"	" "8,60	480	0,41	4LP	8		15	7		50.4	55.4	56.9	
350	"	" "8,65	480	0,?1	4LP	8		14	8		50.4	56.4	58.7	
351	"	" "8,80	480	0,41	4,5LP	10		14	8		49.1	55.8	56.9	
352	"	" "8,97	480	0,40	4,5LP	9		14	8		46.7	52.3	56.0	
353	"	" "9,06	480	0,41	4,5LP	12		14	8		47.2	53.3	56.0	
354	"	" "9,17	480	0,40	4LP	11		14	7		49.1	54.3	56.0	
355	"	" "9,25	480	0,40	4LP	10		14	6		45.8	52.6	56.0	
356	"	" "9,35	480	0,40	4LP	12		14	7		46.7	52.8	56.0	
357	"	" "9,45	480	0,40	4LP	11		14	5		46.7	55.3	58.7	
358	"	" "9,50	480	0,41	3,5LP	14		14	6		45.8	51.6	54.6	
359	"	" "9,60	480	0,40	3,5LP	9		14	9		45.8	54.9	56.9	
360	3/11	" "9,70	480	0,40	3,5LP	10		15	9		48.1	56.3	58.7	
361	"	" "9,80	480	0,40	3,5LP	10		15	10		49.1	53.9	56.4	
362	"	" "9,95	480	0,40	3,5LP	9		14	10		47.2	53.2	56.0	

DATE: 19/1 1976 | JOB NO: 13468 | DRAWING NO: 9 | REV:

GRØNER NOTEBY

JOB CONDEEP
ELF – NORGE A.S – FRIGG TCP 2
CONCRETE QUALITY CONTROL: SUMMARY

RE

REPORT	DATE	STRUCTURAL MEMBER	CEMENT kg/m³	W/C	ADMIXTURES	SLUMP mm	AIR %	TEMPERATURE °C CONCR.	TEMPERATURE °C AIR	COMPRESSIVE STRENGTH MPa 10cm CUBES [illegible]	[illegible]	[illegible]	σ_{56}	σ_{90}
E-363	3/11	C. Walls L.10,10	480	0,40	4LP	10		15	12		49.5	52.8	56.0	
364	"	" 10,30	480	0,41	3,5LP	12		15	13		45.3	52.6	54.2	
365	"	" 10,35	480	0,41	3,5LP	12		15	13		48.6	55.8	57.4	
366	"	" 10,48	480	0,41	3,5LP	10		15	13		49.1	55.8	59.2	
367	"	" 10,55	480	0,41	3,5LP	10		15	13		50.0	56.0	59.2	
368	"	" 10,65	480	0,41	3,5LP	9		16	13		47.2	55.8	58.7	
369	"	" 10,75	480	0,41	3,5LP	9		17	12		49.1	57.6	59.6	
370	"	" 10,75	480	0,41	3,5LP	9		17	12		48.1	58.9	59.6	
371	"	" 11,05	480	0,41	3,5LP	11		17	11		43.9	49.5	53.2	
372	"	" 11,20	480	0,41	3,5LP	15		14	11		44.8	52.3	55.6	
373	"	" 11,25	480	0,40	3,5LP	11		17	8		43.9	51.4	55.6	
374	"	" 11,30	480	0,41	4,5LP	13		17	8		45.3	52.3	56.4	
375	"	" 11,35	480	0,41	4,5LP	12		17	7		46.3	53.5	55.4	
376	4/11	" 11,40	480	0,41	4LP	12		17	7		46.7	55.3	53.6	
377	"	" 11,50	480	0,41	4LP	17		16	8		47.6	52.6	56.0	
378	"	" 11,60	480	0,41	4LP	13		17	8		49.1	55.2	58.9	
379	"	" 11,75	480	0,41	4LP	10		17	7		48.6	56.5	60.5	
380	"	" 12,0	480	0,40	4LP	10		14	8		48.6	56.0	59.6	
381	"	" 12,22	480	0,41	4LP	14		14	12		47.6	56.0	56.9	
382	"	"	480	0,40	4LP	11		14	12		46,7	56,0	57,8	
383	"	" 12,13	480	0,40	4LP	11		16	12		46.3	55.3	61.0	
384	"	" 12,13	480	0,40	4LP	10		17	12		48.6	56.9	60.1	
385	"	" "	480	0,40	4LP	10		17	13		49.5	57.8	59.6	
386	"	" "	480	0,40	4LP	11		16	13		48.6	54.7	59.6	
387	"	" 12,38	480	0,41	4LP	10		17	13		48.6	56.0	61.0	
388	"	" 12,70	480	0,41	4LP	10		17	10		49.1	55.8	59.6	
389	"	" 12,55	480	0,40	4LP	9		18	12		50.4	56.5	60.5	
390	"	" "	480	0,41	4LP	11		17	12		47.6	56.7	58.7	
391	"	" 12,70	480	0,41	4LP	11		16	12		49.1	55.3	56.4	
392	"	" "	480	0,41	4LP	10		16	12		47.6	56.5	58.7	
393	"	" 12,75	480	0,41	4LP	11		16	11		49.5	57.6	61.0	
394	"	" 12,80	480	0,41	4LP	12		17	11		46.7	53.3	56.4	
395	"	" 12,90	480	0.41	4LP	13		17	11		49.1	50.0	57.8	
396	"	" 12,95	480	0,41	4LP	18		16	11		49.1	56.7	60.1	
397	"	" 13,05	480	0,41	4LP	11		17	11		49.1	57.6	61.5	
398	5/11	" 13,15	480	0,41	4LP	10		17	14		50.9	57.4	62.4	
399	"	" 13,25	480	0,41	4LP	10		16	10		48.1	55.6	58.7	
400	"	" 13,25	480	0,41	4LP	12		16	10		46.7	53.9	60.1	
401	"	" 13,40	480	0,41	4LP	12		17	8		49.1	53.5	58.3	
402	"	" 13,40	480	0,41	4LP	13		16	8		47.6	53.2	59.2	
403	"	" 13,50	480	0,41	4LP	13		17	8		48.1	55.4	53.6	
404	"	" 13,65	480	0,40	4LP	13		17	8		47.6	53.5	58.7	
405	"	" "	480	0,40	4LP	12		18	8		45.8	54.4	57.8	
406	"	" 13,85	480	0,40	4LP	15		17	8		47.6	55.1	59.2	
407	"	" 13,94	480	0,41	4LP	14		17	8		50.4	56.0	59.6	
408	"	" "	480	0,41	4LP	13		17	8		47.6	55.1	59.2	
409	"	" 14,05	480	0,40	3,5 LP	12		16	9		49.5	56.7	60.5	
410	"	" 14,14	480	0,40	3,5 LP	8		14	10		50.9	58.5	62.4	
411	"	"	480	0,40	3,5 LP	9		17	10		49.5	56.0	60.1	

DATE	JOB NO.	DWG NO.	REV.
	13468	10	

GRØNER NOTEBY

JOB: CONDEEP
ELF – NORGE A.S – FRIGG TCP 2
CONCRETE QUALITY CONTROL. SUMMARY

RE:

REPORT	DATE	STRUCTURAL MEMBER	CEMENT kg/m³	W/C	ADMIXTURES lt PER m³	SLUMP cm	AIR %	TEMPERATURE °C CONCR	TEMPERATURE °C AIR	COMPRESSIVE STRENGTH MPa 15cm CUBES σ_3	σ_7	σ_{28}	σ_{56}	σ_{90}
E-412	5/11	C.Walls L.14,30	480	0,40	3,5 LP	9		16	10		49.5	57.1	60.1	
413	"	"	480		3,5 LP	9		15	8		48.6	55.4	61.0	
414	"	"	480		3,5 LP	10		16	8		48.6	58.0	60.5	
415	"	" 14,45	480	0,41	3,5 LP	9		16	8		49.5	58.3	61.5	
416	"	" 14,55	480	0,41	3,5 LP	13		16	7		46,7	55.8	59.6	
417	"	" 14,55	480	0,41	3,5 LP	13		16	7		46.7	55.8	59.6	
418	"	" 14,65	480	0,41	3,5 LP	12		16	7		46.7	55.1	59.6	
419	"	" 14,75	480	0,41	3,5 LP	12		14	7		46.7	53.5	59.2	
420	"	" "	480	0,41	3,5 LP	11		15	7		47.6	53.5	56.0	
421	6/11	" 14,90	480	0,41	3,5 LP	11		16	7		47.2	56.7	59.2	
422	"	" 15,00	480	0,41	3,5 LP	11		16	7		44.8	53.5	56.9	
423	"	" 15,05	480	0,41	3,5 LP	10		15	7		48.1	54.2	60.5	
424	"	" 15,15	480	0,41	3,5 LP	12		16	7		47.6	55,8	58.3	
425	"	" 11,25	480	0,41	3,5 LP	12		16	7		46.7	54.4	59.2	
426	"	" 15,40	480	0,41	3,5 LP	11		15	7		48.6	57.2	58.3	
427	"	" 15,47	480	0,41	3,5 LP	11		16	7		45.8	53.5	58.3	
428	"	" 15,60	480	0,42	3,5 LP	15		16	8		45.3	51.4	57.8	
429	"	" 15,68	480	0,41	3,5 LP	12		16	8		46.3	53.7	58.7	
430	"	" "	480	0,41	3,5 LP	12		15	8		45.8	54.0	59.2	
431	"	" 15,75	480	0,41	3,5 LP	10		16	8		45.8	53.0	57.8	
432	"	" 15,90	480	0,41	3,5 LP	9		15	8		48.1	54.2	59.5	
433	"	" 16,05	480	0,40	4,5 LP	10		15	8		48.1	54.2	61.0	
434	"	" 16,12	480	0,40	4,5 LP	11		15	8		47.2	51.8	58.3	
435	"	" 16,20	480	0,40	4,5 LP	12		15	8		46.3	52.8	56.9	
436	"	"	480		4,5 LP	13		16	8		47.2	54.7	60.5	
323							Mean Value				47,7	55,0	58,5	
[illegible]							St. Deviation				1,7	2,0	1,9	
E-437	17/11	Moorings	420	0,42	6LP + 2 R	15		12	3	33.2	40.3	47.9		
438	20/11	Ring beam c. 3	420	0,40	6LP + 2 R			13	1		46.7	54.2	59.6	
439	5/12	St.Cell 5	420		6LP + 2 R								58.3	
440	18/12	" " Decks	480	0,43	6LP	20		7	4		38.5	49.3	52.3	
441	14/1	" " 8+14	420	0,40	6LP + 2 R	14		13	-4		48.8	63.5	55.4	69.7
442	15/1	" " "	420	0,40	6LP + 2 R	15		13	-2		49.8	59.6	61.9	65.4
443	"	" " 13	420	0,40	6LP + 2 R	12		13	-4		42.6	54.4	58.7	61.0
444	"	" " 1 + 24	420	0,40	6LP + 2 R	14		12	-2		43.5	54.9	60.1	64.1
445	16/1	St.C 12+16+LD11	420	0,41	6LP + 2 R	16		7	0		38.5	49.1	53.2	56.0
446	"	St.C 24+LD 11	420	0,40	6LP + 2 R	10		10	2		44.6	53.9	61.5	63.7
447		" 23 "	420	0,40	6LP + 2 R	15		9	1		42.6	56.6	58.7	62.8
448	17/1	St.C 17+21	480	0,40	5LP	11		10	2		49.3	59.9	61.9	64.5
449	18/1	" 3+11	420	0,40	6LP + 2 R	14		7	5		42.6	59.3	61.9	65.4
550	19/1	L.Dome 10	420	0,40	6LP + 2 R	14		9	1		42.6	54.9	61.0	62.4
451	20/1	LD 10+St.C17+18	420	0,40	6LP + 2 R	12		6	3		44.0	54.6	58.3	60.1

DATE	JOB NO.	DWG NO	REV.
19/1 1976	13468	11	

GRØNER NOTEBY

CONDEEP
ELF – NORGE A.S – FRIGG TCP 2
CONCRETE QUALITY CONTROL SUMMARY

REPORT	DATE	STRUCTURAL MEMBER	CEMENT kg/m³	W/C	ADMIXTURES	SLUMP mm	AIR %	TEMPERATURE °C CONCRETE	AIR	COMPRESSIVE STRENGTH MPa [illegible]	[illegible]	[illegible]	σ_{56}	σ_{90}
	1975	Cell Walls												
E-452	23/1	PCL.16,31-50	500	0,40	4LP	13		21	-4	45.8	13.2	59.4	60.5	
453	23/1	" 16,50-80	480	0,40	4LP	10		20	-2		49.5	56.5	61.0	61.5
454	24/1	" 16,70	480	0,41	4LP	11		12	-2	41.2	45.8	55.3	58.7	
455	"	" 17,05	480	0,40	4LP	10		18	-1		47.8	55.1	60.5	63.2
456	"	" 17,30	480	0,40	4LP	9		21	2	48.1	49.5	60.3	61.9	
457	24/1	" 17,42	480		4LP						47.3	56.5	50.5	61.0
458	25/1	" 17,50	480	0,41	4LP	7		18	2	44.4	48.6	57.4	59.6	
459	"	" 17,50	480	0,41	4LP	12		16	2		41.2	49.1	52.3	55.6
460	"	" 17,80	480	0,41	4LP	9		25	-2	43.0	48.6	56.3	59.6	
461	"	" 18,20	480	0,40	4LP	7		12	-2		46.4	53.7	57.8	58.7
462	"	" 18,25	480	0,40	5LP +1 R	10		13	1	44.6	47.2	55.6	61.0	
463	26/1	" 18,50	480	0,40	6LP + 2R	8		22	0		56.0	62.8	70.1	74.0
464	"	" 18,70	480	0,40	6LP + 2R	11		23	-1	37.6	48.6	56.4	57.9	
465	"	" 18,84	480		6LP + 1R	10		13	-2		50.9	55.8	57.8	63.2
466	"	" 18,90	480	0,40	6LP + 1P	9		18	-2	41.7	47.2	56.0	63.7	
467	27/1	" 19,35	480	0,40	6LP	9		15	-1		51.4	58.1	58.7	68.4
468	"	" 19,42	480	0,40	6LP	8		17	-1	42.6	49.1	54.9	64.3	
469	"	" 19,46	480	0,41	5,5 LP	9		13	-2		47.2	56.2	56.9	61.5
470	"	" 19,60	480	0,41	5,5 LP	8		17	-2	47.2	51.4	59.0	61.5	55.8
471	28/1	" 19,79	480	0,41	5LP	9		20	0		50.0	56.7	60.5	66.7
472	"	" 20,10	480	0,40	4LP	10		19	1	45.3	51.9	55.8	59.6	
473	"	" 20,25	480	0,40	4LP	11		22	1		49.1	55.3	55.6	59.6
474	"	" 20,40	480	0,41	4LP	9		16	1		58.3	61.7	64.1	70.5
475	"	" 20,58	480	0,41	4LP	12		20	1		43.0	51.4	55.6	58.7
476	29/1	" 20,35	480	0,40	4LP	10		24	0		56.9	62.4	66.3	62.8
477	"	" 20,98	480	0,40	4LP	11		17	0		47.2	54.7	62.8	63.7
478	"	" 21,18	480	0,40	4LP	11		18	0		52.8	57.8	61.5	64.1
479	"	" 21,30	480	0,40	4LP	8		18	-2	42.1	46.7	53.7	59.2	
480	"	" 21,60	480	0,40	4LP	8		14	-1		53.2	60.3	62.8	64.9
481	"	" 21,70	480	0,40	4LP	8		16	-2	40.3	48.1	54.9	57.8	
482	"	" 21.74	480	0,41	4LP	10		17	-4		52.3	60.6	64.5	54.9
483	"	" 22,0	480	0,42	4LP	10		22	-4		51.9	60.3	62.8	63.4
484	"	" 22,04	480	0,40	4LP	9	–	16	-4		52.3	58.7	62.8	65.9
485	30/1	" 22,20	480	0,40	4LP	10		15	-4		47.6	53.3	58.3	59.6
486	"	" 22,36	480	0,40	4LP	10		17	-4		53.7	59.6	62.8	64.3
487	"	" 22,65	480	0,40	4LP	10		17	-5	44.8	49.1	56.7	57.8	
488	30/1	" 22,85	480	0,40	4LP	10		14	-5		54.2	60.1	60.5	57.5
489	"	" 22,97	480	0,40	4LP	9		18	-6	43.5	49.5	57.4	60.5	
490	"	" 23,16	480	0,40	4LP	13		23	-6		52.3	60.3	61.9	64.5
491	"	23,22	480	0,40	4LP				-6	45.3	50.4	57.2	61.5	
492	31/1	" 23,38	480	0,40	4LP	8		20	-2		53.7	59.6	62.8	64.1
493	"	" 23,59	480	0,41	4LP	12		2	-2		50.0	57.4	61.5	61.9
494	"	" 23,90	480	0,40	4LP	7		23	0	48.1	53.2	60.1	65.4	
495	"	" 24,03	480	8,40	4LP	10		23	1		51.9	57.4	58.7	59.2
496	"	" 24,20	480	0,40	4LP	9		20	2	42.1	49.5	55.3	58.7	
497	"	" 24,30	480	0,40	4LP	12		26	0		50.0	54.2	57.4	59.2
498	"	" 24,50	480		4LP	12		23	0	41.2	48.1	55.4	58.7	
499	"	" 24,82	480	0,40	4LP	10		29	1		53.2	59.2	59.6	61.9
500	1/2	" 25,04	480	0,40	3LP	9		23	1		51.0	57.8	59.6	65.8

REPORT	DATE	STRUCTURAL MEMBER		CEMENT kg/m³	W/C	ADMIXTURES	SLUMP mm	AIR %	TEMPERATURE CONC. °C	TEMPERATURE AIR °C	COMPRESSIVE STRENGTH MPa σ_3	σ_7	σ_{28}	σ_{56}	σ_{90}
E-501	1/2	P.L.	25,10	480	0,40	3 LP	10		33	1		57,8	60,8	62.4	64.5
502	"	"	25,44	480	0,40	3LP	9		26	2	50.4	56.9	60.8	62.4	
503	"	"	25,63	480	0,40	3 LP	9		20	2		50.1	57.6	58.7	62.4
504	"	"	25,82	480	0,40	3 LP	11		23	2	44.8	50.9	54.6	58.3	
505	"	"	26,02	480	0,40	3 LP	9		12	3		50.4	55.6	56.0	62.8
506	"	"	26,09	480	0,40	3 LP	12		22	3	42.1	50.1	54.4	59.2	
507	"	"	26,33	480	0,40	3 LP	10		23	3		50.5	59.0	62.4	65.8
508	2/2	"	26,60	480	0,40	3 LP	14		21	2	43.0	46.7	52.7	56.0	
509	"	"	26,75	480	0,40	3 LP	10		21	2		49.5	56.3	59.2	62.8
510	"	"	26,89	480	0,40	3 LP	10		20	2		53.7	59.6	61.5	63.7
511	"	"	27,10	480	0,41	3 LP	10		21	4	49.5	51.9	58.7	60.1	
512	"	"	27,35	480	0,41	3 LP	11		18	4		46.7	53.5	57.4	58.7
513	"	"	27,43	480	0,41	3 LP	11		18	4	44.8	47.6	54.9	57.8	
514	"	"	27,67	480	0,40	3 LP	12		21	3		48.6	56.9	57.8	61.9
515	"	"	27,84	480	0,41	3 LP	14		16	3	43.9	48.6	57.8	57.8	
516	"	"	27,98	480	0,40	3 LP	10		22	3		48.6	56.2	56.4	62.4
517	3/2	"	28,25	480	0,40	3 LP	10		21	2	49.5	54.2	59.6	61.0	65.4
518	"	"	28,42	480	0,40	3 LP	S		17	1		49.5	56.5	59.2	64.1
519	"	"	28,55	480	0,41	3 LP	11		29	1	51.4	55.6	60.1	63.7	67.5
520	"	"	28,95	480	0,41	3 LP	13		21	1	45.8	48.6	56.2	51.9	
521	"	"	29.05	480	0,40	3 LP	10		21	1		52.8	57.4	61.0	63.2
522	"	"	29,22	480	0,40	3 LP	11		20	1	43.0	48.6	55.3	59.2	
523	"	"	29,43	480	0,40	3 LP	12		21	1		40.8	47.0	48.6	50.0
524	"	"	29,55	480	0,40	3 LP	11		22	1	41.7	45.8	55.9	57.8	
525	4/2	"	29,72	480	0,40	3 LP	8		20	0		50.9	56.7	57.8	61.5
526	"	"	29,90	480	0,40	3 LP	8		20	-1	45.3	50.9	56.9	57.4	
527	"	"	30,30	480	0,40	3 LP	10		22	-2		50.4	58.7	59.2	61.9
528	"	"	30.41	480	0,40	3 LP	12		18	-2	46.3	53.2	59.0	57.4	
529	"	"	30.48	480	0,41	3 LP	12		21	-2		51.4	57.1	57.8	59.6
530	"	"	30,64	480	0,40	3 LP	10		23	0	42.6	46.7	54.6	55.1	
531	"	"	30,93	480	0,41	3 LP	13		28	0		44.4	51.7	53.2	56.0
532	"	"	31,00	480	0,40	3 LP	9		23	-1	43.0	49.1	56.3	56.9	
533	5/2	"	31.15	480	0,40	3 LP	13		28	-1		49.5	55.8	57.4	59.3
534	"	"	31.40	480	0,40	3 LP	12		22	0		48.1	56.9	59.2	59.2
535	"	"	31.55	480	0,40	3 LP	10		29	0		51.4	60.3	61.0	61.9
536	"	"	32.00	480	0,40	3 LP	11		18	-1	50.4	53.2	63.0	63.7	
537	"	"	32,20	480	0,40	3 LP	10		25	2		50.4	59.2	61.0	63.2
538	"	"	32,43	480	0,40	3 LP	10		25	3	46.2	53.2	59.9	60.5	
539	"	"	32,66	480	0,40	3 LP	11		23	1		46.7	57.4	61.0	61.5
540	"	"	32,74	480	0,39	3 LP	8		24	1	48.6	51.9	61.7	65.4	
541	6/2	"	32,87	480	0,40	3 LP	12		21	1		51.4	58.5	61.5	63.2
542	"	"	33,00	480	0,40	3 LP	7		26	1	48.1	56.9	60.6	61.5	
543	"	"	33,25	480	0,40	3 LP	9		19	1		51.9	58.7	60.5	62.4
544	"	"	33,55	480	0,40	3 LP	12		24	0	45.8	50.0	56.7	60.5	
545	"	"	33,70	480	0,40	3 LP	11		24	0		50.4	55.1	56.7	61.9
546	"	"	33,90	480	0,40	3 LP	11		23	0	44.4	50.9	57.4	60.5	[illegible]
547	"	"	34,08	480	0,40	3 LP	10		9	1		46.7	52.8	54.6	57.2
548	"	"	34.28	480	0,41	3 LP	13		25	1	43.1	50.4	57.4	61.0	
549	"	"	34,36	480	0,40	3 LP	10		25	2		47.2	55.1	59.6	61.9
550	7/2	"	34,60	480	0,40	3 LP	12		24	2	44.6	49.1	55.1	[illegible]	

GRØNER NOTEBY

JOB: CONDEEP
ELF-NORGE A.S - FRIGG TCP 2
CONCRETE QUALITY CONTROL SUMMARY

RE:

REPORT	DATE	STRUCTURAL MEMBER		CEMENT kg/m³	w/c	ADMIXTURES PER m³	SLUMP cm	AIR %	TEMPERATURE °C CONCR	TEMPERATURE °C AIR	COMPRESSIVE STRENGTH MPa, 15cm CUBES σ_1	σ_7	σ_{28}	σ_{56}	σ_{50}
E-551	7/2	P.L.	34,75	480	0,40	3 LP	10	2,2	20	3		49.5	53.7	59.5	63.2
552	"	"	34,90	480	0,41	3 LP	14		26	3	45.8	48.6	54.7	61.0	
553	"	"	35,20	480	0,40	3 LP	11		20	2	45.3	51.4	58.5	60.1	
554	"	"	35,35	480	0,40	3 LP	11		24	2		50.4	55.3	60.1	64.1
555	"	"	35,48	480	0,40	3 LP	10		21	2	44.8	48.1	55.6	64.1	
556	"	"	35,65	480	0,40	3 LP	12		26	1		48.6	56.0	61.5	61.9
557	"	"	35,90	480	0,39	3 LP	9		22	1	46.7	48.6	56.7	61.9	
558	"	"	36,02	480	0,39	3 LP	9		23	1		48.6	54.2	58.7	61.5
559	"	"	36,30	480	0,40	3 LP	11		26	1	44.8	50.0	57.2	60.1	
560	8/2	"	36,45	480	0,40	3 LP	9		28	0		51.9	56.7	59.2	59.2
561	"	"	36,70	480	0,40	3 LP	9		22	-1	47.2	51.9	55.6	61.0	
562	"	"	36,86	480	0,40	3 LP	11		26	-1		50.4	57.8	61.0	62.4
563	"	"	37,09	480	0,39	3 LP	9		24	-1	42.6	49.1	56.9	60.5	
564	"	"	37,22	480	0,39	3 LP	8		23	0		51.4	56.9	61.5	62.8
565	"	"	37,40	480	0,40	3 LP	9		19	-1	46,3	51.4	59.5	63.7	
566	"	"	37,75	480	0,41	3 LP	13		28	-2		49.5	56.7	56.9	60.1
567	"	"	37,95	480	0,40	3 LP	12		27	-2	43.9	48.5	55.6	61.0	
568	9/2	"	38,10	480	0,40	3 LP	13		21	-1		50.0	56.9	60.1	61.9
569	"	"	38,30	480	0,40	3 LP	10		23	-2	46.3	50.9	58.1	62.0	
570	"	"	38,46	480	0,40	3 LP	10		21	-2		50.4	56.5	56.8	59.6
571	"	"	38,56	480	0,40	3 LP	10		26	-1		50.0	55.3	59.3	61.5
572	"	"	38,70	480	0,39	3 LP	9		23	1	44.8	50.9	57.4	61.1	
573	"	"	39,00	480	0,40	3 LP	11		22	7		48.1	54.9	56.8	62.4
574	"	"	39,20	480	0,41	3 LP	13		28	9	42.6	50.4	55.1	60.2	
575	"	"	39,40	480	0,40	3 LP	13		29	9		49.1	56.9	60.5	62.9
576	10/2	"	39,50	480	0,40	3 LP	9		26	6	44,8	49.5	57.2	58.4	
577	"	"	39,75	480	0,40	3 LP	10		30	7		48.6	55.3	61.0	61.9
578	"	"	40,31	480	0,40	3 LP	11		25	6	48.1	52.3	59.4	61.0	
579	"	"	40,42	480	0,39	3 LP	9		22	5		49.1	58.0	62.0	62.4
580	"	"	40,60	480	0,40	3 LP	10		25	6	45.3	48.6	58.1	62.5	
581	"	"	40,85	480	0,40	3 LP	9		23	6		51.4	58.1	62.5	63.2
582	"	"	41.00	480	0,41	3 LP	13		23	4	41.7	49.5	57.4	60.1	
583	"	"	41.25	480	0,40	3 LP	12		25	2		50.0	56.9	58.3	62.4
584	11/2	"	41.40	480	0,40	4 LP	11		20	1	45.8	49.5	56.7	59.3	
585	"	"	41.46	480	0,40	4 LP	10		19	1		49.5	54.9	61.1	62.4
586	"	"	41.55	480	0,40	6 LP	13		20	1		50.9	56.4	60.1	64.1
587	"	"	41.25	480	0,38	6 LP 2 R	13		21	5	42.6	48.6	58.1	63.8	
588	"	"	42,05	480	0,42	6 LP 2 R	20		22	5		50.4	59.4	65.5	67.5
589	12/2	"	42,20	480	0,40	6 LP	14		25	3	43.0	48.1	56.7	61.1	
590	"	"	42,45	480	0,40	3 LP	12		23	3		44.4	55.8	56.4	59.2
									Mean Value		44.9	50.1	57.0	60.1	62.6
									St. Deviation		2.7	2.8	2.5	2.8	3.4

DATE: 11/6 | JOB NO: 13468 | DWG NO.: 14 | REV:

GRØNER NOTEBY

JOB CONDEEP
ELF – NORGE A.S – FRIGG TCP 2
CONCRETE QUALITY CONTROL. SUMMARY

RE:

REPORT	DATE	STRUCTURAL MEMBER	CEMENT kg/m³	W/C	ADMIXTURES PER m³	SLUMP cm	AIR %	TEMPERATURE °C CONCR	TEMPERATURE °C AIR	COMPRESSIVE STRENGTH MPa 10cm CUBES σ1	σ7	σ28	σ56	σ90
E-591	30/4	Shell U. Domes	500	0,40	6 LP 2 R				-5		45.3	53.9	58.7	61.5
592	19/2	Element 43,75	500		6 LP 2 R	6		22	-2		53.2	60.4	67.1	
593	25/2	" "	500		6 LP 2 R	6		17	8		56.0	63.2	64.5	72.4
594	28/2	Crane stc. 19	420		6 LP 2 R	13		14	4		42.6	56.9	60.5	63.2
595	3/3	Element 43,75	500		6 LP 2 R	6		20	4		58.7	67.1	70.9	76.0
596	4/3	" "	500	0,40	6 LP 2 R	8		26	4		58.7	66.9	69.2	74.0
597	19/3	Elements U.D.	500	0,40	6 LP 2 R	7		0	0		56.0	60.6	69.7	70.1
		MORTAR, CRACKS PL.42,70												
E-611	5/4	Inside C. 18	EXM			18					45.9	54.0	57.5	
612	6/4	" " "	500	0,42	6 LP 2 R	18		8	5		37.6	49.1	52.3	
628	27/4	" " 6	500		6 LP 2 R	18					41.2	48.1	51.4	
631	29/4	St. C. [illegible] 12	500		6 LP 2 R						38.1	49.8	54.2	
639	5/5	" " 1	500	0,40	6 LP 2 R	16		13	14		38.1	46.1	51.4	
640	7/5	C. 11	510	0,40	6 LP 2 R	15		15	15		36.3	46.3	50.4	
641	8/5	St. C. 2 and 6	500	0,38	6 LP 2 R	13		15	15		37.2	45.1	50.0	
643	11/5	C. 7	EXM								41.0	50.7	54.3	
646	"	C. 7	500		6 LP 2 R	18					40.8	47.9	54.2	
651	12/5	" C. 8 + 6	500		6 LP 2 R	9					45.3	54.8	59.7	
656	13/5	C. 1	500		6 LP 2 R	13					43.0	51.2	54.2	
661	19/5	" C. 3 + 9	500		6 LP 2 R	14					39.4	48.4	49.[illegible]	
665	21/5	" C. 4 + 10	500		6 LP 2 R	10		17	18		43.0	50.9	52.3	
667	25/5	St. C. 19 + 20	500		6 LP 2 R	16					37.6	47.0	51.4	
668	31/5	C. 18 + 19	500		6 LP 2 R						47.6	53.7	58.7	
669	1/6	St. C. 13 + 22	500		6 LP 2 R	15					38.1	44.2	49.0	
670	3/6	C. 17 + 16	500		6 LP 2 R	15		17	13		43.9	53.5	56.9	62.4
680	10/6	C. 9 + 17	500		6 LP 2 R	23		17	22		39.4	49.1	53.2	52.3
685	11/6	C. 18	500		6 LP 2 R	8		20	19		43.9	50.9	54.2	54.2
							Mean value				40.9	49.5	53.4	
							St. Deviation				(3.3)	(3.1)	3.0	
		UPPER DOMES												
E-598	24/3	No. 18 + 19	480	0,39	6 LP 2 R	10		16	5		47.2	54.0	59.2	60.5
599	25/3	" 18 + 19	460	0,40	6 LP 2 R	10		14	1		48.1	53.1	57.8	59.2
600	"	" 18 + 19	460	0,39	6 LP 2 R	7		15	7		51.4	59.6	67.1	68.4
601	"	" 18 + 19	480	0,41	6 LP 2 R	13		8	3		47.2	55.4	59.2	62.4
602	1/4	" 7 + 8	480	0,40	6 LP 2 R	13		14	5		45.7	56.7	57.6	60.1
603	"	Shaft f. C. 3	460	0,40	6 LP 2 R	11		11	4		45.3	59.2	61.5	
604	"	No. 7 + 8	460	0,42	6 LP 2 R	16		14	2	40.8	48.6	57.9	60.5	61.5
605	2/3	" 7 + 8	460		6 LP 2 R	11					48.6	57.6	63.2	
606	2/4	" 7 + 8	460	0,40	6 LP 2 R	10		13	2		51.4	59.6	64.5	69.4
607	"	" 7 + 8	480	0,41	6 LP 2 R	14		14	5		46.3	55.1	61.0	
608	"	" 8 + 7	460	0,40	6 LP 2 R	6		8	3	41.2	49.1	59.0	64.5	65.4
609	"	" 8 + 7	460	0,40	6 LP 2 R	7		8	2	[illegible]	50.9	62.8	67.5	
610	3/4	" 7 + 8	460		6 LP 2 R	8		10	2			54.5	58.3	61.0
613	7/4	" 4	440		6 LP 2 R	6		10	5		51.4	59.7	65.9	70.1
614	8/4	" 6 + 4	480	0,40	6 LP 2 R	14		8	0		46.7	57.4	61.9	

DATE 12/11-76 | JOB NO 13468 | DWG NO 15 | REV.

GRØNER NOTEBY

JOB: CONDEEP
ELF – NORGE A.S – FRIGG TCP 2
CONCRETE QUALITY CONTROL. SUMMARY

RE.

REPORT	DATE	STRUCTURAL MEMBER	CEMENT kg/m³	W/C	ADMIXTURES PER m³	SLUMP cm	AIR %	TEMPERATURE °C CONCR	TEMPERATURE °C AIR	COMPRESSIVE STRENGTH MPa 15cm CUBES σ_1	σ_7	σ_{28}	σ_{56}	σ_{90}
E-615	8/4	No. 6 + 4	480		6 LP 2 R	8		9	-1			56.9	64.5	65.2
616	"	" 12	440	0,39	6 LP 2 R	10		10			50.4	59.2	51.5	
617	"	" 12 + 4 + 6	480		5 LP	5		25	6		50.9	56.0	60.5	63.7
618	"	Shaft f.C. 3	480		5 LP	9		20	6		46,7	52.6	54.6	
619	"	No. 6 + 4	480	0,40	6 LP 2 R	7		9	3			58.5	62.3	65.4
620	"	" 12	440	0,40	6 LP 2 R	6		15	3		49.1	57.2	61.3	
621	9/4	" 6	440		6 LP 2 R	9		6	7			56.5	62.4	63.2
622	"	" 4	440		6 LP 2 R	7		6	7			57.9	54.1	67.5
623	10/4	" 21	440	0,40	6 LP 2 R	9		12	7			49.3		5[illegible].6
624	23/4	" 2	420	0,41	6 LP 2 R	17		9	7		43.0	51.2	58.3	59.2
625	"	" 2	420		6 LP 2 R	18		9			43.9	53.0	58.3	
626	24/4	" 2	420	0,40	6 LP 2 R	9					45.7	54.6	59.2	62.4
627	26/4	" 1	440	0,40	6 LP 2 R	14		9			38.5	46.0	50.0	
629	27/4	" 1 + 2	440	0,40	6 LP 2 R	14			3		41.2	53.7	58.7	62.4
630	28/4	" 1	440		6 LP 2 R	22		9	7		45.8	57.4	59.6	
632	29/4	" 10 + 11	400	0,41	6 LP 2 R	16		9	5		43.0	54.0	56.0	59.6
633	30/4	" 10 + 11	400	0,41	6 LP 2 R	13		10	2		46.7	57.2	57.8	
634	"	" 10 + 11	400	0,41	6 LP 2 R	12		10	2		44.4	56.0	61.5	
635	"	" 10 + 11	400		6 LP 2 R	6		10	6		45.3	58.5	59.6	
636	30/4	" 10 + 11	400		6 LP 2 R	18		9	6		42.1	53.3	55.1	58.7
637	"	" 10 + 11	400		6 LP 2 R	5		11	5		47.6	59.0	61.5	
638	4/5	" 5	440	0,41	6 LP 2 R	17		10	10		40.3	49.6	53.7	
642	11/5	" 14 + 16	400	0,41	6 LP 2 R	17		16	14		45.8	55.3	57.3	59.3
644	"	" 14 + 16	400	0,40	6 LP 2 R	12		16	14		49.5	56.9	63.7	
645	"	" 14 + 16	400	0,40	6 LP 2 R	12		18	14		47.5	57.4	59.6	59.3
647	11/5	" 14 + 16	440		6 LP 2 R	9		14	12		50.0	56.0	60.1	
648	"	" 14 + 15+16	440		6 LP 2 R	18		14	10		43.5	54.0	59.2	58.8
649	"	" 14 + 15+16	400		6 LP 2 R	12		13	10		50.0	61.0	62.8	
650	12/5	" 14 + 15+16	400	0,40	6 LP 2 R	10		14	12		49.1	56.7	61.0	62.4
652	"	" 14 + 15+16	400	0,40	6 LP 2 R	10		14	17		50.9	58.8	60.5	
653	"	" 14 + 15+16	400		6 LP 2 R	6		14	12		44.8	52.1	59.2	55.5
654	12/5	" 14 + 15+16	400		6 LP 2 R	7		13	10		47.6	58.3	60.2	[illegible]
655	"	" 14 + 15+16	400		6 LP 2 R	7		13	9		47.2	59.0	60.5	64.9
657	13/5	" 13	440		6 LP 2 R	17		13	9		52.3	60.1	64.1	
658	"	" 13	400		6 LP 2 R	6		12	8		48.1	59.6	60.5	62.8
659	19/5	" 9	440		6 LP 2 R	20		18	23		44.4	49.8	55.5	
660	"	" 9	440		6 LP 2 R	18		17	22		42.1	52.3	54.6	
662	20/5	" 17	480		6 LP 2 R	10		16	20		49.5	58.3	61.9	
663	"	" 17	400		6 LP 2 R	9		15			44.8	52.8	56.0	
664	21/5	" 17	400		6 LP 2 R	8		12	17		46.3	54.7	55.1	59.6
666	"	" 17	400		6 LP 2 R	9		16	18		49.1	56.4	54.2	
								Mean Value			46.9	56.1	60.0	61.9
								St. Deviation			(3.2)	(3.3)	(3.6)	(4.2)

DATE 12/11-76 | JOB NO. 13468 | DWG. NO. 15 | RVS.

GRØNER NOTEBY

JOB: CONDEEP
ELF-NORGE A.S - FRIGG TCP 2
CONCRETE QUALITY CONTROL. SUMMARY

RE.

REPORT	DATE	STRUCTURAL MEMBER	CEMENT kg/m³	W/C	ADMIXTURES PER m³	SLUMP cm	AIR %	TEMPERATURE °C CONCR	TEMPERATURE °C AIR	COMPRESSIVE STRENGTH MPa 15cm CUBES σ_3	σ_7	σ_{28}	σ_{56}	σ_{90}
		SHAFTS 1+3+5												
E-671	8/6		480		2,5 LP	8,5		16	15		46.7	50.9	58.3	
672	"	P.L. 45,60	480	0,41	2,5 LP	14		17	15		45,8	52,1	55.1	
673	"	" 46,80	480	0,42	2,5 LP	17		16	10		45.8	51.4	54.2	
674	9/6		480		2,5 LP	19		17	16		40.4	49.5	52.3	
675	"		480		2 LP	16		17	18		43.0	47.7	52.3	
676	"	" 48,25	480	0,41	2 LP	16		19	19		42.6	48.6	52.3	
677	"	" 48,70	480	0,40	2 LP	10		16	14		42.1	49.6	54.2	
678	10/6	" 50.00	480		1,5 LP	15		16	21		40.8	46.5	50.4	
679	"	" 51,50	480		1 LP	19		17	22		41.2	48.4	51.4	
681	"	" 51.00	480	0,42	1 LP	10		17	17		40.8	49.8	53.2	
682	10/6	" 51,45	480		1 LP	14		26	19		43.9	52.8	53.2	
683	11/6	" 52,90	480		1 LP	15		24	20		44.4	51.4	55.1	
684	"	" 53,45	480		1 LP	12		25	18		43.5	49.1	54.2	55.1
686	"	" 53,90	480	0,42	1 LP	12	1,7	24	16		43.5	49.5	51.4	
687	11/6	" 54.25	480	0,42	1 LP	13		25	17		46.7	52.6	54.2	
688	"	" 54,70	480	0,41	1 LP	15		25	13		49.1	53.3	55.1	
689	12/6	" 55,80	480	0,42	1 LP	15	1,7	26	17		45.3	49.3	55.1	
690	"	" 50.35	480	0,42	1 LP	16		26	17		43.9	50.0	52.3	
691	"	" 56,80	480	0,43	1 LP	17		29	18		43.0	47,9	53.2	
692	"	" 57,50	480	0,43	1 LP	12	2,0	28	17		43.9	50,2	54.2	
693	"	" 58,00	480	0,43	1 LP	15	2,5	25	17		43.0	50.0	53.2	
694	13/6	" 59,30	480	0,43	1 LP	18	1,9	25	13		44.4	48.9	51.4	
695	"	" 59,65	480	0,42	1 LP	13		29	16		49.1	56.0	59.6	
696	"	" 50,30	480	0,42	1 LP	12	1,9	28	18		43.9	50.2	54.2	
697	"	" 60,79	480	0,41	1 LP	16		29	15		43.5	49.8	54.2	
698	"	" 61,00	480	0,42	1 LP	15	--	17	15		43.5	51.4	53.2	
699	14/6	" 62,60	480	0,42	1 LP	16	2,0	27	16		44.8	51.8	53.7	
700	"	" 57,20 C.20	480	0,42	2 LP	13		26	16		44.4	52.7	51.8	
701	"	" 63,75	480		1 LP	13	1,8	25	18		44.8	50.0	52.3	
702	"	" 58,45 C.20	480		2 LP	16		25	15		49.5	53.9	58.8	
703	15/6	" 64,45 C.20	480	0,40	1 LP	12		25	13		47.6	53.2	54.6	
704	"	" 65,90	480	0,42	1 LP	12	1,9	24	12		47.6	54.4	56.4	
705	"	" 66,35	480	0,42	1 LP	15		25	12		41.7	48.2	51.4	51.4
706	"	" 66,80	480		1 LP	12	2,0	25	15		44.8	49.1	55.4	
707	"	" 67,45	480		1 LP	11		22	14		45.8	51.6	53.7	
708	"	" 61,15 C.20	480	0,[illegible]	3 LP	12		24	11		50.0	56.2	58.7	
709	16/6	" 69,20	480	0,42	1 LP	13	2,0	23	13		47.6	51,6	56,9	
710	"	" 69,95	480	0,43	1 LP	17		25	17		40.3	47.9	50.4	
711	"	" 70,35	480	0,42	1 LP	12	1,9	25	19		43.0	49.8	52.3	
712	"	" 70,85	480	0,42	1 LP	13		26	18		46.3	53.5	58.3	
713	"	" 71,25 C.20	480		1 LP	14			17		46.3	52.8	57.9	
714	17/6	" 73,00	480	0,42	1 LP	13	1,9	28	14		46.3	53.7	53.2	
715	"	" 73,40	480	0,42	1 LP	13		27	20		43.5	51.7	54.2	
716	"	73,80	480	0,43	1 LP	14	1,9	18	18		39.4	45.6	49.1	
717	"	" 74,00	480		1 LP	19		17	18		40.3	46.5	49.9	
718	18/6	" 75,60	480	0,43	1 LP	16	1,9	25	16		43.0	46.0	51.9	
719	"	" 76,00	480	0,42	1 LP	11		27	17		41.2	45.1	51.8	
720	"	" 77,00	480	0,42	1 LP	12	1,9	18	19		43.9	48.6	52.3	

DATE	JOB NO	DWG NO.	REV.
12/11-76	13468	17	

CONCRETE QUALITY CONTROL SUMMARY

RE:

REPORT	DATE	STRUCTURAL MEMBER	CEMENT kg/m³	w/c	ADMIXTURES per m³	SLUMP cm	AIR %	TEMPERATURE °C CONCR	TEMPERATURE °C AIR	COMPRESSIVE STRENGTH MPa, 15cm CUBES σ_1	σ_7	σ_{28}	σ_{56}	σ_{90}
E-721	18/6	P.L.69,80	480	0,41	2 LP	14		18	14		42.1	47.4	49.9	
722	19/6	" 79,10	480	0,42	1 LP	15	1,9	25	15		48.1	52.6	56.5	
723	"	" 80,20	480	0,43	1 LP	15	1,8	24	15		45.3	51.4	56.5	
724	20/6	" 82,20	480	0,40	1 LP	20	2,0	20	12		47.2	53.0	54.6	
725	"	" 82,60	480	0,40	1 LP	13		20	13		42.1	51.2	49.5	
726	"	" 83,30	480	0,41	1 LP	16	2,0	28	12		45.7	55.1	56.4	
727	"	" 76,10	480	0,39	1,5 LP	15		28	11		48.1	53.0	55.6	
728	21/6	" C.20	480	0,41	1 LP	12		27	14		52.8	59.2	60.1	
729	"	C.20	480	0,41	1 LP	11		25	14		49.5	54.6	57.4	
730	"	" 78,65 C.20	480		1,5 LP	15		26			48.1	54.7	56.4	
731	"	" 86,50	480	0,38	1 LP 0,15L	15	4,5	22	11		43.9	51.8	53.7	
732	22/6	" 87,50 C.20	480	0,38	1 LP 0,15L	12	3,3	28	11		48.1	53.2	57.4	
733	"	" 89,45 C.20	480	0,39	1 LP 0,15L	12	3,5	29	14		49.1	54.0	54.5	
734	"	" 91,60	480		1 LP 0,18L	14	3,7	25	12		44.4	54.2	54.2	
735	23/6	" 92,65 C.20	480		1 LP 0,19L	17	3,7	23	9		45.3	52.8	53.2	
736	"	" 93,60 C.20	480		1 LP 0,18L	14	3,6	27	15		47.2	53.4	56.4	
737	"	" 94,60	480	0,39	1 LP 0,18L	15	5,0	19	17		40.3	46.3	48.6	
738	24/6	" 96,40	480	0,40	1 LP 0,16L	15	4,4	18			43.9	50.5	54.6	
739	"	" 97,85	480	0,40	1 LP 0,12L	14	3,8	17	18		38.5	46.7	49.1	
740	"	" 98,30	480	0,40	1,5LP0,12L	17	3,7	20	19		40.3	48.4	52.4	
741	25/6	" 99,50	480	0,40	1,5LP0,12L	16	4,3	19	16		45.8	51.9	54.2	
742	"	" 92,00 C.20	480	0,40	2 LP 0,12L	13	3,8	20	17		43,5	50.7	56.4	56.0
743	"	" 102,00	480	0,39	1,5LP0,12L	16	4,1	18	15		41.2	47.7	51.4	
744	26/7	" 103,00	480	0,38	1 LP 0,12L	16	3,8	17	15		47.6	53.5	55.1	
745	"	" 97,00 C.20	480	0,40	1,5LP0,15L	16	3,9	18	17		39.4	44.4	46.3	
746	"	" 107,80	480	0,40	1 LP 0,15L	17	4,3	18	13		41.2	49.6	51.9	
747	"	" 108,40	480	0,39	1 LP 0,15L	11	3,2	19	13		48.1	52.5	59.6	
748	27/7	" 109,35	480	0,40	1 LP 0,15L	14	4,7		14		42.1	48.2	46.7	
749	"	" 109,80	480	0,40	1 LP 0,15L	16	4,4	17	15		40.8	49.6	52.3	
750	28/7	" 111,00	480	0,39	1 LP 0,15L	15	4,9	14	14		41.2	47.2	45.3	
751	"	" 111,50	480	0,40	1 LP 0,15L	17	4,5	25	14		42.6	49.8	49.1	
752	29/7	" 113,10	480	0,39	1 LP 0,12L	15	4,6	14	17		38.5	46.7	49.5	
753	"	" 114,80	480	0,40	1 LP 0,15L	17	3,9	22	16		44.8	49.5	52.3	
754	30/6	" 116,90	480	0,40	1 LP 0,18L	16	4,6	20	13		41.7	48.6		
755	"	" 118,20	480		1 LP 0,12L	12	3,5	27	11		45.3	49.5	51.4	
756	1/7	" 121,20	480	0,41	1 LP 0,12L	19	3,7	24	14		35.4	43.9	41.2	48.6
757	"	" 122,20	480	0,40	1 LP 0,12L	14	3,9	22	14		39.4	47.6	48.6	
758	2/7	" 123,00	480	0,39	1 LP 0,12L	12	4,4	21	14		42,6	50.9	52.3	
759	"	" 125,30	480	0,40	1,5LP0,08L	13	4,0	15	12		44.8	54.2	53.2	58.7
760	3/7	" 126,60	480	0,40	2 LP 0,09L	15	3,6	15	13		44.8	51.1	55.1	
							Mean value				44.2	50.6	53.2	54.0
							St. Deviation				3.3	2.9	4.0	-

DATE | JOB NO | DWG NO | RVD

Enclosure no 18

GRØNER-NOTEBY CONSULTING ENGINEERS, PARTNERS OF NORCONSULT A.S.
QUALITY CONTROL AND SITE INSPECTION FOR
OFFSHORE STRUCTURES

Norwegian Contractors,

Site.

Your ref.:

13468/Riise/Mauring/GK Andalsnes 25/8-76

Condeep, Frigg TCP-2

Subject: Grouting of anchor bolts

It is demonstrated that the houses of anchor bolts have untight connection between the spiro duct and the inner tube.

Water, ordinary grout (Betokem IN (B)) and thixotropic grout (CBP 208) were separately pumped into the outer tube.

The water streamed easely through the tube connections. Also the two types of grout passed through. The thixotropic one, however, proved the lowest flowing rate.

The amount of grout through the connections decreased rapidly and seemed to stop after short time.

The mounting of the Dywidag bars and the routine of grouting are given by drwg. 1745 - 07 - 320, dated 25.5.76.

Grouting test on a bolt, scale 1 : 1, was carried out during week 33/76.

After grouting the bolt was cut at critical zones, shown on the enclosed sketch. The following inspection proved that the exposed sections of the ducts were completely filled with grout.

Based on this full scale test Grøner-Noteby recommends the following grouting procedure:

- Injection between inner and outer tube up to P.L. 129,40 with a thixotropic grout with composition as below:

Cement PC 300	100 kg per batch
Water	40 lt " "
CBP 208	0,6 kg " "

During grouting of outer tube water shall be kept in inner tube to prevent grout leakage through the untight connections.

Inner tube must be flushed with water before hardening of grout in the outer tube.

Ordinary grout with the mix proportions below, should be used by the injection of the inner tube:

Cement PC 300	100 kg per batch
Water	40 lt " "
Betokem IN (B)	1,5 kg " "

The tube is first to be filled slightly above the inlet. No futher injection must take place before water below the inlet has escaped and the bottom of the tube is filled with grout.

The mentioned trial demonstrated that a waiting time of 30 minutes satisfies this requirement.

The injection of the inner tube will after this be completed.

A grouting outlet from the top of the inner tube must be designed by Grøner, Oslo. The bleeding ~~of~~ grout will consequently be stored in the flexible outlet, otherwise directly underneath the hexagon nut.

Air inside the inner tube above the grouting outlet, must be evacuated through a drilled out hole, Ø 2-3 mm, in the bearing plate.

Grouting should be finished by keeping a pumping pressure of 10 bars at the inlet of the tube for approximately 1 minute.

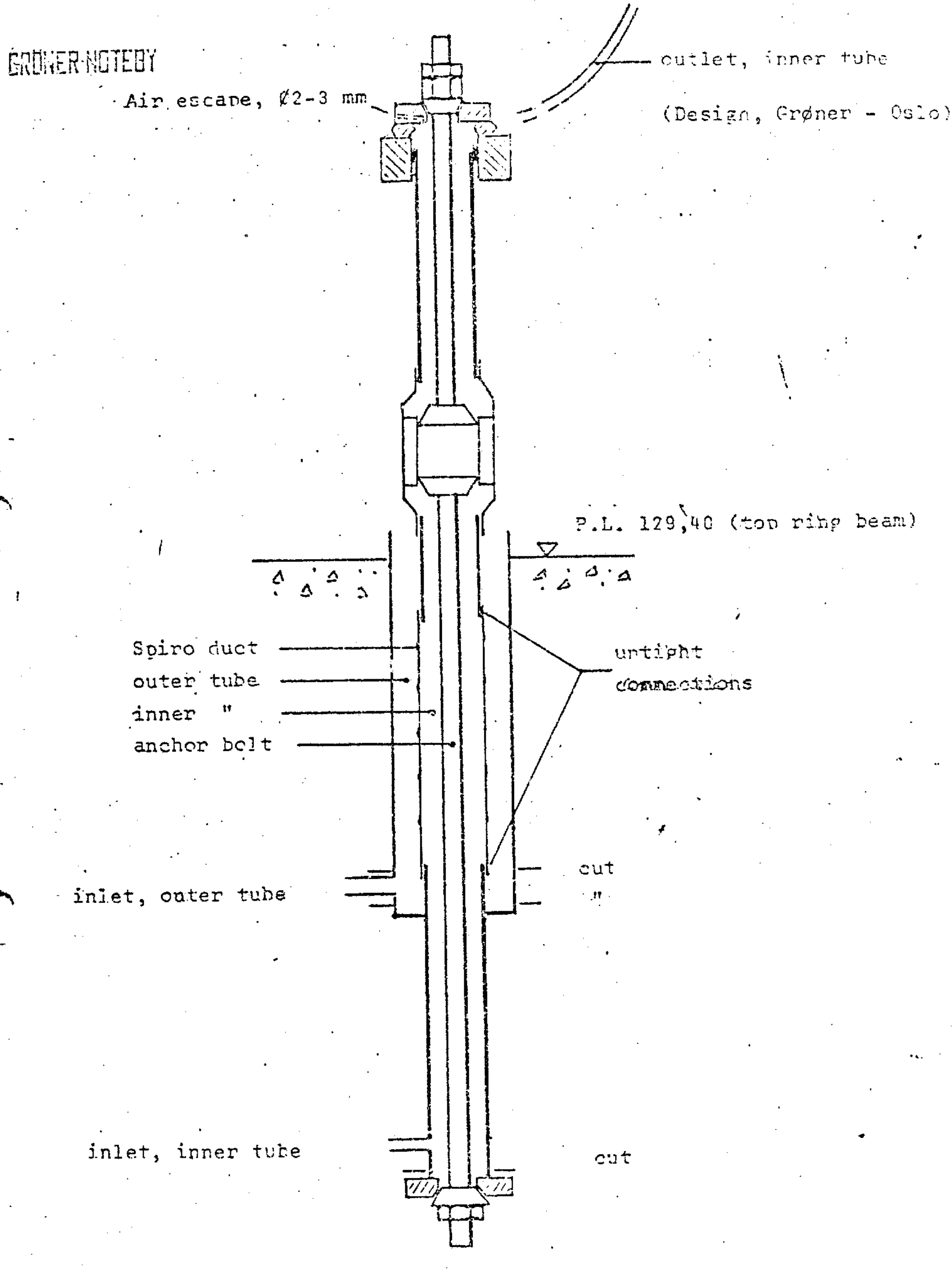
If grouting disagree with this procedure, permission shall be given by the designer.

Regards
Grøner-Noteby

Dagfinn Riise

Kåre Mauring

cc: TNO, site
DnV, "
STUP, "
Grøner, site
Grøner-Noteby, site
" Stavanger
Grøner, Oslo



ANCHOR BOLT

Enclosure

GRØNER-NOTEBY CONSULTING ENGINEERS, PARTNERS OF NORCONSULT A.S.
QUALITY CONTROL AND SITE INSPECTION FOR
OFFSHORE STRUCTURES

Saksbehandler: Lillesto | Kopi sendt |
- 9 MAI 1977
Besvart: Lyngstad

Encl. 15

OK

NORWEGIAN CONTRACTORS
Site Office
Åndalsnes

Condeep Site Office
P.O.Box 3115, 4031 Hinna
Telephone 045/38 020

Your ref.: Our ref.: Riise/al ~~xxxx~~. Åndalsnes, 9.5.77

Condeep, Frigg TCP-2.

DECK/SHAFT CONNECTION, AS MADE REPORT

The connection of the steel deck to the shafts has been carried out during the weeks 16-18/77 by the firm Precon A/S, Lillestrøm.

Grøner-NoTeBy managed the contractor's site control.

For all the grouting operationsof the bolts, mortar of the following composition was used:

100 kg. OP cement + 41 lt water + 1,5 kg Betokem IN(B) per batch. This mortar proved an exellent workability and has the following characteristics:

max expantion ~ 2,8% within 3 hrs.
" bleeding ~ 1,6% " 5 "
no " after 18 "
mean 28-days strength 36 MPa(10 cm^3 cubes)

A prefabricated dry mortar, Rescon Nonset120, was used for the grouting under the steel deck. 17 lt water was added to 80 kg (2 bags) dry mortar and mixed for about 1 min (high speed mixer) before the grout could be pumped into the aggitator. The fluidity of fresh grout was determined to 30-35 sec by using a Marsh Cone.

During effective production time of 11, 12 and 17 hours, (shaft 1, 3 and 5) 27 + 20,5 + 35 tons of dry mortar was mixed and placed between the transition units and the deck.

Grouting was started against the inner shutter. The injection pipe was pulled towards the inlet as the mortar had reached the lower side of the steel ring. The placing of mortar alternated in both directions from the first inlet until the ring was filled.

.../2

Some places the side shutters had to be placed against the underside of the steel ring. After removal of the formwork some minor honeycombs were detected at these sections. All defects were repaired before tensioning of the DYWIDAG bars.

The bolts were tensioned 3 - 5 days after grouting. Curing tests demonstrated that the mortar strength requirement for this operation was achieved after 2 days.

A mean strength value of 42,1 MPa from 7 samples tested after 7 days indicates the general strength requirement to be met.

Max mortar expantion reached 2,5% within 5 hours. No bleeding was observed.

Highest mortar temperature during the hydration was measured to 54°C, 14 hours after casting.

The DYWIDAG bars were tensioned in accordance with the designers working procedure. However, the retensioning of the bars to 84 MP was neglected as the final elongation proved to agree with the first stressing to this level.

The total elongation of bars could be estimated to 8 - 9 mm by recording the data made available by the final tightening of the hexagon nuts. This is approximately 1 - 2 mm more than the theoretical value indicated by Precon A/S.

Calibration of the manometer connected to the pump was done before tensioning started through any manhole. This routine test was based on precision manometers approved by the technical university of Norway - Trondheim.

The designers tensioning procedure requires an initial stressing of the bolts to 85% of the yield strength, 95,2 Mp. The final force in the bolts, however, is lowered to 84 Mp. Taking into account the area of the pump's cylinder pistol, 235,62 cm^2, and the current friction loss in the jack, 5%, the correspondant pumping pressure will be:

$$95{,}2 \text{ Mp} \times 1{,}05 \times 235{,}62 \text{ cm}^2 = 424{,}2 \text{ kp/cm}^2$$

$$84{,}0 \text{ Mp} \times 1{,}05 \times 235{,}62 \text{ cm}^2 = 374{,}3 \text{ " "}$$

Before leaving a group of bolts with access through a certain manhole, one occasional bolt was destressed and retensioned to 84 Mp. The elongation could accordingly be compared with the first stressing.

One bolt, no. 111 - manhole 1.2 - shaft 1, was lost during tensioning as a matter of unproper connection between the coupling and the upper part of the bar.

7 bolts got an elongation less than 90% of the mean value. All bolts, however, were stressed with the required force.

Taking into account the unsteadiness by measuring the elongation of short bars, the total result of the tensioning should be looked upon as satisfactory.

By the grouting of the inner tubes the following 36 bolts proved to be blocked:

shaft 1 - 169

shaft 3 - 414, 431, 433, 334, 337, 339, 341, 352, 335, 356, 361, 372, 378, 379, 387, 389, 301 and 447.

shaft 5 - 662, 634, 649, 616, 666, 563, 565, 567, 568, 598, 600, 601, 513, 515, 517, 669 and 674.

The bolts had to be grouted from the top and retensioned as the grout was still fluid.

The teoretical volume of the inner tube is about 4.0 lt. It was demonstrated during filling these tubes that the mean amount of mortar was lying above this value, which proves a proper filling of the ducts.

10 bolts had a need of grout less than 4.0 lt.

Bolts no. 517, 355, 361 and 379 were filled by approx. 3,5 lt, ~ 0,5 lt was sufficient for bolts no. 567, 598, 513, 515, 414 and 389. ?

The reduced need of grout for the first group may be explained by a more obvious initial blockage of the grouting inlet.

An uncontroled filling from the top gives the reason of the moderate amount of grout used for the second group. Some sections between vertical steel bracings had to be filled with mortar as the square bearing plates didn't cover all the boltholes through the lower deck flange. Concequently the mortar could stream easily down through simular openings and into neighbour bolts. By retensioning of these bolts a significant loss of the momentary elongation was registrated. ?

The upper part of bolt including the nuts were covered by mortar filled into PVC-tubes of Ø 16 (partly Ø 14 cm).

The filling was mainly carried out in two steps. The initial streaming of grout through the groove in the hexagon nut tightened the tube to the bearing plate. The final sealing was done by filling the tube from the top.

Before this pouring was executed it was discovered that grout in some tubes had streamed backwards through the groove and led to minor openings just beneath the hexagon nut.

Holes, Ø 5 mm, were carefully drilled through the upper bearing plates into the openings. The open zones were successfully injected by pressing mortar into the openings until grout was streaming out of the groove. ?

The average amount of grout for this operation could be estimated to 35 cm^3 per bolt.

All together 63 bolts as situated below were regrouted from the top.

bolt number?

Shaft 1 - Manhole	1,1	3	bolts
"	1,3	3	"
"	1,5	3	"
"	1,6	6	"

Shaft 3 - Manhole	3,1	4	bolts
"	3,2	1	"
"	3,3	20	"
"	3,4	3	"
"	3,5	4	"

Shaft 5 - Manhole	5,3	15	bolts
"	5,5	1	bolt

Yours sincerely,

for GRØNER-NOTEBY

Dagfinn Riise

Enclosed:

- Tensioning/grouting lists for DYWIDAG bars
- Temperature records

Copies:

Elf/TNO, site
DnV, " "
PRECON, Lillestrøm
Grøner, Oslo
Grøner-NoTeBy, Stavanger

16760b conde n
16192b verit n

Enclosure 15

iod-roel/ahe/whc 20.5.77 telex no. 51063

to: norwegian contrators, oslo, att.: mr. wollf

copy to:
norwegian contractors, aandalsnes, att.: maage
elf-norge a/s, aandalsnes, att.: mr. duvet
elf-norge a/s, stavanger, att.: mr. a. delmar
npd, stavanger, att.: control section
dnva, aandalsnes

---

re.: condeep platform tcp 2
deck-shaft connection, tensioning and grouting of
dywidag bolts

---

we refer to groener-noteby's report ''deck/shaft connection, as made report'' dated 9.5.1977.

we have reviewed this report and have the following comments:

1. the tensioning of the bolts appears tp be carried out according to procedure agreed upon, refer to our telex no. 7786 dated 11.5.1976.

2. the grouting of bolts is carried out with several deviations from agreed procedure. 36 bolts had to be grouted from the top according to g-n's description. the procedure and the grouting results appear in general to be

acceptable. however, 10 bolts are improperly grouted according to g-n's report, and without further documentation the grouting of these bolts can not be accepted. a statement should be submitted to dnv as to the consequencies of disregarding bolts no. 517, 355, 361, 379, 567, 598, 513, 515, 414 and 389 in the structural calculations.

3. a major dnv reservation for accepting the steel quality of dywidag bolts was 100 percent corrosion protection of the bolts by cement grout. therefore the 36 bolts not having been grouted according to agreed procedure, are to be considered as significant objects for future in-service inspection refer to par. 7 in our telex no. 7786 dated 11.5.1976.

4. the 63 bolts having been regrouted from the top should be identified with bolt numbers.

5. in general groener-noteby's own conclusions regarding the quality of the result of grouting operations are missing in the report, and should be included for a final assesment of the quality of the deck/shaft connection.

regards fjeld/roeland

veritas o+++++

gd
16192b verit n
16760b conde n

NORWEGIAN CONTRACTORS

[illegible] • HØYER-ELLEFSEN • THOR FURUHOLMEN

i samarbeid med JERNBETON

Steen/smsm
20.10.75

Enclosure 4

1 NOV. 1975

Roland, Oslo
Pedersen, Bergen

PROCEDURE FOR TREATMENT OF CRACKS AT THE SLAB AND THE DOMES

1. The surface has to be cleaned with air pressure and dried up with propan, if it is wet.

2. Mix the epoxy TJ, and place it over the cracks in thickness 2-3 mm. Epoxy TJ is a equivalent epoxy to P-1.

The possibility for penetration is better if the temperature of the epoxy exceed 15°C.

J.E. Steen

J.E. Steen

NORWEGIAN CONTRACTORS
• HØYER-ELLEFSEN • THOR FURUHOLMEN
I samarbeid med JERNBETON

Steen/Mordal/smsm
31.10.75 Rev. A

- 1 NOV. 1975

PROCEDURE FOR SEALING UNDER STAR CELLS

1. The surface has to be treated with air pressure to clean it for loose particles.

2. Betokem BI, in fluid form, to be sprayed on to the surface, and to be active for about 10 - 15 minutes.

3. In cases where only sweating is observed, cement or BI-powder to be applied on the surface by throwing.

4. Where water leakage is observed, a mortar of cement mixed in BI fluid (never the other way around) to be pressed into the cracks.

   Mixing by hand is recommended (rubber gloves) in a half globular shaped container made by rubber, (diameter ~ 15-20 cm).

   After mixing the mortar the container to be pressed on the spot until the mortar has stiffened. The mixing time must be less than 15 seconds.

5. After treating the leakage as described and the mortar has stiffened in 10-15 minutes, the repairing must be inspected to ensure that the leakage is stopped. The repaired area to be coated with 1 layer of P-1 epoxy.

6. Observe that P-1 epoxy cannot be appled direct on surface with only BI fluid. Cement or BI-powder has to be put on to make the surface as dry as possible.

NORWEGIAN CONTRACTORS
SELMER • HØYER-ELLEFSEN • THOR FURUHOLMEN
I samarbeid med JERNBETON

Steen/smsm
20.10.75

- 1 NOV. 1975

PROCEDURE FOR TREATMENT OF HONEYCOMBED

1. Complete chiseling of the honeycombed.

2. Mix the epoxy ML-1 with sand 1:1 or 1:2, or use this without sand - depending on which consistence you want to work with.

   The mix shall cover the surface of the honeycombed and can be sprayed on.

3. Use gunite after this mix:

   1. Part cement.

   2. Parts sand.

   1% HS-2 (of the cement weight)

   V/C $< 0,4$.

4. The gunite must be placed within two hours after the coating in item two is placed.

J.I. Steen

[signature]

NORWEGIAN CONTRACTORS
F. SELMER * HØYER-ELLEFSEN * THOR FURUHOLMEN
i samarbeid med JERNBETON

Nordal/smsm
31.10.75

- 1 NOV. 1975

PROCEDURE FOR SEALING TIE-HOLES IN PLINTHS

Sealing of tie-holes in plinths has to be performed as described below:

EPOXY P-1
SAND) Mixed 1:1

To make the mortar tixotrop, add 1 to 2% Betokem Tix.

The tie-holes have to be cleaned and dried before the Epoxy mortar is placed.

The same procedure can be used for

EPOXY-SPACKEL P
SAND) Mixed 1,5 : 1

Tixed: 1 to 2 %.

The quantity of sand can be variated depending on suitable consistence.

Enclosure 18

FRIGG TCP-2.

Report on Epoxy repair works on top of shafts

Introduction

After mating of the deck in Åndalsnes, the spaces between the steel rings and the previously slipformed shafts were filled with concrete. Some time later it was observed that cracks had formed in this concrete on both faces of the wall. The cracks were evenly distributed round the perimeter at a distance of approximately 35 cm. The crack width was assessed to 0.1 - 0.2 mm. On the inner faces the cracks were of smaller width than on the outer.

Repair works

After the platform had been installed at the Frigg field an inspection of the cracks took place on June 29th 1977. On this occasion DnV was represented by mr. N.F. Braathen.

After the inspection, NC's representative presented a proposal for repair method to DnV. The method implied thorough wire brushing and coating with 1-2 mm epoxy Rescon L. on the outer face of the shafts.

The repair works on shaft no. 3 were completed on July 5th 1977 and accepted by DnV the same day.

Formal acceptance of the proposed method of repair was given by DnV in telex no. 70312 dated July 7th 1977 on the condition that it could be shown that the cracks are surface cracks. On July 9th chiselling of the concrete was carried out at some of the cracks on the outside face, in order to determine the crack depth. It was found that the depth was less than 10 cm.

On the same occasion DnV inspected the epoxy repair works on shaft no. 5 and this was accepted by note and signature in the log-book. The same note specifies that the repair works on shaft no. 1 should be carried out by applying the epoxy only in the vicinity of the cracks, leaving uncovered portions of concrete between the cracks, in order to facilitate future inspection. This work was carried out the same day.

Conclusion

The repair works have been planned and executed in close connection with DnV's representatives onboard the TCP-2.

We therefore conclude that the repair works are complete and have been performed in accordance with agreed procedures.

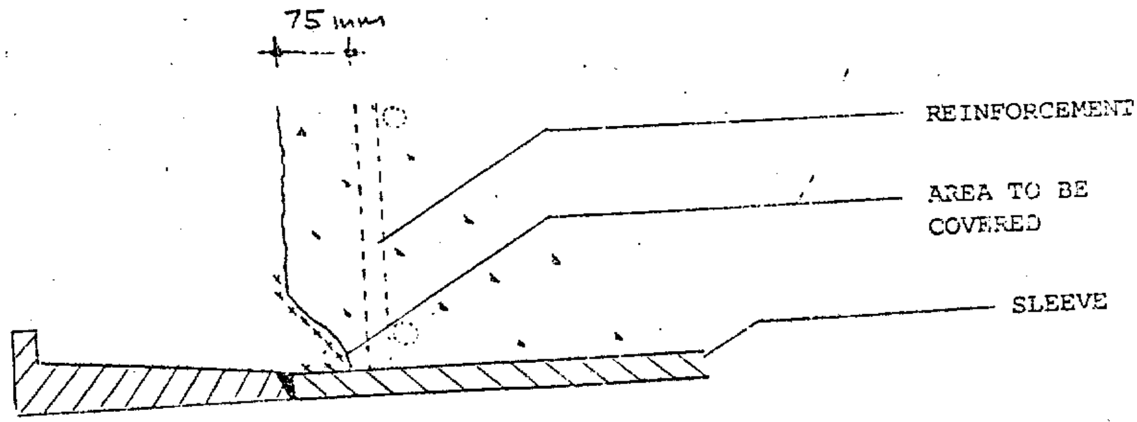
6/9-77
EW/alo

NORWEGIAN CONTRACTORS
A/F F. SELMER * HØYER-ELLEFSEN * THOR FURUHOLMEN
i samarbeid med JERNBETON

Enclosure 19

FRIGG TCP 2

PROCEDURE FOR REPAIRING OF CONCRETE AROUND 51 SLEEVES IN SHAFT 3



1. Steel brushing of the area to be covered, in order to take away all loose particles.

2. The area to be coated with a approx. 20 mm thick layer of tixotropic epoxy Rescon L.

   The epoxy will be filled with Sylodex 25 and sand in order to be able to place it in one operation.

3. The job is planned to start Friday 2nd September, 1977.

Åndalsnes, 26. august 1977

Jan Erik Steen

Steen/smsm