PROJECT 227

MSL

JOINT INDUSTRY PROJECT

DEVELOPMENT OF GROUTED TUBULAR JOINT TECHNOLOGY FOR OFFSHORE STRENGTHENING AND REPAIR

SPECIFICATIONS AND PROCEDURES FOR MATERIALS, FABRICATION, INSTRUMENTATION AND TESTING

DOC REF C141R007 Rev 0 MARCH 1994

MSL Engineering Limited

Purpose of Issue	Rev	Date of Issue	Author	Agreed	Approved
Issued to PSC	0	March 1994	DJM/RvF	NS	NS

JOINT INDUSTRY PROJECT

DEVELOPMENT OF GROUTED TUBULAR JOINT TECHNOLOGY FOR OFFSHORE STRENGTHENING AND REPAIR

SPECIFICATIONS AND PROCEDURES FOR MATERIALS, FABRICATION, INSTRUMENTATION AND TESTING

DOC REF C141R007 Rev 0 MARCH 1994

MSL Engineering Limited
Technology Transfer Centre
Silwood Park, Buckhurst Road
Ascot, Berkshire. SL5 7PW

Tel: ++44 (0) 344-874424
Fax: ++44 (0) 344-874338

MAINTENANCE OF OFFSHORE STRUCTURAL INTEGRITY

MSL Engineering Limited (MSL) has recently launched a joint-industry project on the 'Development of Grouted Tubular Joint Technology for Offshore Strengthening and Repair'. The findings of another major joint-industry development project on the subject of SMR - 'Strengthening, Modification and Repair' of offshore installations, also undertaken by MSL, have shown that the requirement for strengthening and/or repair of tubular joints has continued to remain high, and is likely to increase with time. It has also revealed that there is little or no guidance available in codes, guidance documents or technical literature on the grout-filling of tubular joints.

It has increasingly been recognised that chord grout-filling of tubular joints offers an extremely technically efficient and cost-effective method to meet strengthening/repair requirements in one or more of the following ways:

- the presence of grout increases the radial stiffness of the chord and restricts local chord wall deformations, which leads to a reduction of stresses and associated stress concentration factors (SCFs),
- chord member bending stiffness is increased,
- ovalisation of chord cross-section is restricted which gives an increase in joint capacity.

In response to the identified need and the identified substantial economic, safety and technical benefits over 'conventional' strengthening/repair techniques, MSL has launched this joint industry initiative to develop grouted joint technology as a viable strengthening/repair solution. The primary objectives are, firstly, to generate specific data and information on grouted joint behaviour to develop a detailed design practice and, secondly, to develop and prepare deployment procedures.

The results from this project will provide guidance for an immediate application of grouted tubular joint technology. This method of strengthening/repair will enable safe, cost-effective and technically efficient applications. The work is being sponsored by the Health and Safety Executive, Minerals Management Service and several oil and gas operating organisations. Anyone wishing to consider participation should contact N Sondhi at MSL Engineering Limited, tel: 0344 874424.

NOTICE OF MEETING

Meeting	Second Project Steering Committee (PSC) meeting of JIP on 'Grouted Tubular Joint Technology for Strengthening/Repair'.
at	MSL Engineering Limited, Technology Transfer Centre, Silwood Park, Buckhurst Road, Ascot, Berkshire. SL5 7PW
on	Thursday, 24 March 1994 — **at** 10.00am

AGENDA **CONFIDENTIAL**

(Note: Lunch will be provided)

		PAPERS
1.	Welcome and Introduction	
2.	Apologies for Absence	
3.	Participation Status	
4.	Minutes of First PSC Meeting (8/11/93)	Minutes
5.	Progress Statement	Progress Report No. 1
✓6.	Specifications and procedures for materials, fabrication, instrumentation and testing	C141R007
7.	Procedures for grouting of test specimens	C141R006
8.	Technical report on Preload investigation	C141R008
9.	Technical paper on lead-tin alloy scale testing	C141R009
10.	Any Other Business	
11.	Date of Next Meeting	

NUMBER	DETAILS OF REVISION
0	Issued to PSC, March 1994

JOINT INDUSTRY PROJECT

DEVELOPMENT OF GROUTED TUBULAR JOINT TECHNOLOGY FOR OFFSHORE STRENGTHENING AND REPAIR

SPECIFICATIONS AND PROCEDURES FOR MATERIALS, FABRICATION, INSTRUMENTATION AND TESTING

CONTENTS

1. INTRODUCTION

This report presents specifications and procedures for materials, fabrication, instrumentation and testing. The specifications/procedures cover all the test specimens (5 No. T joints, 10 No. DT/X joints) and the test rig. The report is structures as follows:

APPENDIX A - The steel specification is presented covering mechanical properties and weld material. Specimen nominal dimensions for the T and DT/X joints are shown for the test series.

APPENDIX B - The fabrication procedure for test specimens is shown in this appendix, covering weld details and welding sequence of tubular connections.

APPENDIX C - Detailed sketches show the proposed new test rig designed to test all specimens for all loading cases.

APPENDIX D - Test rig and loading methods are presented in this appendix.

APPENDIX E - Instrumentation (strain gauges and strip gauges) are detailed for T and DT/X joints.

APPENDIX A

STEEL SPECIFICATION AND SPECIMEN DIMENSIONS

STEEL SPECIFICATION

Mechanical properties

The circular hollow sections are hot finished seamless steel tubes in accordance with API-5L Gr. X52N or steel grade Fe 510 D in accordance with Euronorm EN 10025 (or prEN 10210 draft). The actual mechanical properties f_y (yield stress), f_u (ultimate stress), permanent elongation and necking of the different CHS will be determined with tensile tests and carried out in accordance with Euronorm EN 10.002 "Tensile tests for steel". The hollow section will be ordered with a 3.1.b. certificate.

Weld material

All test specimens will be welded with basic electrodes with a higher nominal yield stress and ultimate stress, than that of the hollow section material. The proposed electrode type used by the manufacture has to be approved by TNO.

Dimensions

The test series and nominal dimensions for the T- and DT-joints are shown in Tables 1 and 2. The configuration and dimensions of the specimens are shown in Figures 1, 2 and 3. The chord length is equal to 6 times the chord diameter. The brace length is 5 times the brace diameter.

Test series and nominal dimensions for T-joints Steel grade Fe510D or API-5L Gr. X52N							
Chord		$\beta = 0.41$		$\beta = 0.67$		$\beta = 1.0$	
	$2\gamma = D/T$	Braces	Specimen	Braces	Specimen	Braces	Specimen
406.4x25	16.3	168.3x17.5	T1			406.4x17.5	T3
406.4x20	20.3			273x14.2	T5		
406.4x14.2	28.6	168.3x10	T7			406.4x10	T9

Table 1: Nominal dimensions for T-joints

Test series and nominal dimensions for **DT/X** joints Steel grade Fe510D or API-5L Gr. X52N							
Chord		$\beta = 0.41$		$\beta = 0.67$		$\beta = 1.0$	
	$2\gamma = D/T$	Braces	Specimen	Braces	Specimen	Braces	Specimen
406.4x25	16.3			273x17.5	DT2	406.4x17.5	DT3
				273x10	DT10 τ=0.5		
406.4x20	20.3	168.3x14.2	DT4	273x14.2	DT5 τ=0.75	406.4x14.2	DT6
				273x20	DT11 τ=1.0		
				273x14.2	X1 Θ=45		
406.4x14.2	28.6			273x10	DT8	406.4x10	DT9

Table 2: Nominal dimensions for DT-joints and X-joints

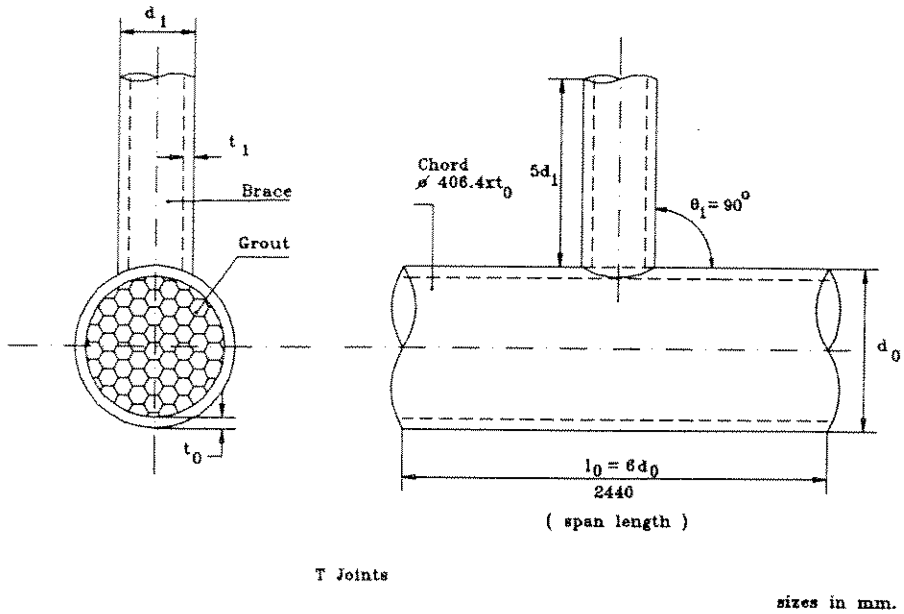


Figure 1: Configuration of T-Joints

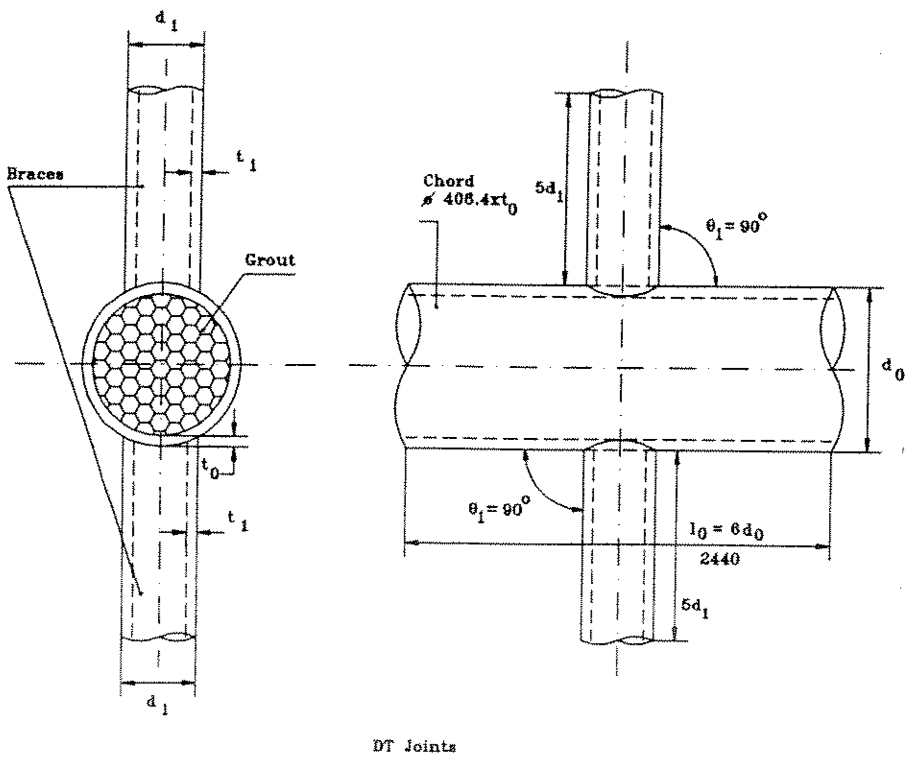


Figure 2: Configuration of DT-Joints

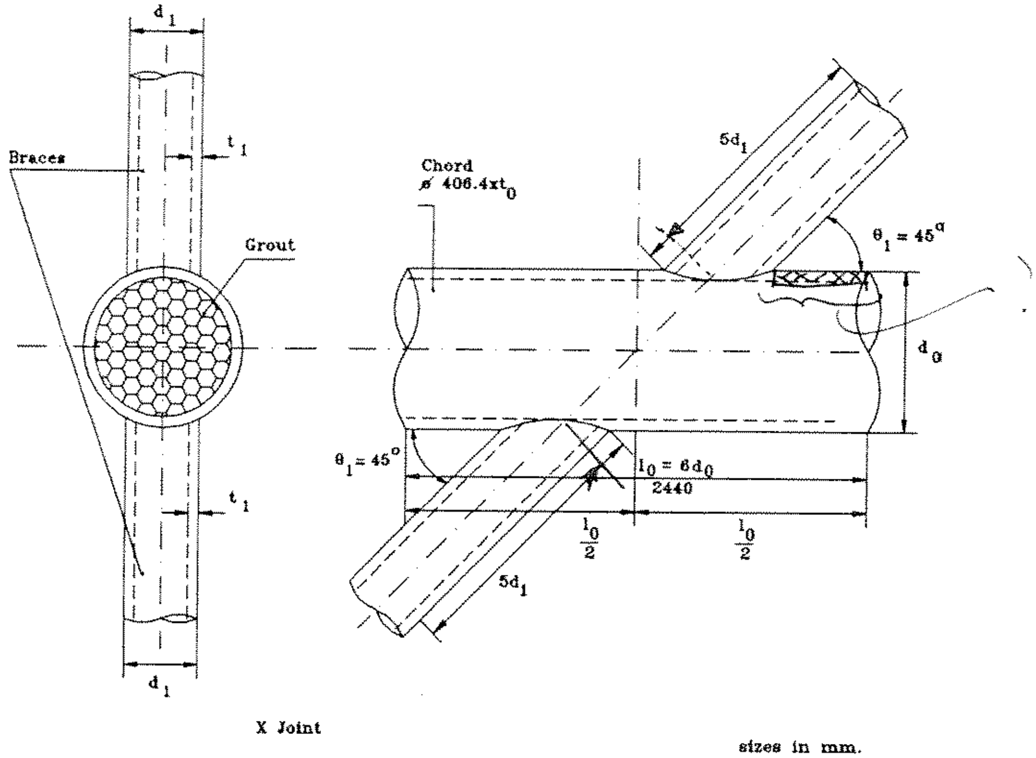


Figure 3: Configuration at X-Joint

APPENDIX B

WELDING DETAILS

WELDING DETAILS

The weld design is based on full capacity related to the brace dimensions. All welding is carried out using shielded metal arc welding (SMAW), in welding position 2G (axis of the weld horizontal) in accordance with section 5.8 of ANSI/AWS D1.1-90 Structural Welding Code for Steel. The welding sequence of the tubular connection is shown in Figure 1.

The welding details for the T and DT-joints are shown in Figure 2 and for the X-joint in Figure 3.

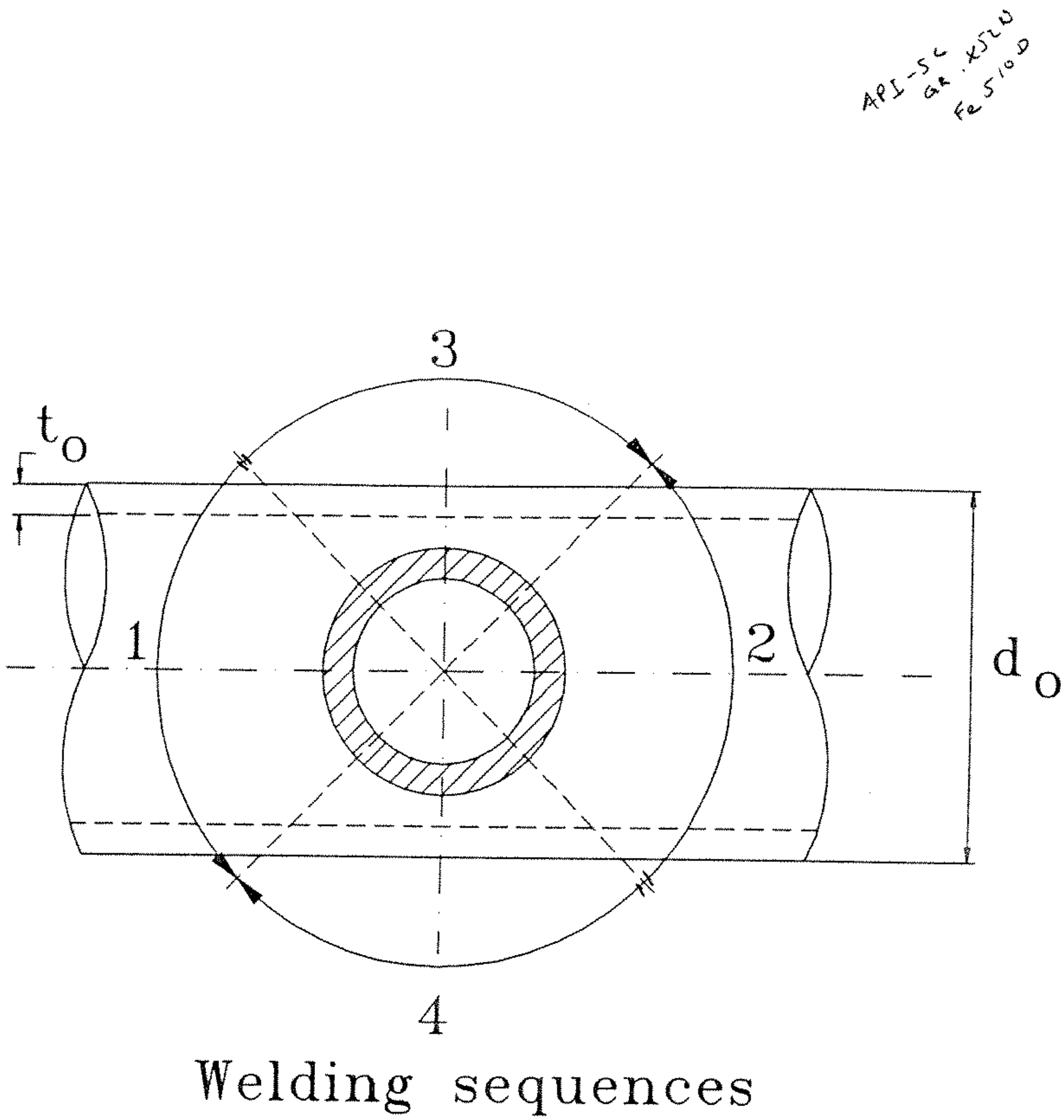


Figure 1: Welding sequence for tubular connection.

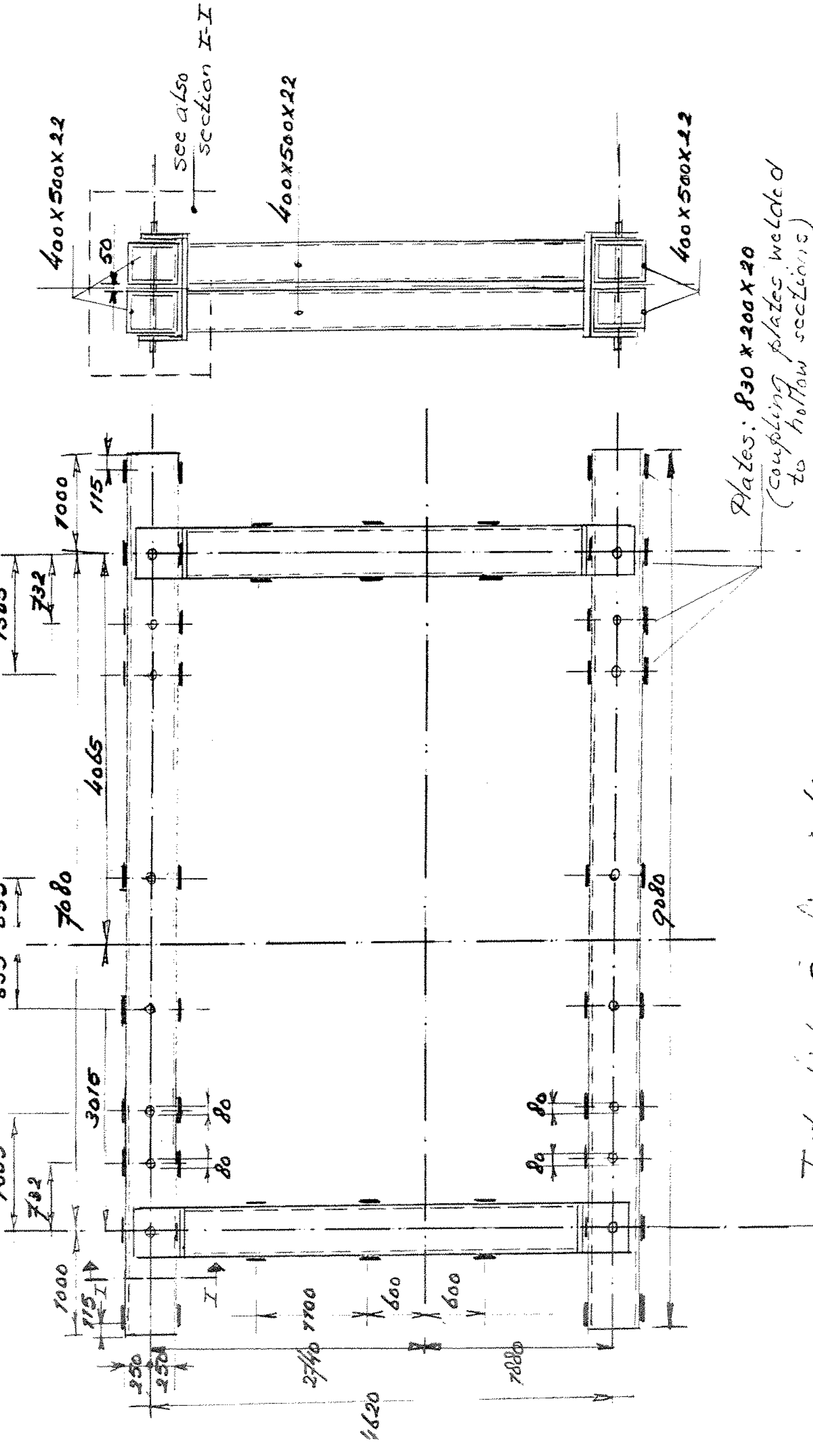
Test Rig

Research programme:
"Grouted tubular joint technology for strengthening/repair.

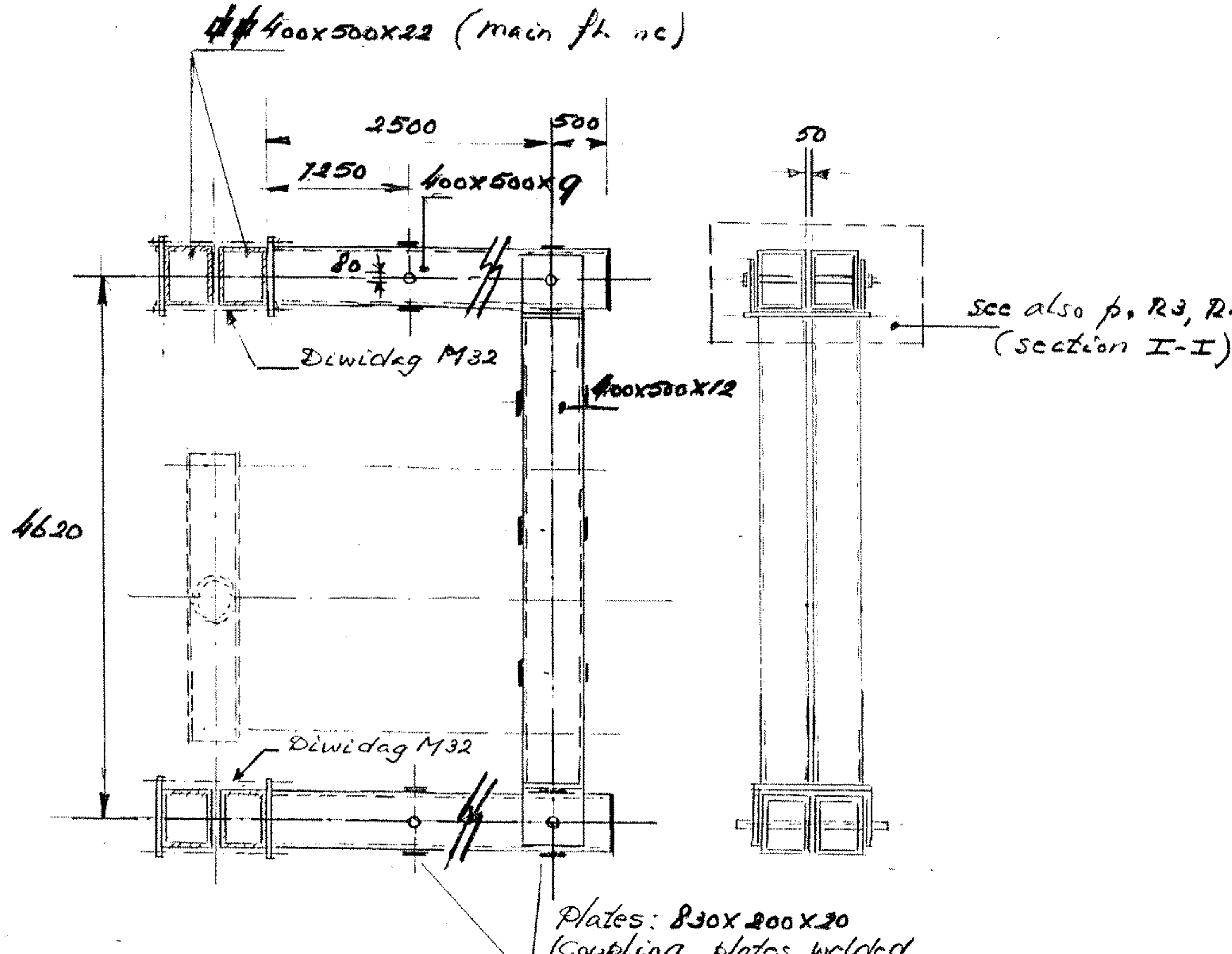
Research institutes

M.S.L. - England
TNO - Bouw - The Netherlands
TU - Delft (Civil Eng.) - The Netherlands

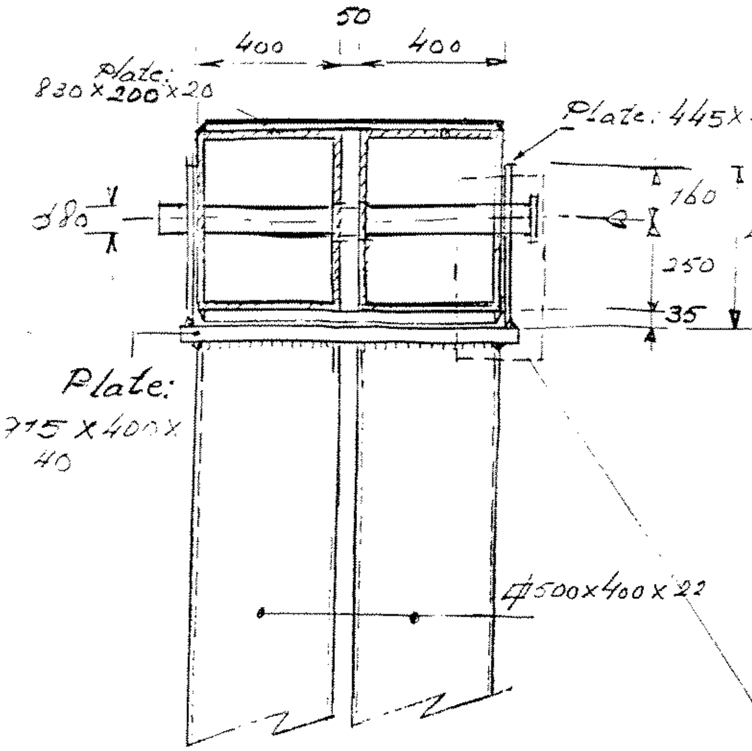
p. 21 - 25



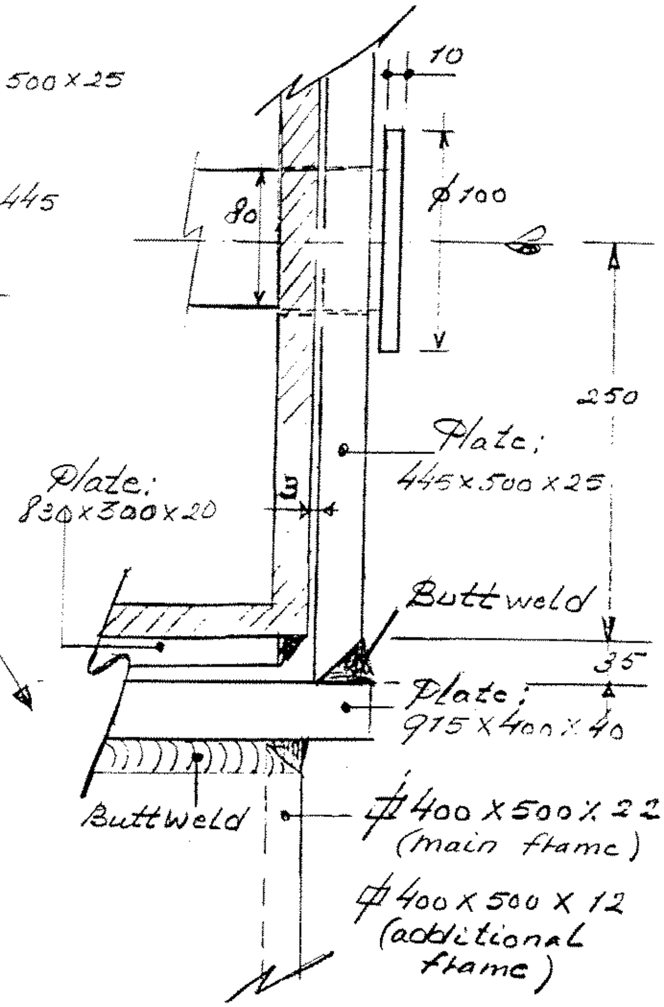
Test rig configuration

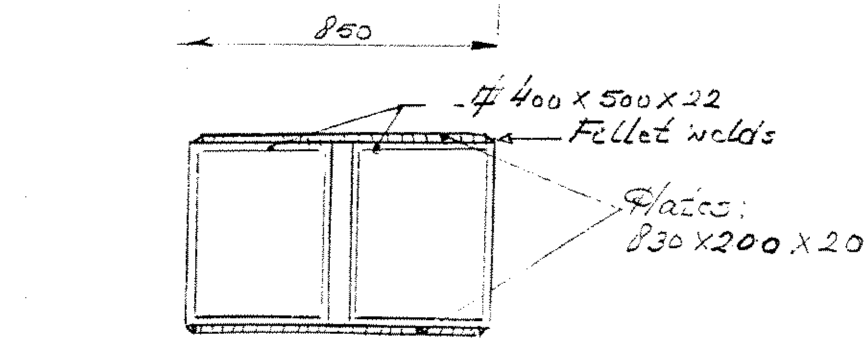


Additional frame for out-of-plane bending
(DT and T joints)

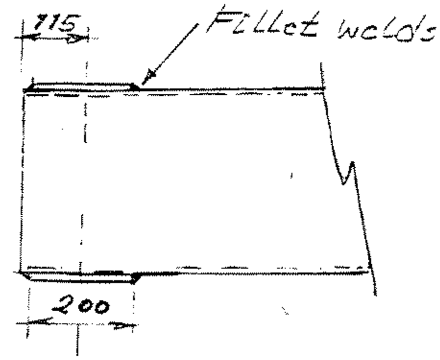


Section I-I

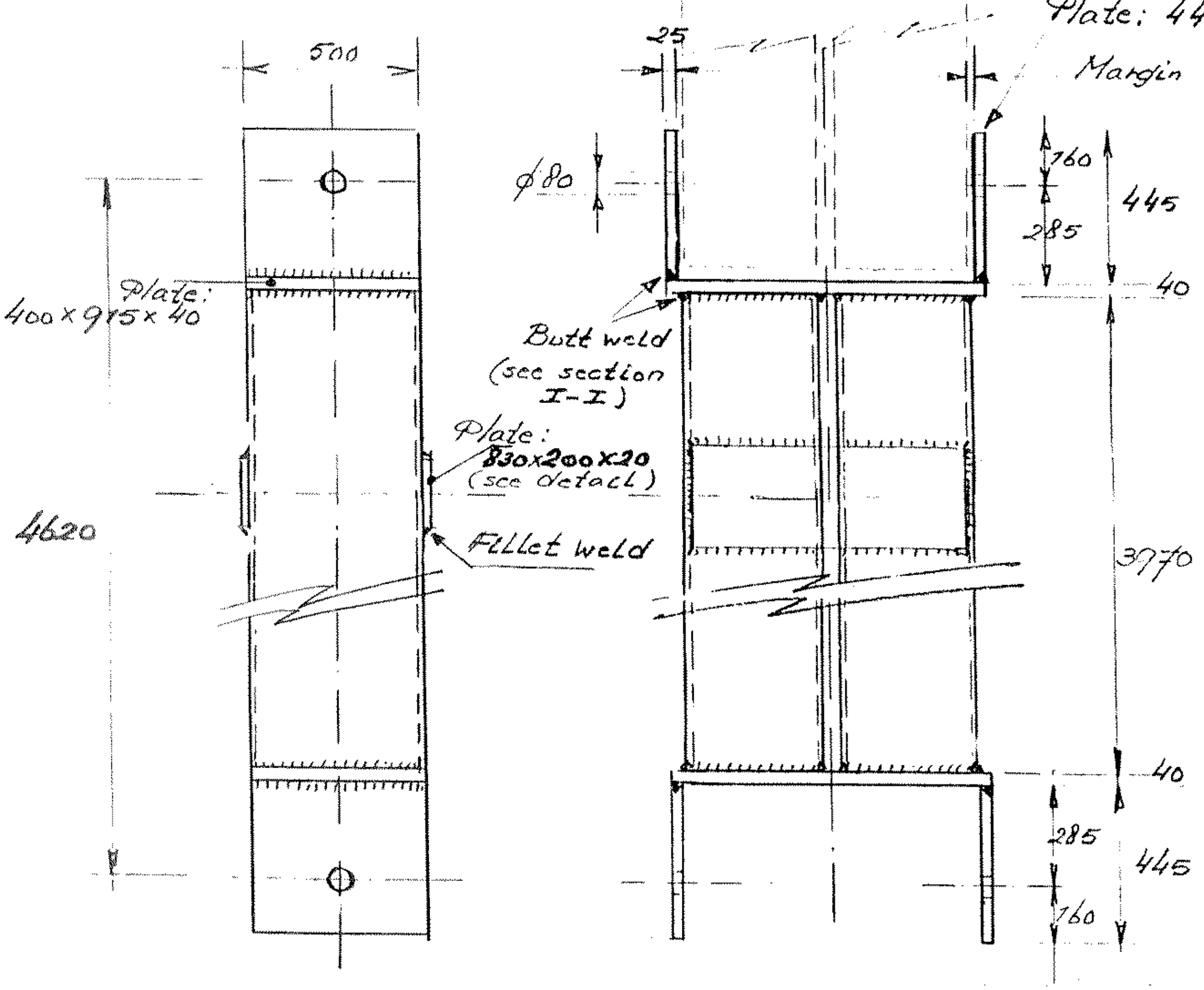




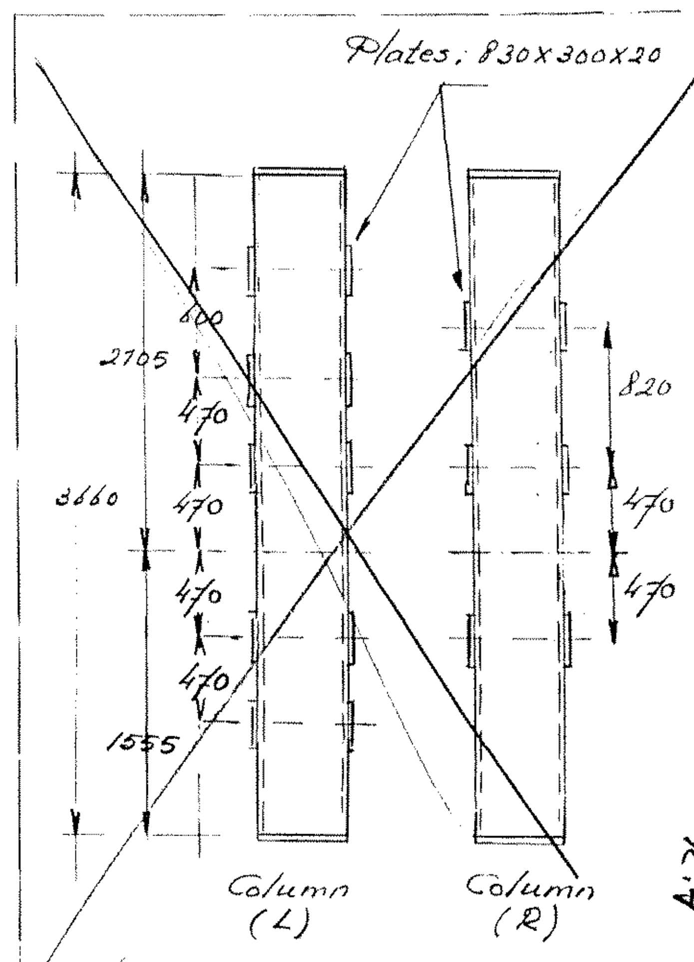
Section II-II



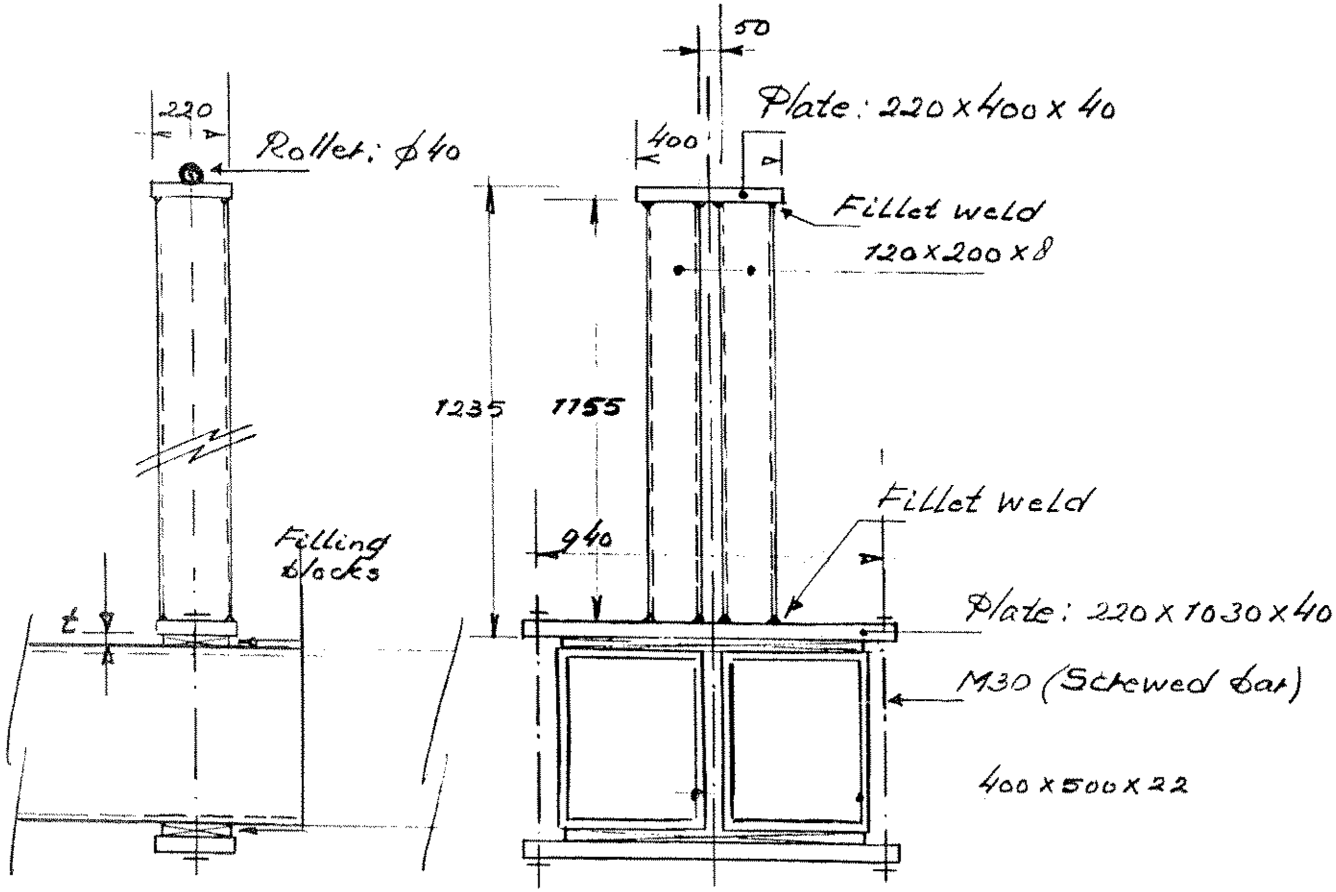
R.4



Columns



Detail colums with coupling



Adjustable support (2x)

<u>Filling blocks</u>

$t = 30$ (4x)

$t = 30 + 85 = 115$ (2x)

$t = 30 + 85 + 75 = 190$ (2x)

<u>Roller:</u>

φ40, $\ell = 400$ (2x)

<u>Screwed bars</u>

M30, $\ell = 880$ (4x)

APPENDIX D

LOAD CASES

LOAD CASES

All specimen are tested under axial tension and compression, in plane bending and out of plane bending to determine the strain concentration factors. The failure load is determined either for in-plane bending or for out-of-plane bending. An overview of the load cases is shown in Figure 1.

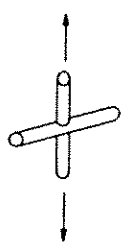
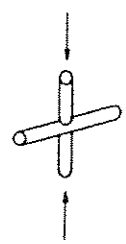
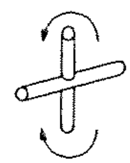
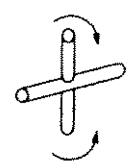
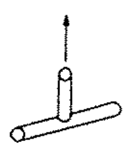
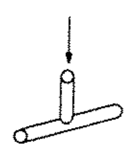
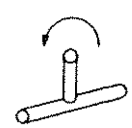
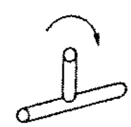
Specimens	Load case			
	(1) axial−t.	(2) axial−c.	(3) i.p.b.	(4) o.p.b.
DT2, DT3 DT4, DT5 DT6, DT8 DT9 DT10, DT11 X1	 DT... −1	 DT... −2	 DT... −3	 DT... −4
T1, T3, T5 T7, T9	 T..... −1	 T..... −2	 T..... −3	 T..... −4

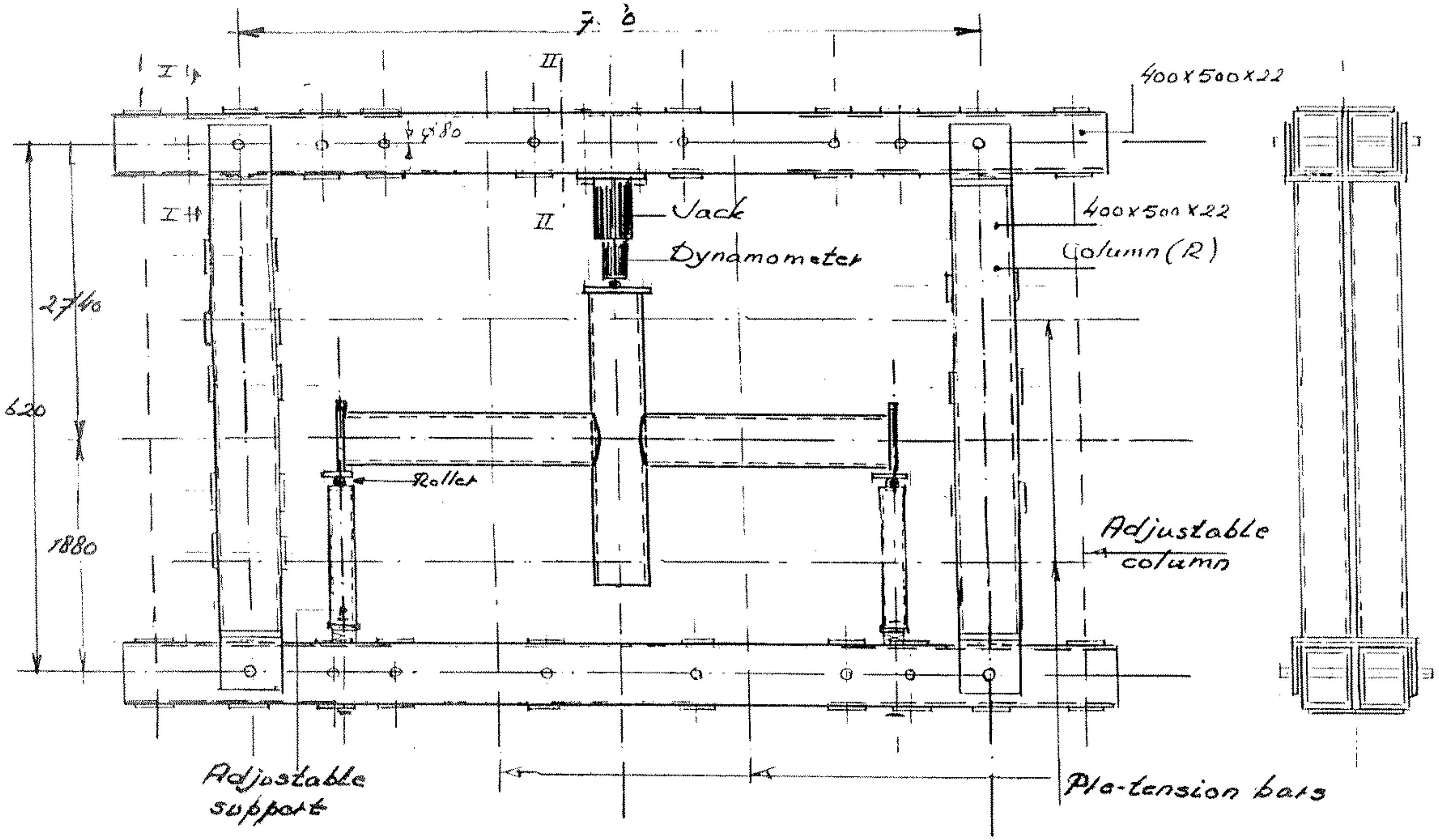
Figure 1: Overview of Load Cases

Load cases

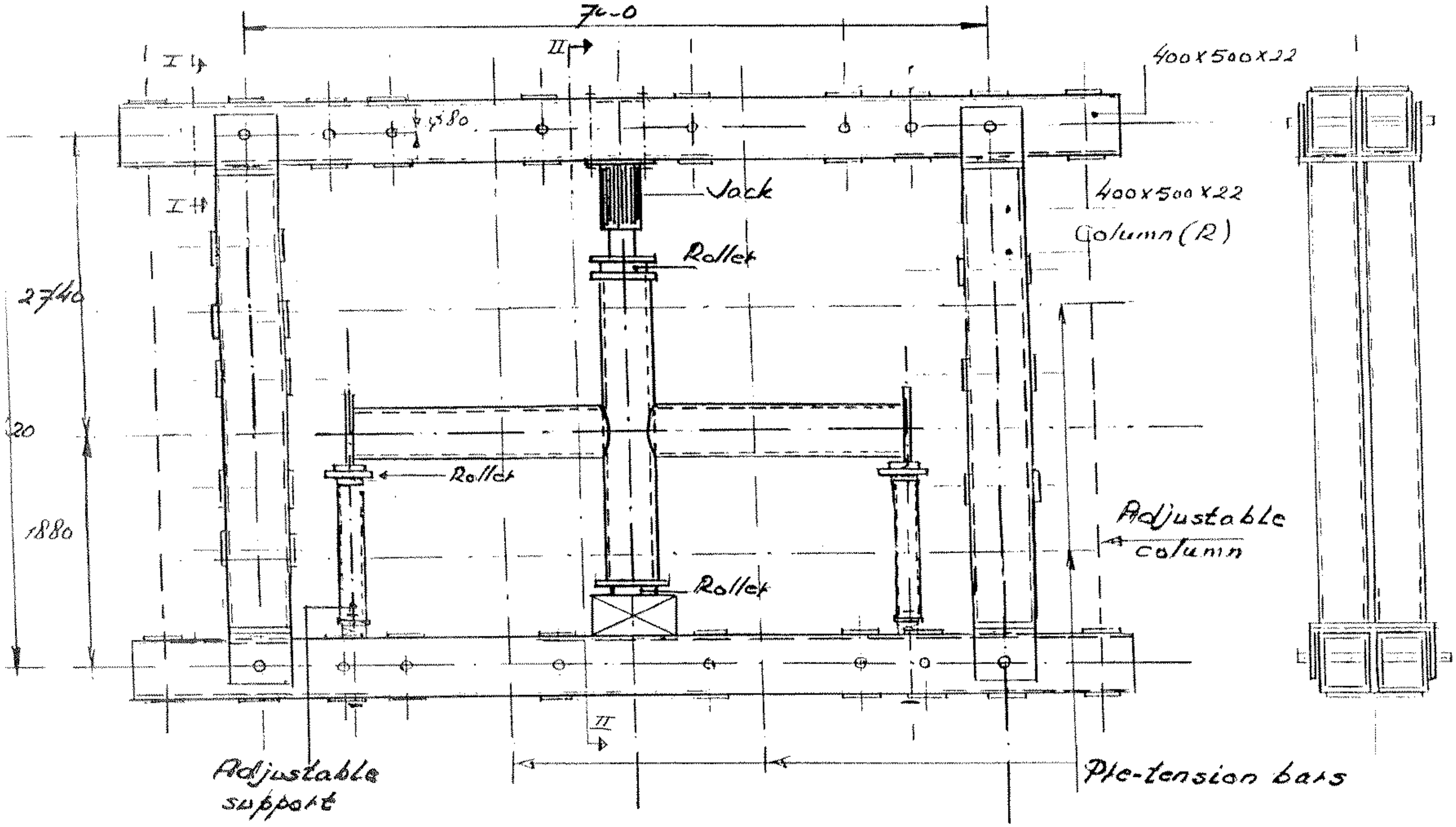
Research programme
"Grouted tubular joint technology for strengthening/repair.

Research institutes

M.S.L. - England
TNO - Bouw - The Netherlands
TU - Delft (Civil Eng.) - The Netherlands

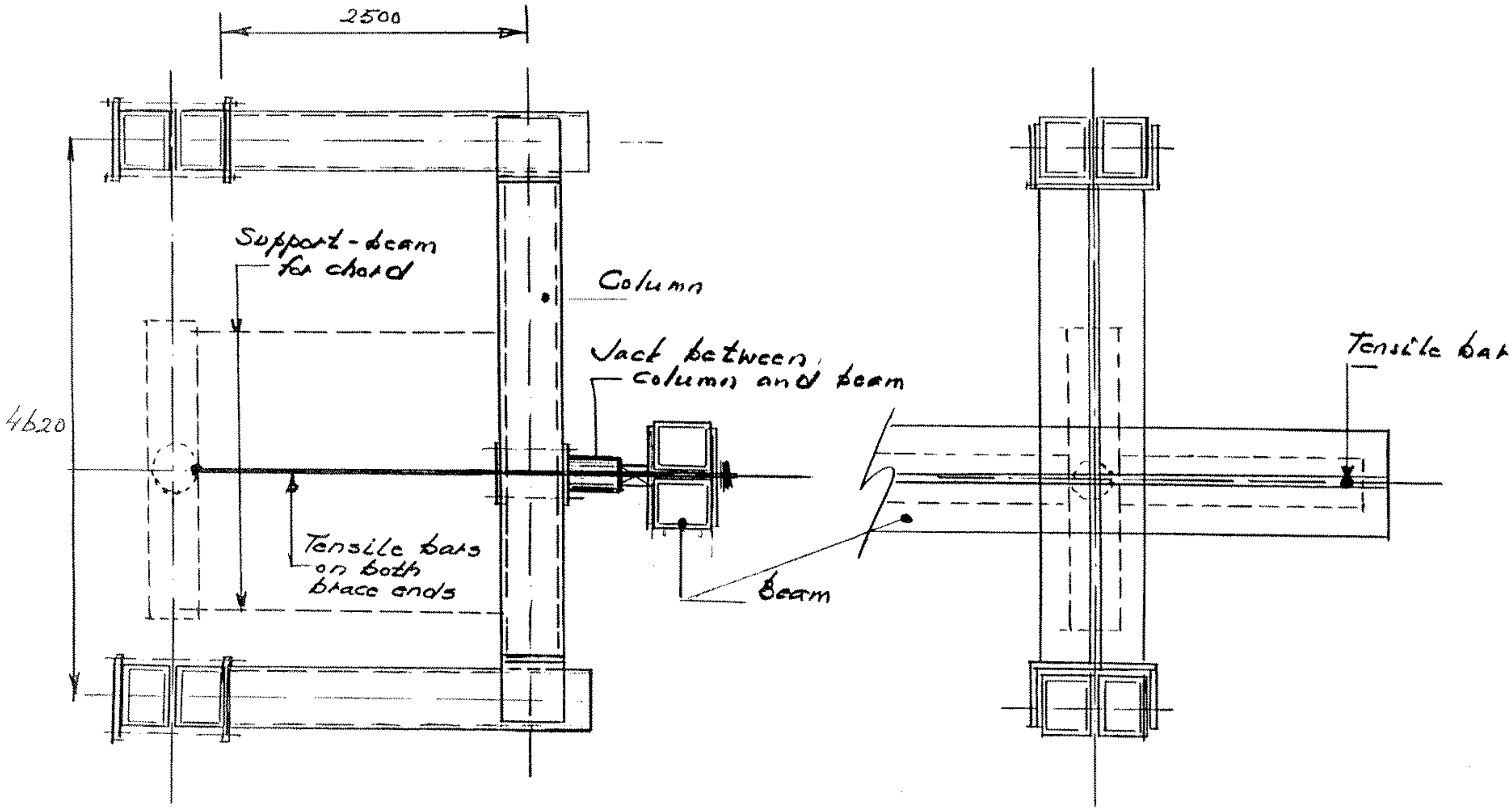


Test rig configuration for DT joints
- Load case: In-plane bending -

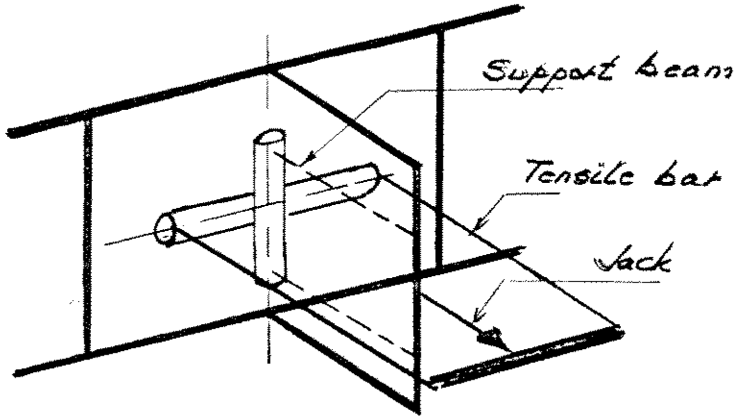


Test rig configuration for DT joints

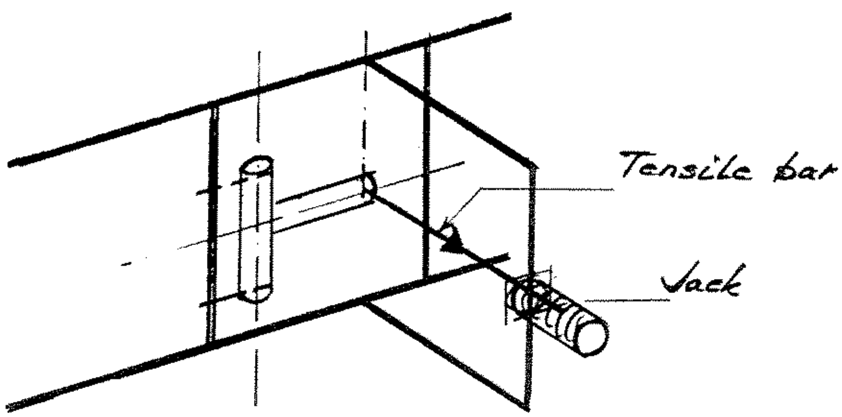
– Load case: Out-of-plane bending –
see also p. 3a and 3b



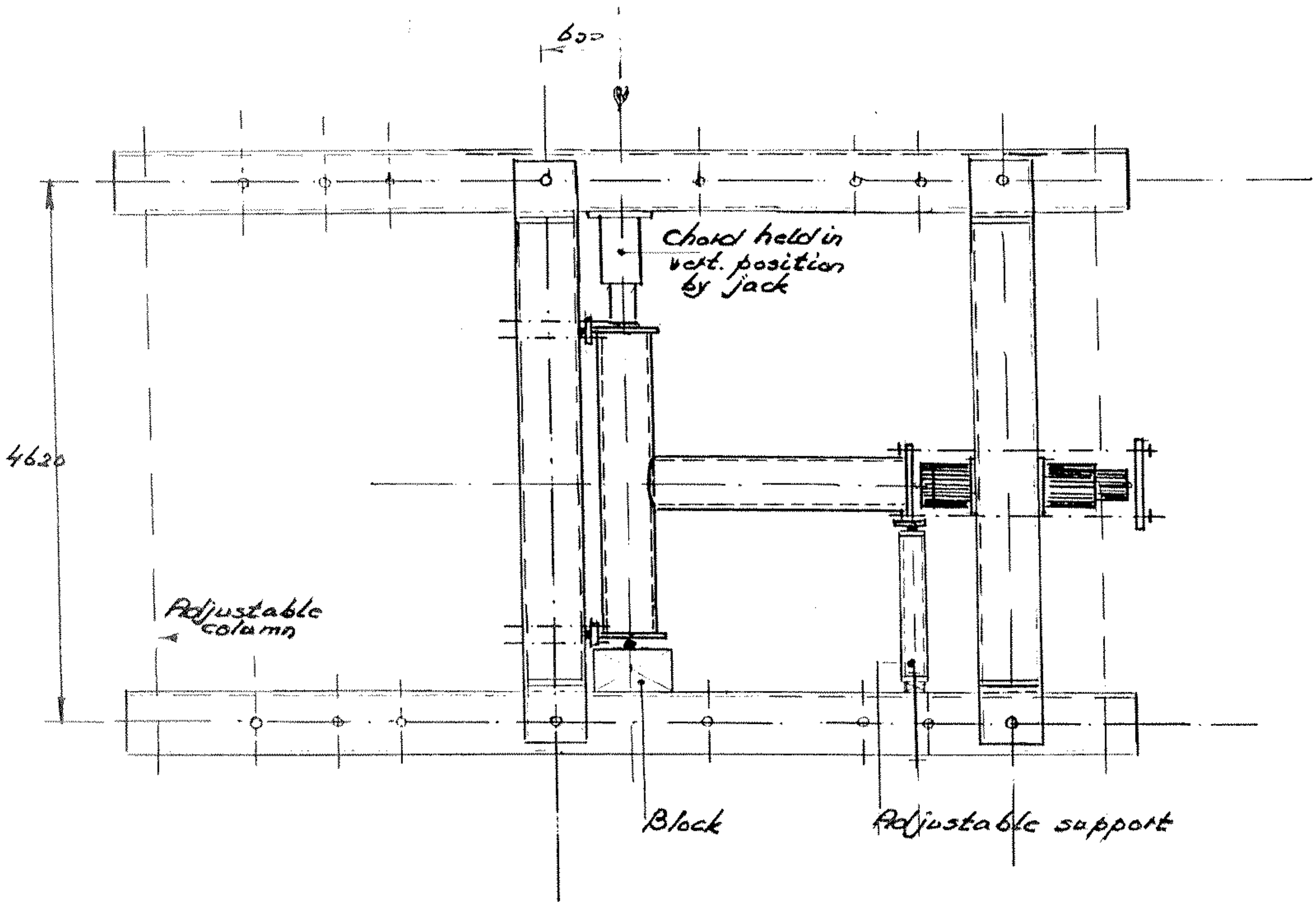
- Load case: Out-of-plane bending (DT and T joints) (see also page 3b)



DT joints (o.p.b.)

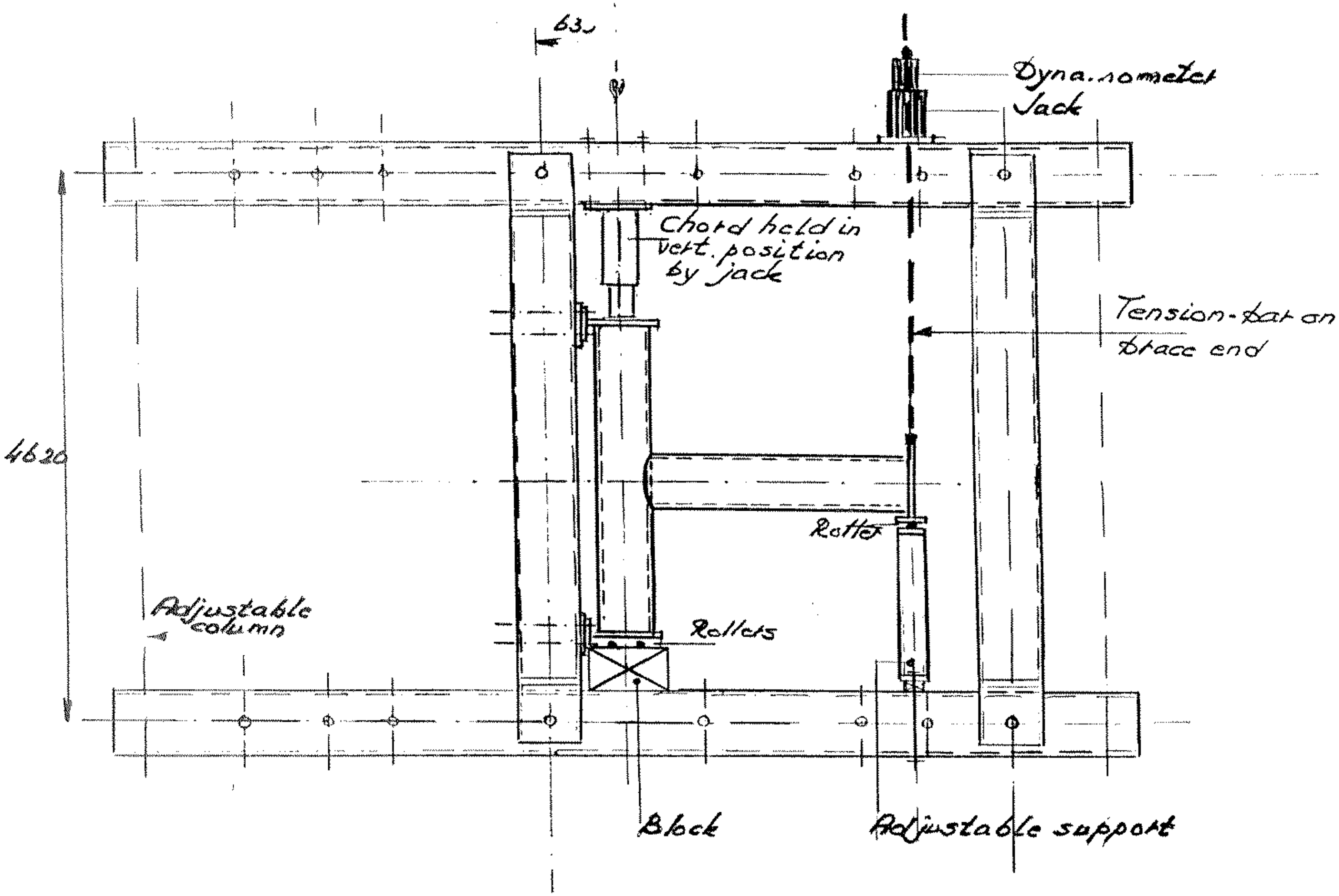


T joints (o.p.b.)



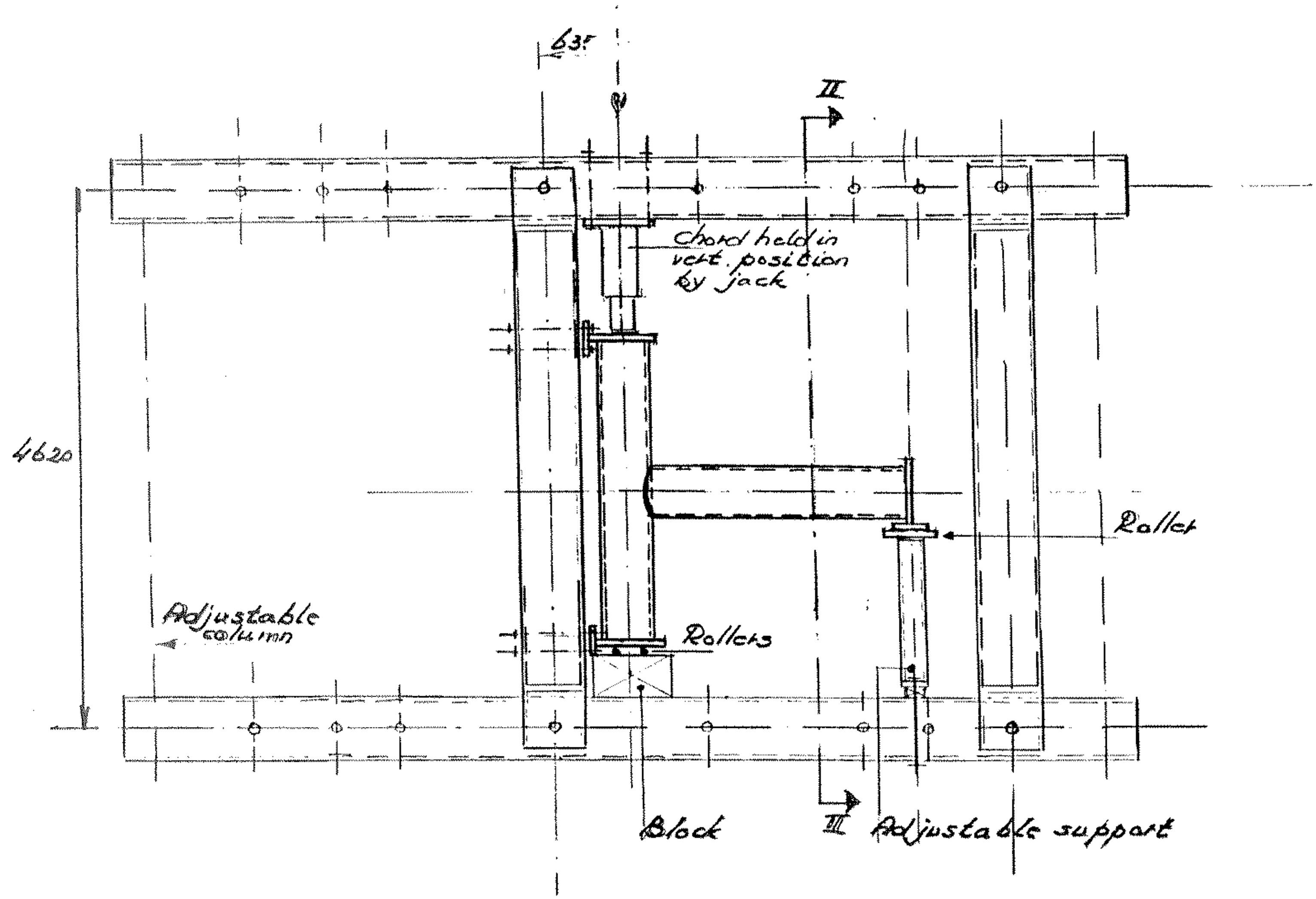
Test rig configuration for T joints

-Load case: Axial, compression-tension-



Test rig configuration for T joints

– Load case: In-plane bending –



Test rig configuration for T joints

– Loadcase: Out-of-plane bending –
see also p. 3a and 3b.

APPENDIX E

INSTRUMENTATION

<u>Location strain gauges + strip gauges on specimens</u>

Research programme
"<u>Grouted tubular joint technology for strengthening/repair.</u>"

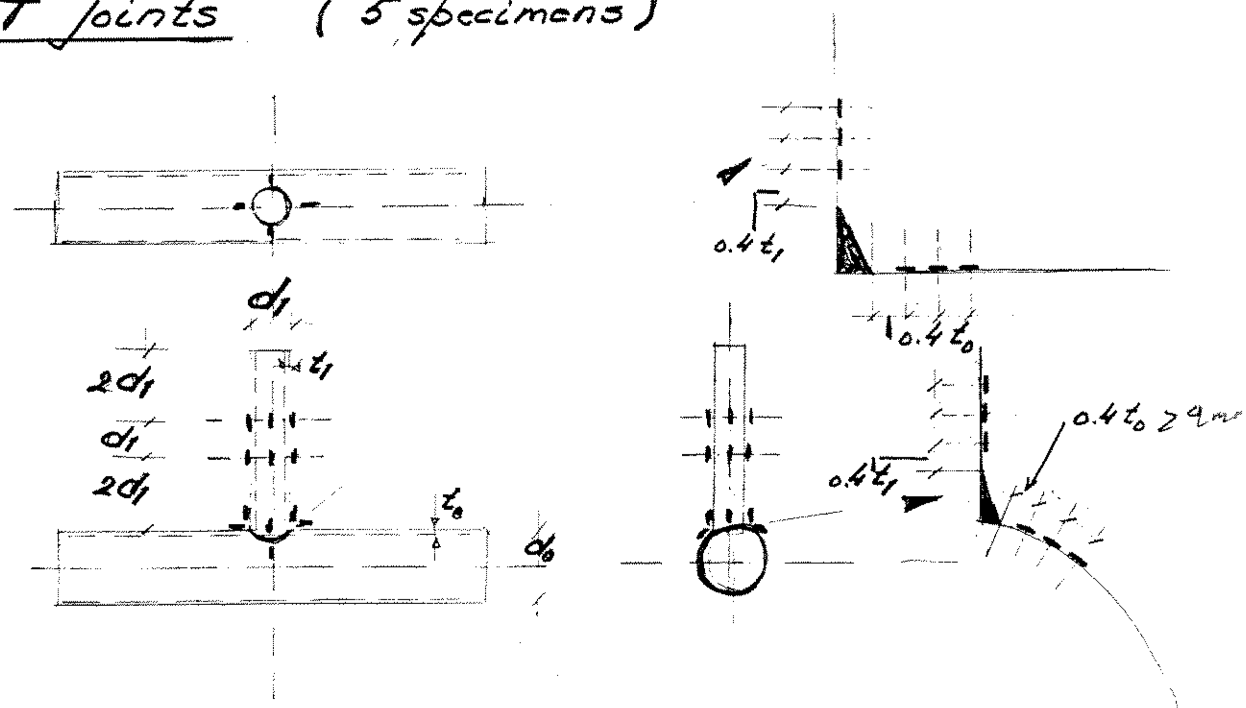
<u>Research institutes</u>

M.S.L. - England
TNO - Bouw - the Netherlands
TU - Delft (Civil Eng.) - The Netherlands

V.I.P. - Grouted Joints

Strain gauges + strip gauges

T joints (5 specimens)



Strain gauges:

Brace: 2 * 4 = 8

Total:

5 * 8 = 40

Strip gauges:

Brace: 4 — $5(4*3^{*)}) = 60$

Chord: 4 — $5(4*3) = 60$

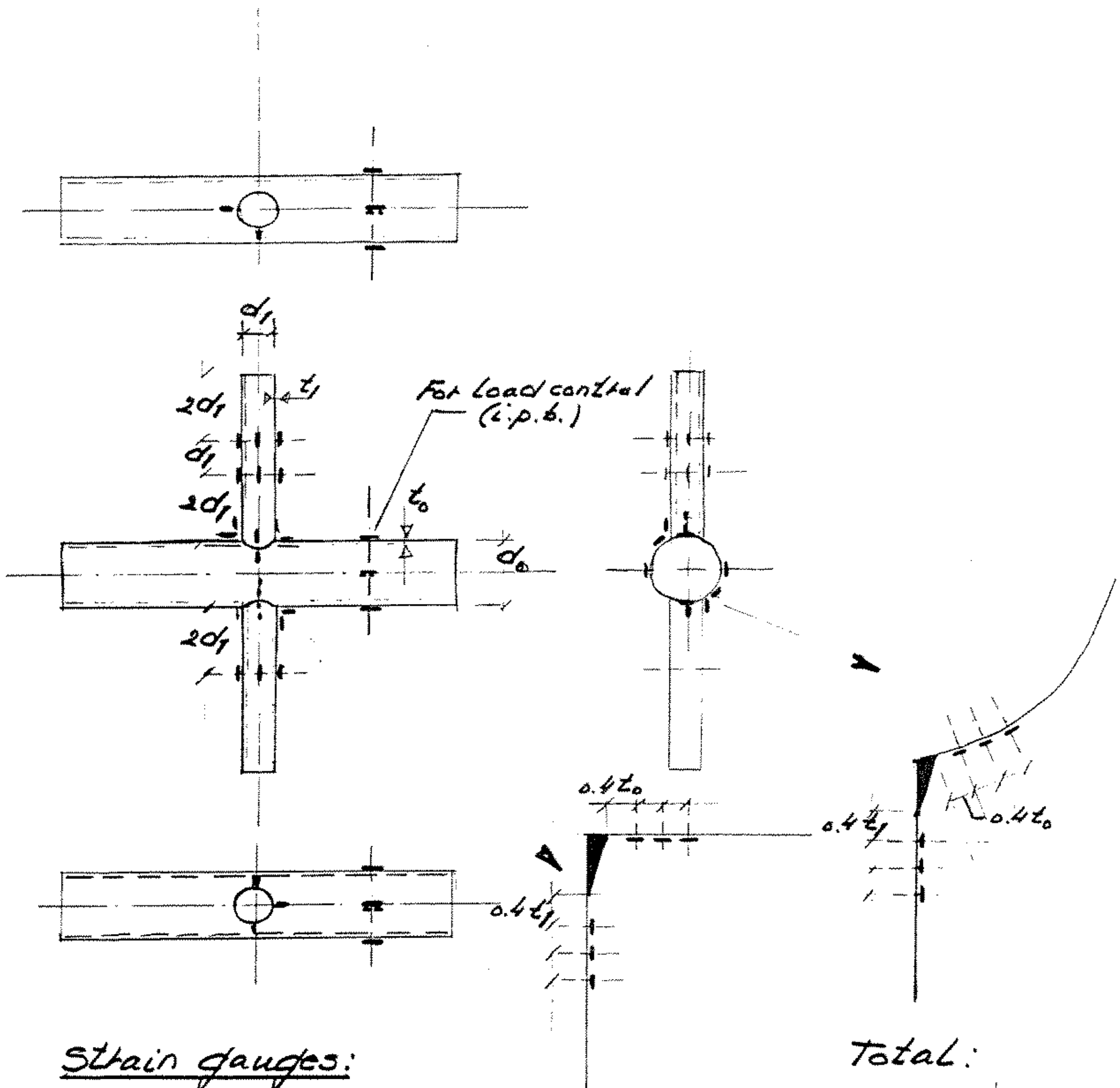
8 — 160

*) 3 measuring poin[ts]

Strain gauges : 40

Strip gauges : 40

DT joints (9 specimens) + 1 X-JOINT



Strain gauges:

Braces : 3 * 4 = 12

Chord : 1 * 4 = 4

Total:

(1 + 9) * 16 = 160

Strip gauges:

Braces : 4

Chord : 4

8

(1 + 9) · (4 * 3 *)) = 120

(1 + 9) · (4 * 3) = 120

400

Strain gauges: 160

Strip gauges: 80

*) measuring points