NGI

KONTRAKT RAPPORT

NVE GRASDALEN
SNØFORSKNING
INSTRUMENTERING AV FORBYGNING

75420-2 10. JANUAR 1977

Norges Geotekniske Institutt

20/4-22

Kontrakt Rapport

NVE GRASDALEN

SNØFORSKNING

INSTRUMENTERING AV FORBYGNING

75420-2 10. JANUAR 1977

DENNE RAPPORT INNEHOLDER EN KORT INSTRUMENTERINGSBESKRIVELSE AV 30 STK. P-200 MÅLERE OG 1 STK. SNØTRYKKSDÅSE PÅ SNØFORBYGNINGEN I GRASDALEN.

VEDLAGT FØLGER TEGNING AV FORBYGNING, FERDIG INSTRUMENTERT, SAMT EN TEKNISK BESKRIVELSE AV P-200 MÅLEREN OG SNØTRYKKSDÅSE, SOM BLE MONTERT PÅ ET PÅSVEISET STATIV PÅ FORSIDEN AV HE 160 B BJELKEN.

for NORGES GEOTEKNISKE INSTITUTT

Elmo DiBiagio

Elmo DiBiagio

Leif E. Johansen

Leif Egil Johansen

Norges geotekniske institutt NGI

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Postboks 40 Tåsen Oslo 8	Sognsveien 72	GEOTEKNIKK	(02) 23 03 88	19787 ngi n

20/6-77

75420-2 datert 10.01.77

INNHOLD

1. PARAMETRE SOM SKAL MÅLES

Opptredende spenninger og momenter i konstruksjonen som følge av snøbelastningen.

2. HENSIKT MED MÅLINGENE

Skaffe til veie data om snøbelastningens innvirkning på denne type konstruksjoner, slik at fremtidige dimensjoneringsproblemer lettere kan løses.

3. BESKRIVELSE AV MONTERINGSFORLØPET

HE 160 B bjelkene ble instrumentert med 20 stk. P-200 spenningsmålere, som ble skrudd fast til flensene. Frekvensen til disse målerne ble innstilt på ca. 1350 Hz, d.v.s. midt på måleområdet. HUP 88,9 x 6,5 profilene ble instrumentert med 4 stk. P-200 målere, og HUP 101,6 x 4,9 profilene med 8 stk. P-200 målere. Alle disse 12 P-200 målere ble innstilt på ca. 1300 Hz. På forsiden av forbygningen ble det montert en spesialkonstruert snøtrykkscelle for måling av snøtrykk. 0-frekvensen ble innstilt på ca. 1300 Hz. Snøtrykkscellen ble skrudd fast til et spesialkonstruert stativ, som ble sveiset fast til HE 160 B bjelken.

4. KABELSPESIFIKASJONER

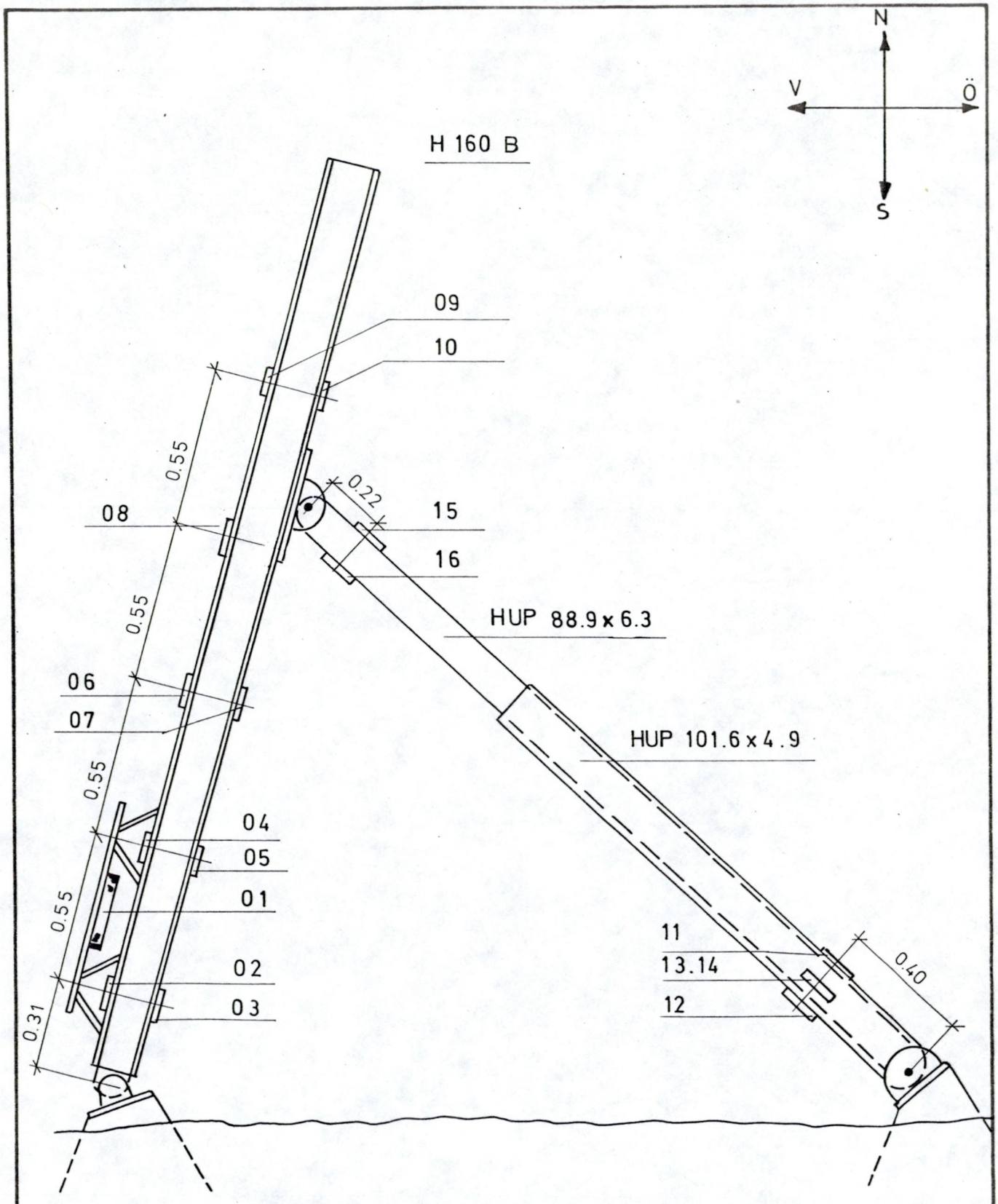
Fra snøtrykkscellen og P-200 målerne på HE 160 bjelken går det 1 par og 2 par PPOP kabler til kontroll-modul. Fra HUP-profilen fører 4 par PPOP kabler fram til samme modul.

LEJ/ag

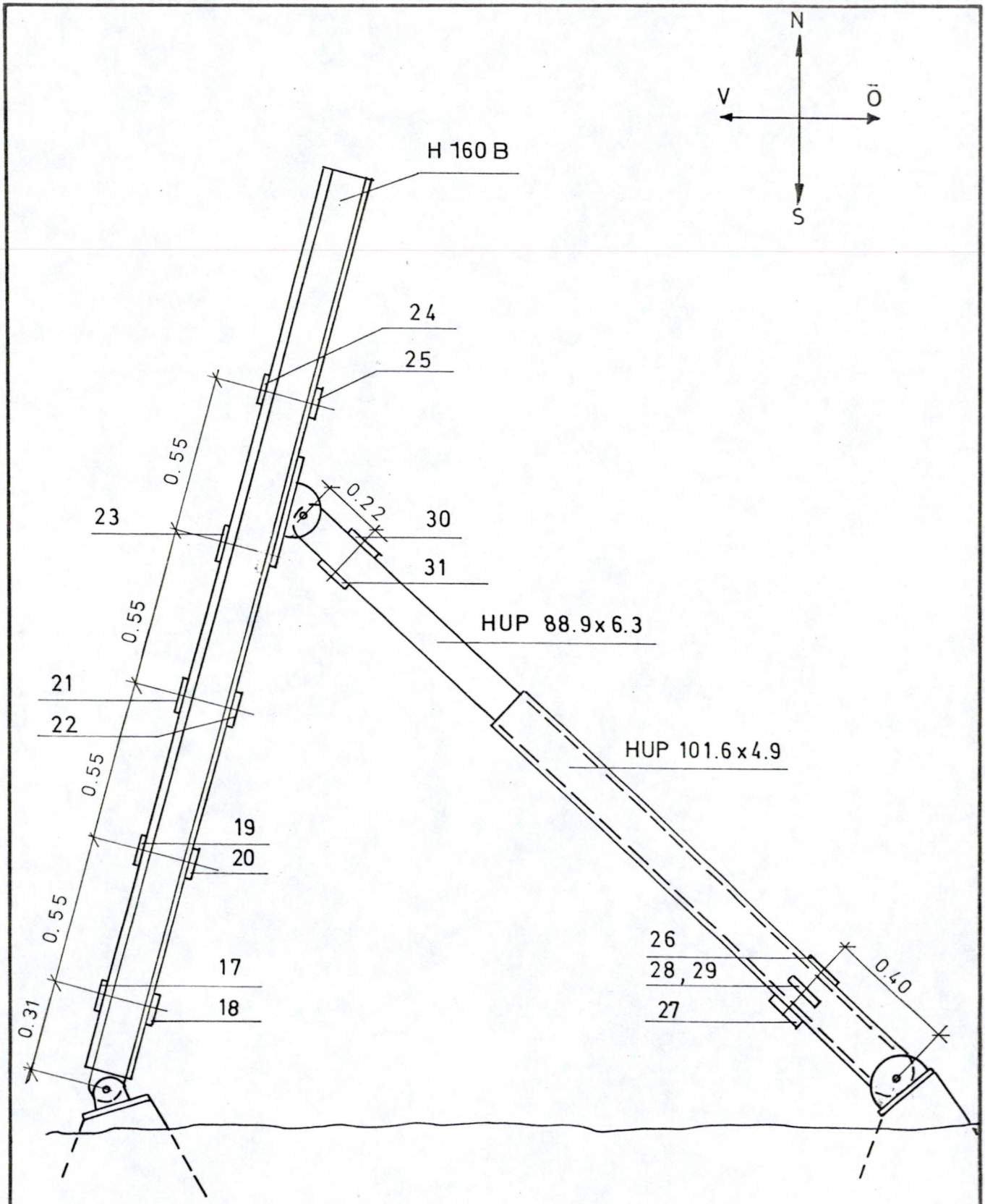
5. BILAG I

Tegninger av forbygning

Tegn. nr. 1 : Nordre bjelke
Tegn. nr. 2 : Søndre bjelke



NVE GRASDALEN	Dato 24.1.77	Tegner dø
SNÖFORBYGNING NORDRE BJELKE	Godkjent	
	Oppdr. nr. 75420	
Norges geotekniske institutt	Tegn. nr. 1	



NVE GRASDALEN	Dato 25.1.77	Tegner
SNÖFORBYGNING SØNDRE BJELKE	Godkjent	
	Oppdr. nr. 75420	
Norges geotekniske institutt	Tegn. nr. 2	

6. BILAG II

Avleste frekvenser i Hz for snøtrykksmåler og P-200 målere samt verdier omregnet til trykk og spenninger.

Tabell 1 : Avleste frekvenser for nordre støtte.
" 2 : " " " søndre "
" 3 : Utregnede verdier, nordre støtte.
" 4 : " " søndre "

20/4-77

NORGES GEOTEKNISKE INSTITUTT P.O. BOX 40 TRSEN, OSLO 8

PROSJEKT NR. 75420

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* *
* GRASDALEN *
* SNØFORDBYGNING *
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SUMMARY OF MEASURED FREQUENCIES IN HZ. FOR GAUGES ON NORTHERN SUPPORT :-
NO. OF MEASUREMENT POINT :-

DATE	*01*	*02*	*03*	*04*	*05*	*06*	*07*	*08*	*09*	*10*	*11*	*12*	*13*	*14*	*15*	*16*
751018	0.	1085.	1273.	1277.	1490.	1273.	1259.	1352.	1043.	1386.	1577.	1340.	1419.	1307.	1245.	1430.
751105	0.	0.	1298.	1264.	1498.	1245.	1269.	1330.	1023.	1394.	1570.	1320.	1405.	1297.	1219.	1413.
751106	0.	0.	1274.	1284.	1478.	1268.	1248.	1348.	1044.	1379.	1571.	1329.	1392.	1311.	1219.	1415.
751204	0.	1085.	1297.	1260.	1496.	1247.	1266.	1331.	1021.	1390.	1568.	1325.	1403.	1290.	1214.	1410.
760106	0.	929.	1412.	1015.	1699.	930.	1514.	1249.	988.	1407.	0.	0.	1455.	1096.	1109.	0.
760121	0.	892.	1434.	950.	1743.	831.	1569.	1235.	997.	1394.	0.	0.	1468.	1015.	1042.	0.
760202	1127.	904.	1430.	973.	1733.	835.	1546.	1296.	1046.	1349.	0.	0.	1454.	964.	1016.	1338.
760219	1128.	916.	1427.	993.	1724.	925.	1527.	1333.	1080.	1323.	0.	0.	1446.	944.	1018.	1326.
760229	1132.	913.	1431.	994.	1726.	953.	1516.	1395.	1129.	1269.	0.	0.	1417.	897.	968.	1293.
760310	1134.	933.	1426.	1036.	1706.	1040.	1469.	1479.	1197.	1202.	0.	0.	1389.	878.	933.	1270.
760331	1138.	939.	1428.	1054.	1700.	1102.	1436.	1563.	1268.	1117.	0.	0.	1330.	857.	877.	1227.
760414	1142.	946.	1430.	1070.	1695.	1146.	1415.	1614.	1312.	1060.	0.	0.	1305.	830.	839.	1206.
760430	1145.	951.	1432.	1082.	1688.	1190.	1382.	1672.	1356.	991.	0.	0.	1260.	811.	785.	1172.
760518	1120.	836.	1477.	835.	1833.	759.	1619.	1335.	1083.	1321.	0.	0.	1353.	948.	949.	1298.
760526	1089.	1048.	1315.	1249.	1505.	1246.	1257.	1344.	1021.	1400.	1017.	0.	1388.	1302.	1198.	1417.
760913	1093.	0.	0.	1256.	1485.	1243.	1240.	1349.	0.	1394.	1117.	1203.	1376.	1300.	1205.	1407.

Tabell 1, Bilag II

20/4-77

NORGES GEOTEKNISKE INSTITUTT P.O. BOX 40 TØSEN, OSLO 8

PROSJEKT NR. 75420

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* GRASDALEN *
* SNØFORBYGNING *
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SUMMARY OF MEASURED FREQUENCIES IN HZ. FOR GAUGES ON SOUTHERN SUPPORT :-
NO. OF MEASUREMENT POINT :-

DATE	*01*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*24*	*25*	*26*	*27*	*28*	*29*	*30*	*31*
751018	0.	1354.	1388.	1360.	1422.	1380.	1407.	1267.	1317.	1438.	1417.	1370.	1368.	1192.	1435.	1353.
751105	0.	1347.	1387.	1354.	1410.	1364.	1415.	1247.	1300.	1459.	1411.	1354.	1346.	1208.	1404.	1351.
751106	0.	1353.	1386.	1340.	1406.	1361.	1410.	1246.	1317.	1448.	1417.	1354.	1347.	1205.	1405.	1348.
751204	0.	1350.	1379.	1355.	1402.	0.	1397.	1256.	1312.	1432.	1415.	1354.	1350.	1206.	1422.	1339.
760106	0.	1230.	1505.	1062.	1625.	0.	1640.	0.	1482.	1455.	0.	0.	0.	1027.	1330.	0.
760121	0.	1194.	1535.	971.	1686.	0.	1708.	0.	0.	1455.	0.	0.	- 0.	899.	1273.	0.
760202	1127.	1197.	1534.	974.	1686.	0.	1699.	1157.	0.	1418.	0.	0.	1409.	820.	1247.	1269.
760219	1128.	1203.	1532.	991.	1681.	0.	1685.	1198.	0.	1391.	0.	0.	1409.	789.	1244.	1259.
760229	1132.	1210.	1536.	993.	1684.	0.	1673.	1277.	0.	1325.	0.	0.	1412.	647.	1221.	1213.
760310	1134.	1218.	1529.	1043.	1661.	0.	1631.	1380.	0.	1248.	0.	0.	1419.	528.	1194.	1191.
760331	1138.	1222.	1528.	1072.	1650.	0.	1595.	1489.	0.	1144.	0.	0.	1400.	413.	1151.	1143.
760414	1142.	1229.	1533.	1091.	1647.	0.	1574.	1550.	0.	1075.	0.	0.	1396.	399.	1124.	1117.
760430	1145.	1237.	1534.	1117.	1642.	0.	1547.	1626.	0.	988.	0.	0.	1371.	410.	1091.	1081.
760518	1120.	1149.	1561.	0.	1747.	0.	1705.	1226.	1348.	1344.	0.	0.	1445.	495.	1184.	1255.
760526	1089.	1287.	1447.	1312.	1450.	1350.	1400.	1226.	1287.	1425.	0.	0.	1368.	1118.	0.	1360.
760913	1093.	0.	1378.	0.	1403.	0.	0.	0.	0.	1422.	0.	0.	1150.	1383.	1362.	0.

Tabell 2, Bilag II

20/4-77

NORGES GEOTEKNISKE INSTITUTT P.O. BOX 40 TRSEN, OSLO 8

PROSJEKT NR. 75420

GRASDALEN
SNØFORBYGNING

SUMMARY OF CALCULATED SNOW PRESSURE (T/M2) AND STEEL STRESSES (KP/CM2) ON NORTHERN SUPPORT :-
NO. OF MEASUREMENT POINT :-

DATE	*01*	*02*	*03*	*04*	*05*	*06*	*07*	*08*	*09*	*10*	*11*	*12*	*13*	*14*	*15*	*16*
****	T/M2	KP/CM2	KP/CM2	KP/CM2	KP/CM2	KP/CM2	KP/CM2	KP/CM2	KP/CM2	KP/CM2	KP/CM2	KP/CM2	KP/CM2	KP/CM2	KP/CM2	KP/CM2
751018	*****	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
751105	*****	*****	70.	-28.	26.	-59.	28.	-50.	-35.	24.	-24.	-58.	-43.	-28.	-70.	-53.
751106	*****	*****	3.	15.	-39.	-11.	-30.	-9.	2.	-21.	-21.	-32.	-83.	11.	-70.	-47.
751204	*****	0.	67.	-36.	20.	-55.	19.	-47.	-38.	12.	-31.	-44.	-49.	-48.	-83.	-62.
760106	*****	-264.	407.	-504.	726.	-635.	771.	-225.	-94.	64.	*****	*****	113.	-553.	-349.	*****
760121	*****	-321.	475.	-612.	892.	-781.	956.	-254.	-79.	24.	*****	*****	154.	-739.	-506.	*****
760202	.95	-302.	463.	-575.	854.	-776.	877.	-125.	5.	-110.	*****	*****	110.	-849.	-564.	-278.
760219	.98	-264.	453.	-542.	820.	-643.	814.	-43.	66.	-186.	*****	*****	84.	-891.	-560.	-312.
760229	1.07	-269.	466.	-540.	827.	-598.	777.	99.	157.	-339.	*****	*****	-6.	-985.	-668.	-407.
760310	1.11	-258.	450.	-468.	752.	-453.	624.	302.	290.	-519.	*****	*****	-92.	*****	-741.	-471.
760331	1.20	-248.	456.	-437.	730.	-341.	520.	517.	437.	-734.	*****	*****	-267.	*****	-851.	-588.
760414	1.29	-257.	463.	-408.	712.	-258.	455.	653.	532.	-869.	*****	*****	-338.	*****	-922.	-644.
760430	1.36	-229.	469.	-386.	686.	-172.	354.	813.	631.	*****	*****	*****	-464.	*****	*****	-732.
760518	.80	-402.	611.	-784.	1242.	-877.	1129.	-38.	71.	-192.	*****	*****	-199.	-882.	-708.	-393.
760526	.13	-66.	118.	-59.	49.	-57.	-5.	-18.	-38.	43.	*****	*****	-95.	-14.	-125.	-40.
760913	.21	*****	*****	-45.	-16.	-63.	-52.	-7.	*****	24.	*****	-380.	-131.	-20.	-107.	-71.

Tabell 3, Bilag II

20/0-77

NORGES GEOTEKNISKE INSTITUTT P.O. BOX 40 TRSEN, OSLO 8

PROSJEKT NR. 75420

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* GRASDALEN *
* SNØFORBYGNING *
* *
****

SUMMARY OF CALCULATED SNOW PRESSURE (T/M2) AND STEEL STRESSES (KP/CM2) FOR SOUTHERN SUPPORT :-
NO. OF MEASUREMENT POINT :-

DATE ****	*01* T/M2	*17* KP/CM2	*18* KP/CM2	*19* KP/CM2	*20* KP/CM2	*21* KP/CM2	*22* KP/CM2	*23* KP/CM2	*24* KP/CM2	*25* KP/CM2	*26* KP/CM2	*27* KP/CM2	*28* KP/CM2	*29* KP/CM2	*30* KP/CM2	*31* KP/CM2
751018	*****	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
751105	*****	-16.	-3.	-14.	-37.	-37.	25.	-42.	-37.	66.	-18.	-48.	-65.	42.	-96.	-6.
751106	*****	-2.	-6.	-45.	-49.	-44.	9.	-44.	0.	31.	0.	-48.	-62.	34.	-93.	-15.
751204	*****	-9.	-27.	-11.	-62.	*****	-31.	-23.	-11.	-19.	-6.	-48.	-53.	37.	-40.	-41.
760106	*****	-269.	369.	-606.	674.	*****	774.	*****	388.	54.	*****	*****	*****	-399.	-316.	*****
760121	*****	-342.	468.	-762.	894.	*****	1022.	*****	*****	54.	*****	*****	*****	-668.	-478.	*****
760202	.95	-336.	465.	-757.	894.	*****	989.	-224.	*****	-62.	*****	*****	124.	-816.	-550.	-240.
760219	.98	-324.	458.	-729.	876.	*****	937.	-143.	*****	-145.	*****	*****	124.	-870.	-558.	-268.
760229	1.07	-330.	472.	-725.	887.	*****	893.	21.	*****	-340.	*****	*****	133.	*****	-620.	-392.
760310	1.11	-294.	448.	-640.	803.	*****	742.	251.	*****	-556.	*****	*****	155.	*****	-691.	-449.
760331	1.20	-286.	445.	-588.	763.	*****	615.	514.	*****	-827.	*****	*****	97.	*****	-801.	-571.
760414	1.29	-271.	462.	-554.	753.	*****	543.	670.	*****	-994.	*****	*****	84.	*****	-867.	-635.
760430	1.36	-255.	465.	-506.	735.	*****	451.	872.	*****	*****	*****	*****	9.	*****	-947.	-722.
760518	.80	-431.	556.	*****	1123.	*****	1011.	-86.	69.	-285.	*****	*****	236.	*****	-717.	-279.
760526	.13	-149.	182.	-108.	88.	-69.	-21.	-86.	-66.	-41.	*****	*****	0.	-186.	*****	21.
760913	.21	*****	-30.	*****	-59.	*****	*****	*****	*****	-50.	*****	*****	-598.	536.	-223.	*****

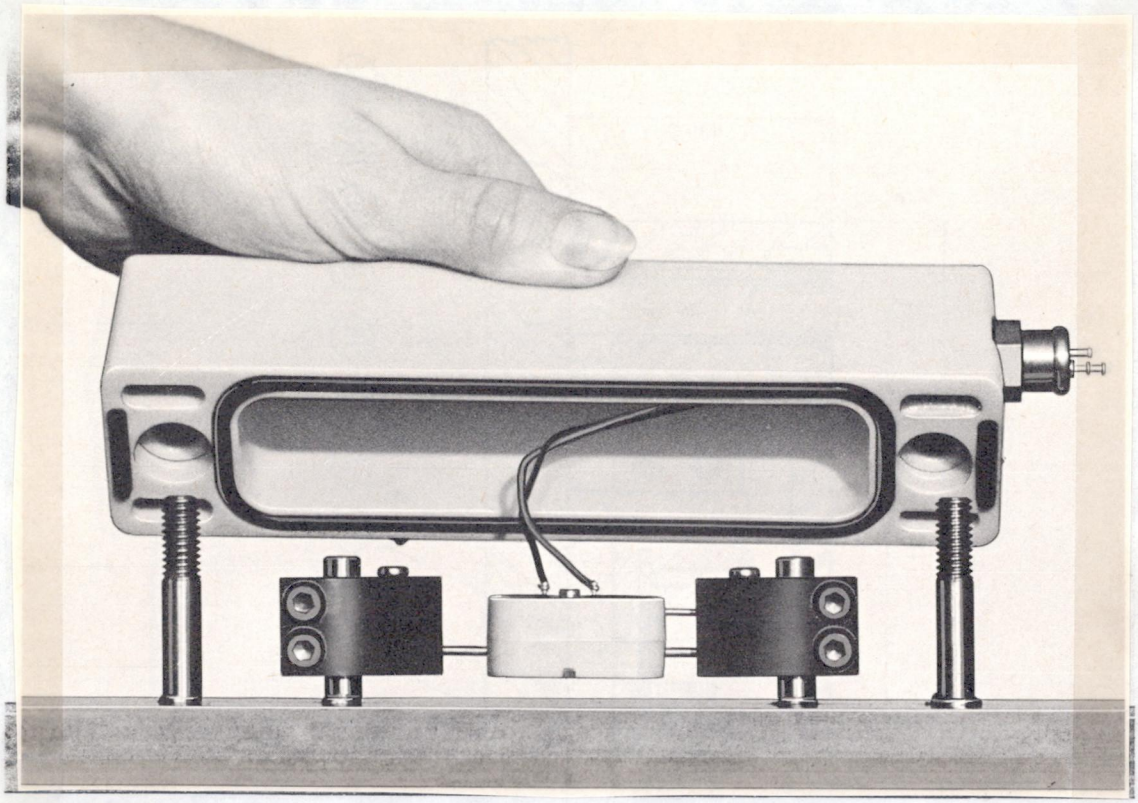
EFIN NGSBH

Tabell 4, Bilag II

7. BILAG III

Beskrivelse av snøtrykksmåler.
Beskrivelse av P-200 måler.

P-200-220 VIBRATING-WIRE STRAIN GAUGE



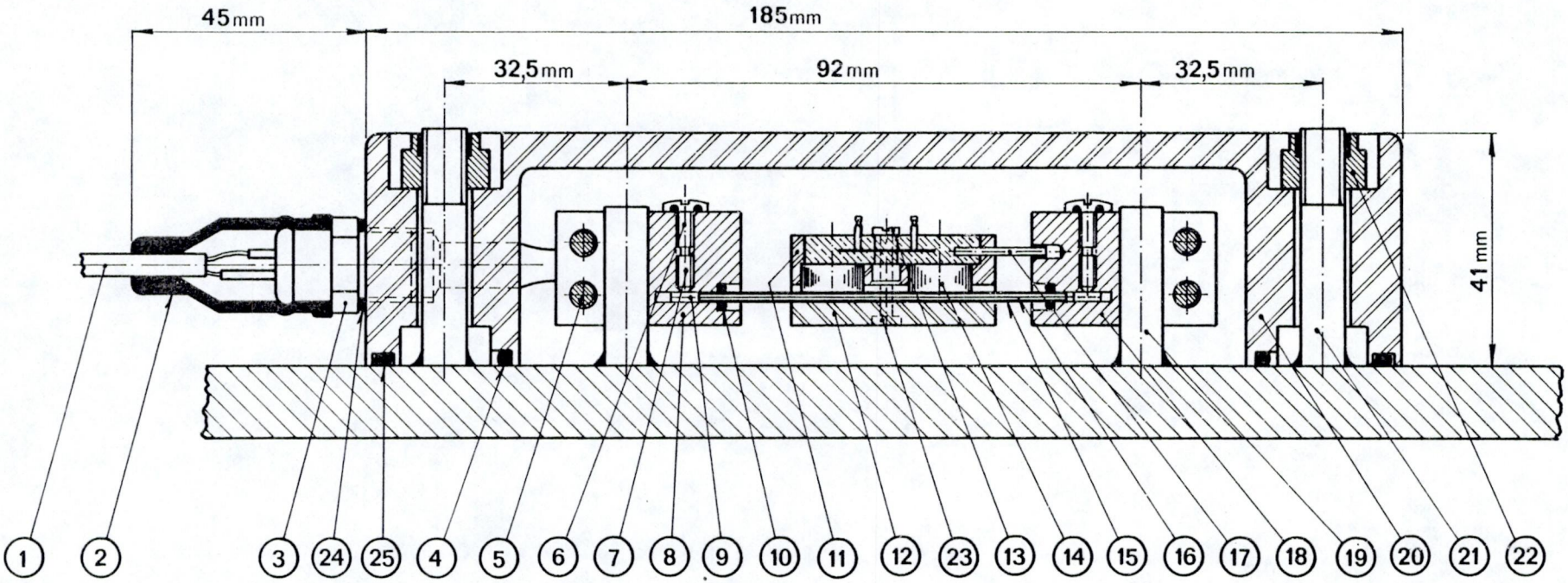
USES

The Preassembled and Sealed Vibrating-Wire Strain Gauge is a surface mounting gauge that is used to measure strains or stresses in any structural element to which it can be mounted. The gauge is fastened directly to two support posts which have been previously attached to the structural element. The support posts can be set in drilled and tapped holes; they can be mounted by a stud-welding process or they can be cast in concrete members. The gauge can be used under water. The housing is highly resistant to impact. Since the measurements can be taken far away from the gauge itself, the use of the gauge does not cause inconvenience to construction.

FEATURES:

- Convenient, accurate, sensitive, and stable.
- Rugged construction and waterproof.
- Quick and simple installation.
- Remote and fast measurement.
- Easy maintenance and repair.

GEONOR AS


45mm
185mm
32,5mm
92mm
32,5mm
41mm
1
2
3
24
25
4
5
6
7
8
9
10
11
12
23
13
14
15
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17
18
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22

DESCRIPTION

A complete GEONOR Vibrating-Wire Strain Gauge consists of two preassembled components: the P-200 vibrating-wire gauge itself and the P-220 protective housing fitted with a sealed electrical cable lead through.

The strain gauge itself consists of all the parts between parts No. 5 and 19 in the illustrated drawing. All of these parts are preassembled. The gauge-wire is inside a stainless steel tube (15) which has an O.D. of 2 mm and is about 1 mm shorter in length than the gauge-wire. The magnet holder assembly (11) and (12) is mounted on the steel tube. A clamping pin (9) is swaged onto each end of the gauge-wire. One end of the gauge-wire is clamped by the setscrew (7) during assembly of the gauge. The other end is clamped during installation of the gauge in the field.

The gauge itself is waterproof. The two O-rings (10) provide a seal around the stainless steel tube and the self-sealing screws (6) prevent leakage through the holes for the setscrews. The protective housing, which is made of plastic, is also waterproof since it is fitted with an O-ring seal in the base and a sealed electrical cable lead through. (The effectiveness of the O-ring seal in the base of the housing will of course depend on the relative roughness of the surface on which the gauge is mounted.)

The electrical connections to the gauge housing can be made in a number of different ways. The standard connection is shown in the assembly drawing. The soldered electrical connections to the gauge housing are made via a two-terminal connector that is screwed into the housing. It can be screwed into the end, side or top of the housing if desired and a 90° elbow connector can be included if specified.

The standard connector is shown on the assembly drawing as part No. 3. The connector consists of a 2-pin lead through. The outer shell is brass and the space between the shell and the terminals is filled with epoxy. One end of the connector is threaded to screw into the housing and an O-ring in the brass shell seals this connection. The other end is normally turned down to a constant diameter to receive a neoprene boot which is filled with a sealant after the electrical connections have been made.

The gauge is connected directly to the GEONOR Read-Out Unit (See special leaflet) or, if desired, indirectly through a switch box. After the electrical connections have been made and the unit is turned on, the gauge-wire will start to vibrate and after a few seconds the vibrations will attain a constant amplitude and the wire will continue to oscillate as long as the unit is turned on. The frequency of vibration of the gauge-wire will be indicated by the digital display in the Read-Out Unit.

Once the change in the square of the frequency of the gauge-wire is known, the corresponding change in stress in the structural member is given by the following theoretical expression which has been verified by extensive laboratory investigations:

$$\Delta\sigma = (\sigma - \sigma_o) = \frac{4L^2\rho}{g}\,\frac{L}{L_g}\,\frac{E_m}{E_w}\cdot(f^2 - f_o^2)\cdot 10^{-3}$$

where σ_o = stress in the structure at the frequency f_o
σ = stress in the structure at frequency f
L = length of gauge-wire
L_g = gauge length (center to center of the support posts)
ρ = density of the gauge-wire material
E_w = modulus of elasticity of the gauge-wire
E_m = modulus of elasticity of the structural member
g = acceleration due to gravity
k = a constant depending on the end condition of the gauge-wire, 1.00 for wire with simply supported ends and 1.06 for wire with fixed or clamped ends.

For a given design of the strain gauge and for an installation on a particular structural material, the above expression can be simplified as follows:

$$\Delta\sigma = K\cdot(f^2 - f_o^2)\cdot 10^{-3}$$

where K = strain gauge constant depending on the properties of the materials and gauge dimensions.

The current GEONOR Vibrating-Wire Strain Gauge is designed such that the distance between the support posts, L_g, is 92 mm center to center and the length of the gauge-wire, L, is 66 mm. The gauge-wire is made of silver plated steel. If the gauge is mounted on a steel member and the frequencies f and f_o are expressed in cycles per second, the strain gauge constant, K, of 1.09 will give the stress change in kg/cm² and K of 15.5 will give the stress change in lbs/in².

Detailed step-by-step instructions for installation of the GEONOR Vibrating-Wire Strain Gauge are supplied with the instruments.

SPECIFICATIONS:

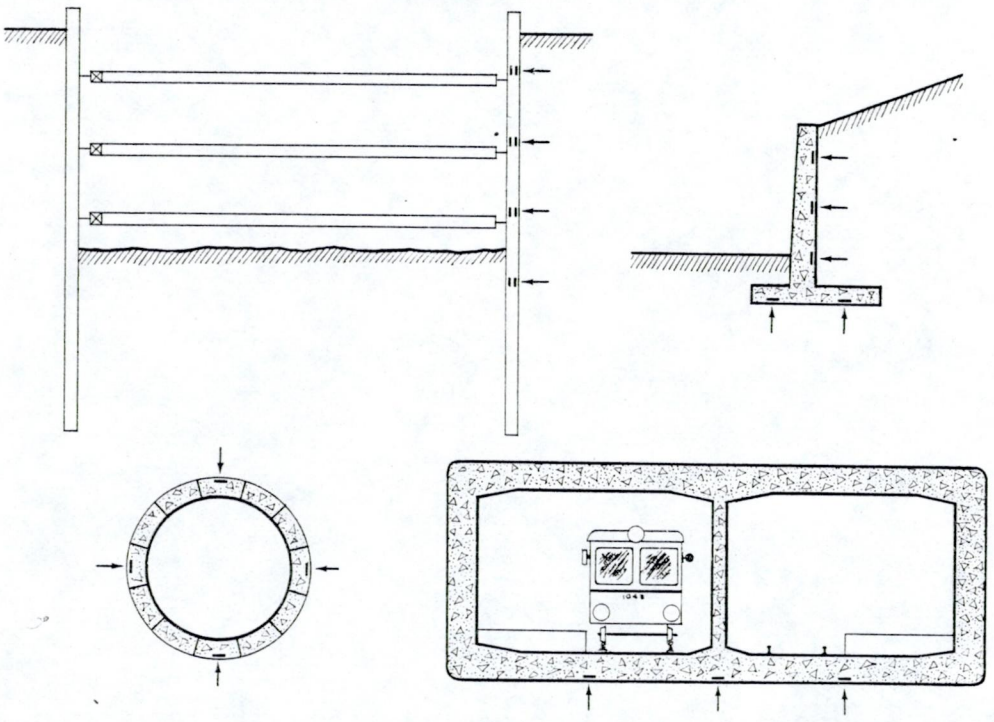
Recommended operating frequency range 700–1500 c/s.
Accuracy ± 5 %.
Operating temperature – 20° to + 50° C.
Shipping dimensions P-200 155 x 39 x 27 mm;
P-220 215 x 47 x 44 mm
Shipping weights P-200 155 grams
P-220 219 grams

A separate information sheet which describes the operating principle of the vibrating-wire instruments is available upon request. Please ask for the General Introduction to the Geonor Vibrating-Wire Instruments.

P-100 and P-150 PRESSURE CELLS

Pressure cells provide a means by which the stability during construction and overall performance of many structures, excavations and embankments or foundation projects can be evaluated. These instruments can be used, for example, to measure earth or water pressure acting on sheet piles, retaining walls, tunnels, and foundations.

GEONOR can supply two basic types of vibrating-wire gauge pressure cells. One of these, Type P-100, has a relatively small membrane and is intended for measurements in fine grained material whereas the larger cell, Type P-150, is intended for use with coarse grained material. Each of these cells can be modified to suit the particular needs of the user.



GEONOR AS

TYPE P-100 PRESSURE CELL

This cell was originally developed and used for earth pressure measurements on sheet pile cofferdams during construction of the Oslo Subway. The primary requirement was to construct a pressure cell that was robust enough to tolerate pile driving and stable enough to permit long term measurements.

Subsequently the P-100 cell has been used to measure total pressure and/or pore pressure acting on sheet piles, retaining walls, foundations, tunnels, and silos as well as stresses in earth dams.

The P-100 pressure cell consists of a floating circular membrane set in a rigid housing; the shape and size of the housing depends on the nature of the installation. The membrane, which is machined out of one piece of stainless steel, has two protruding arms between which the gauge-wire is stretched. When an external pressure is applied to the membrane, the two arms will, due to the deflection of the membrane rotate slightly, and cause an increase of the stress in the wire, and thus, an increase of the natural frequency of the gauge-wire. The change in frequency of the gauge-wire is, thus, a measure of the change in pressure acting on the membrane. The pickup and exciter magnet system for the vibrating-wire gauge are mounted in the housing.

The cell must be mounted such that the membrane is flush with the surface of the structure at the point where pressure is to be measured. In embankments the cell is attached to a steel plate in a special manner such that the membrane is flush with one side of the plate.

The construction of the housing depends on the type of installation planned. Two of the basic types are shown in the illustrations. In all cases, the membrane rests on steel balls set at three points on a shoulder in the housing, and is held in position by an O-ring to minimise the transfer of stresses from the housing to the membrane. The assembled cell is watertight. Generally the electric lead wires are encased in a plastic tube which is connected to the housing at one end and open to the atmosphere at the other end so that atmospheric pressure is maintained inside the cell.

Technical Specifications Type P-100 Pressure Cell.

Type P-100 membrane:

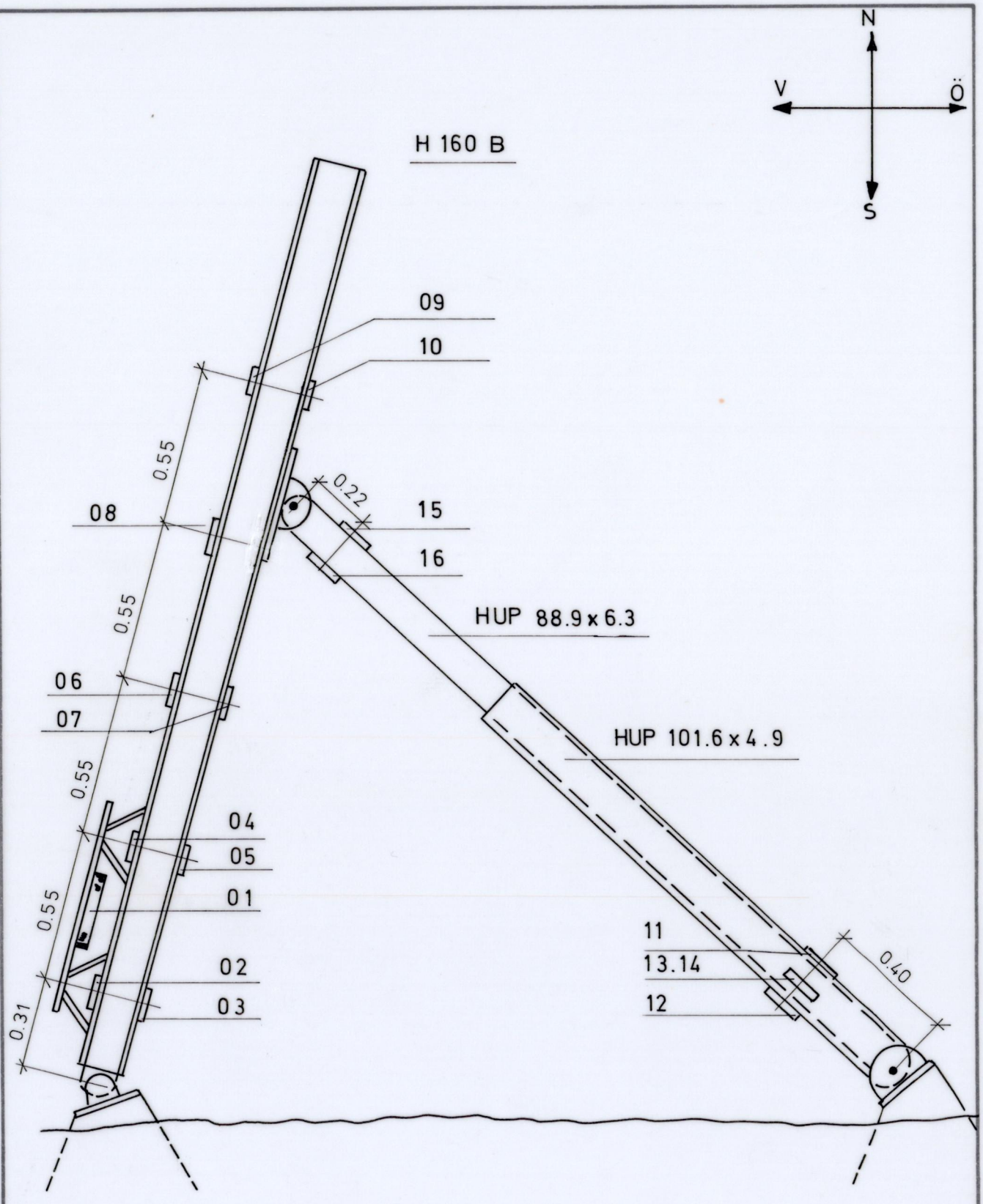
Maximum diameter:	94 mm (3¾ in.)
Active diameter:	75 mm (3 in.)
Diameter/deflection ratio:	≧ 1000
Standard pressure ranges:	0–2,5; 0–5; 0–10; 0–15; 0–25 kg/cm²
Material:	Stainless steel
Sensitivity:	$\Delta f^2/1000 \geqq 2000$ sec^{-2} at P_{max}
where:	Δf^2 = change in square of frequency of vibration of the gauge-wire
	P_{max} = maximum design pressure
Reading accuracy:	± 0.15 % of P_{max}

Housing:
The shape and size of the P-100 housing depends on the nature of the installations. The housing is generally manufactured of mild steel; the minimum thickness available is approximately 25 mm.

Lead-wires:
100 ft of shielded cable supplied with each gauge. Longer lengths available at slight additional cost.

Calibration:
A calibration report is supplied with each gauge.

Inquiries:
State type of installation, pressure range, and whether total pressures and/or pore pressures are to be measured.
On many engineering projects in Norway the P-100 pressure cell has been mounted on piles that were subsequently driven into the ground. Generally a 3 ton drop hammer and a free fall of 50 cm has been used. Although the cells have performed most satisfactorily under these local conditions, GEONOR can not guarantee that the cells will withstand piledriving in all types of soil and with all types of piledriving equipment.



NVE GRASDALEN	Dato 24.1.77	Tegner dø
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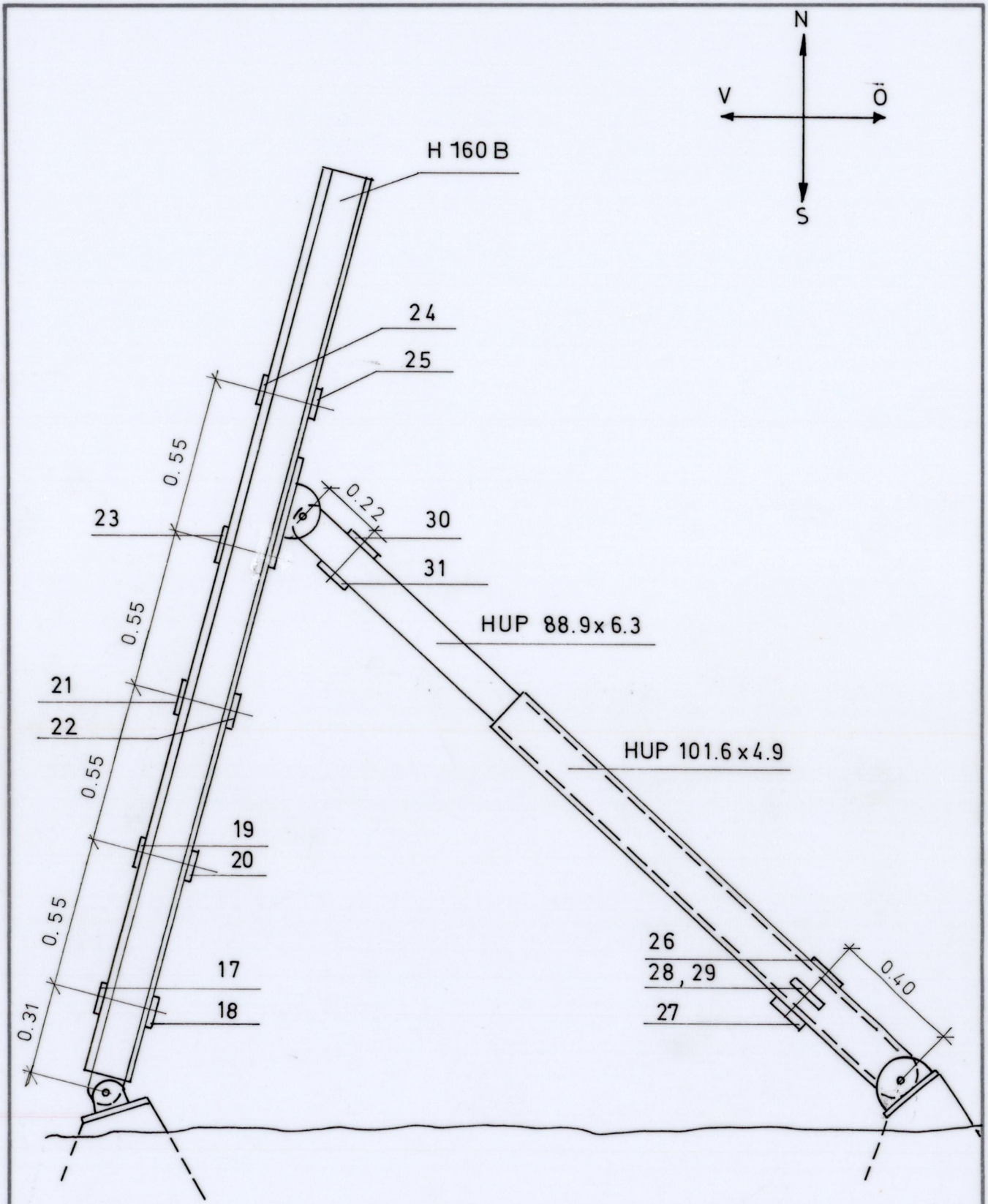
	Oppdr. nr. 75420	
Norges geotekniske institutt	Tegn. nr. 1	



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	Oppdr. nr. 75420	
Norges geotekniske institutt	Tegn. nr. 2	