Consulting Engineers, Planners, Environmental Scientists & Project Managers

(5)

Maunsell

Transport SA

Rapid Bay Jetty

Structural Assessment Report

June 1998

Project No.: 10998.00

COPY NO. [2]

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Rapid Bay Jetty

Structural Assessment Report

REVISION	REVISION DATE	DETAILS	AUTHORISED	
			NAME/POSITION	SIGNATURE
A	04/08/97	Draft to TSA for Comment	Tim Austin – Project Manager	Original Previously Signed
B	25/06/97	Issued to TSA	Tim Austin – Project Manager	

TABLE OF CONTENTS

1. INTRODUCTION

1.1 Background and Objectives

In July 1997 Transport SA commissioned Maunsell Pty Ltd to assess the structural capacity of the Rapid Bay Jetty. This Report presents the results of that investigation.

The Rapid Bay Jetty was built in the early 1940s by the BHP Proprietary Company Ltd as a load out jetty for limestone from the adjacent quarry. Sections of it, especially the loading head, were rebuilt in 1968. BHP handed over the jetty to the Department of Marine and Harbors in 1981 after the company ceased shipping limestone from Rapid Bay and it became surplus to their needs.

Adelaide Brighton Cement (ABC) subsequently leased the jetty for load out of limestone for its Adelaide cement manufacturing operation. In the early-mid 1990's ABC stopped using Rapid Bay limestone and therefore the jetty. The conveyor system has subsequently fallen into disrepair.

The jetty is currently extensively used by recreational fishermen.

The piles and superstructure have suffered considerable corrosion and consequently the structural capacity of the jetty is much reduced from the original. Replacement of some deck sections has been carried out and supplementary steel piles and cross beams have been added since initial construction.

ABC now intends to dismantle and remove the conveyor system including pulleys, motors and gearboxes from the jetty.

ABC wishes to obtain a determination of the maximum axle load which can be sustained by the structure generally and in particular adjacent to the machinery shed locations. This will permit ABC to determine the optimum truck and crane types to use in the demolition work.

1.2 Conduct of the Study

1.2.1 Information

Copies of available drawings of the jetty together with a copy of DMH Report, Rapid Bay Jetty Structural Status, 1987 were provided by Transport SA.

1.2.2 Inspection

Maunsell personnel (T. Austin and D. Lee) inspected the jetty on 11 July 1997. This comprised a visual inspection from the deck only. The underside was not inspected from below and specific member thickness measurements were not taken.

General corrosion condition of the members was noted together with any critical areas. A series of photographs were taken and copies are included in Appendix B to this Report.

1.2.3 Analysis

The various jetty element were analysed using a conservative worst case estimate of the member thicknesses and allowing a 15% Factor of Safety applied to working stress calculations.

For most elements a single point load was applied at centre span, representing the rear wheel of a vehicle. Spans are such that, with this scenarios, the front wheel of a typical design vehicle would be supported by the adjacent span.

The exception was the 0.35 m span stringers. In this case, a 3.5 m wheelbase vehicle was adopted with a 0.6:1.0 front:rear load ratio.

No load sharing was assumed between adjacent similar elements, ie the member under consideration was subjected to the full wheel load at its centre point. The same approach was taken with the piles; the wheel load was directly applied to the top of the pile, without inclusion of the intermediate supporting members.

Results of the analysis appear in Sections 3 and 5. The calculations are included in Appendix A.

Supplementary calculations to determine the scale of any repairs to critical areas are also included in Appendix A. The results of these are summarised in Section 4.

2. STRUCTURAL CONDITION

2.1 Jetty Description

The jetty can be divided into two sections, namely, the approach jetty (Bent 1 to Bent 80 approximately 467 m long) and the 'T' head (Bent 81 onwards, approximately 200 m long).

The older approach jetty section generally comprises of 225 x 75 mm timber decking and 225 x 150 mm timber cross beams supported on steel 330 x 125 mm TFB stringers and double 300 x 88 mm steel channel cross heads. Piles are 450 diameter timber. Additional steel piles at some bents have been used to supplement the original corroded timber piles for strength and stability. The 'T' head section has a similar arrangement except that the structure is solely supported by deep I-section steel crossheads and steel piles.

A typical cross section is as shown in Figure 2.1.

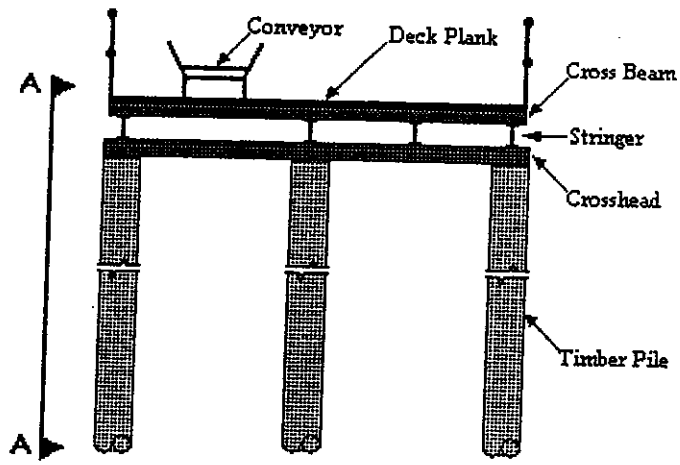
The two motor rooms are located between Bents 37 and 38 and Bents 79 and 80.

2.2 Jetty Condition

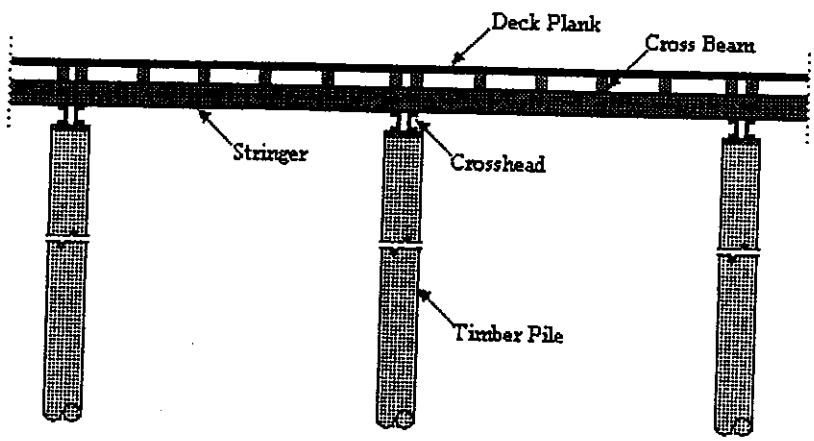
There is a high variation in condition for different parts of the jetty, although the general condition can be considered as poor. Serious degradation of steelwork is reflected by the fact that most of the pile bracing has rusted away. Moreover, a large portion of stringers and crossheads are in a state of moderate to severe corrosion.

It is common that the flange thicknesses of stringers and crossheads appear to be reduced to less than half of their original dimensions. At Bent 17, in particular, the seriously corroded crossheads are twisted with the western stringer detached although the neighbouring structure is still in serviceable condition.

Previous replacement of timber decking is observed at the approach jetty on the eastern side of the original location of the removed conveyor. The approach jetty is supported by a mixture of timber piles and steel piles. The degree of corrosion for timber piles ranges from zero diameter to their original diameter just above seal level. The steel piles exhibit significant corrosion to the flange edges in the inter-tidal zone but are considered serviceable and adequate. Critical bents exist where there are no replacement steel piles for those fractured timber piles (eg Bents 27 and 32).



Cross Section



View A

Figure 2.1 Typical Jetty Construction

3. STRUCTURAL CAPACITY

3.1 Decking

The jetty deck comprises of 5" x 7" (DMH 225 x 150 mm) ironbark cross beams supporting 10" x 3" (DMH 225 x 75 mm) tallow wood deck planks. A constant decking arrangement is found throughout the whole jetty where the centre-to-centre distance of the cross beams is 800 mm. In the approach jetty section, timber planks run along the length of the jetty. The eastern 3 m width section, which has been replaced previously, is in a better condition that the rest.

From the structural analysis of these two decking components, it is the deck plank which presents the more critical load limitation. In fact, it is one of the most critical components of the whole jetty structural system. The deck planks are assumed to function separately, ie there is no load sharing between plans.

A maximum wheel load of 2.7 tonne was determined by applying a single wheel load at the mid span of a single typical deck plank. A Factor of Safety of 1.15 was adopted, which accounts for the variation in the timber condition.

The timber cross beam capacity is 3.0 tonne, assuming a single wheel directly over the cross beam and no counterbalancing between spans.

If a dual wheel truck distributes the wheel load to two planks, the maximum allowable wheel load would increase to 5.4 tonnes.

Similarly, the load imposed on any plank by crane outrigger loads at the motor room bays must be kept within the 2.7 tonne limit by the use of a spreader plate across two or more deck planks.

A 500 x 500 x 20 mm thick steel plate would adequately distribute the point load to two planks. Alternatively appropriate timber spreaders may be used.

3.2 Substructure

Both the 13" x 5" (330 x 125 mm) TFB stringers and 12" x 3.5" (300 x 88 mm) channel cross heads were structurally analysed to assess their residual strengths in their present condition.

(a) Crosshead

For the crosshead, the flange thickness was assumed to be reduced to 5 mm from the original thickness of 13.6 mm, while the web thickness was 8 mm instead of the original 10.16 mm. In this generalised case, the adopted dimensions were taken at the worst section of the crossheads. A conservative simply supported span between two piles with a point load at mid-span was considered (ie the wheel is directly over the crosshead). A maximum allowable wheel load of 7 tonne resulted. It is clear that even with such severe corrosion, the crosshead is not the critical part of the whole structural system.

(b) Stringer - 4.5 m span

A more elaborate approach to the calculation of the stringer's residual strength was carried out which has considered the corrosion and the drilled holes at their flanges. The wheel load was assumed to be directly over a stringer (ie no load sharing) and any counterbalancing from other wheel loads in the adjacent span was ignored. A 33% remaining flange thickness and 83% remaining web thickness were adopted (ie 5 mm and 10 mm respectively). A two-span model having a mid-span point load in only one span gave the highest resultant moment. A 4.5 tonne maximum allowable wheel load resulted.

(c) Stringer - 9.35 m span

In several locations, eg Bents 27 and 32, the pile bent provides no support t the stringers because of pile failure. The stringers are therefore spanning across two bays, ie 9.35 m.

For this situation, a 3.5 m wheel base vehicle was assumed, with a front wheel load of 0.6 x the rear wheel load. This results in a maximum rear wheel load of 1.0 tonne compared with 4.5 tonne for the 4.5 m span. The corresponding front wheel load is 0.6 tonne.

There are several approaches which could be adopted to improve these critical spans. These are discussed in Section 4 below.

3.3 Machinery Bays

The machinery bays refer to bays between Bents 37 to 38 and Bents 79 to 80 under lifting conditions where motor rooms are situated, and they are prospective locations for a stationary crane. Additional steel UB cross heads and steel piles are located adjacent to the typical timber pile bents. By inspection, these additional supporting steel structures, which are in a reasonable condition, would not form any limitation to the size of the crane nor become a critical component of the structural analysis for these sections of the jetty.

The maximum wheel or outrigger load will be governed by the capacity of the stringers, assuming that appropriate steps are taken to spread the loads across the deck planks, as discussed above.

This limiting load will be as discussed under 3.2(b) above. This could be increased by ensuring that the point of application of the load is coincident with the UB crossheads. This would necessitate the use of temporary support beams under the outriggers and spanning between the crossheads.

However, it is considered that the limiting condition will not be the stationary crane operating at the machinery bay but rather the unladen wheel loads imposed by the same crane travelling down the approach jetty.

3.4 Piling

For Bents 1 to 7, the timber piles are generally in good condition. Bent 8 to Bent 26, the timber piles are subjected to varying degrees of corrosion/degradation and are non-functional. They have been replaced with steel piles. Additional steel piles and crossheads are located at every fifth bent from Bent 28 to the jetty head while the 'T' head and motor rooms are supported by steel piles. Generally, the steel piles are in a reasonable state and critical locations exist at the timber pile bents.

Thus, a critical location exists between Bents 29 to 31 where the remaining timber pile diameter at Bent 30 is about 200 mm, compared with the original 450 mm. Even with only 20% remaining of the original cross-sectional area, an estimated 2.2 tonnes allowable wheel load was obtained based on an assumed typical truck wheel load configuration.

Complete loss of pile capacity is covered under 3.2(c) Stringer - 9.35 m, above.

4. STRUCTURAL CAPACITY INCREASE

4.1 Critical Stringers

The critical spans at the missing Bents 27 and 32 present a significant limitation to vehicle size traversing the jetty. There are several approaches available to deal with this restriction:

1. Accept as is - this limits the load to a 2 tonne axle load.

2. Replace the 9.35 long stringers with two new 310 UB 46.2 beams in the line of the wheels. This would increase the stringer allowable wheel load to 3.1 tonne.

3. Repair the broken piles which would restore the 4.5 m span and raise the stringer limit to 4.5 t (see 3.2(b) above). Vertical steel straps bolted to the sound pile sections could be used.

Choice of approach will depend on the relative costs and merits of the alternatives. Alternative 1 is clearly cheaper but would restrict the demolition operation significantly. Alternative 3 would most likely be less expensive than Alternative 2 assuming a straight forward bolted connection arrangement could be devised. It also provides a higher allowable load.

4.2 Piles

The 2.2 tonne limit imposed by degraded piles at some locations could be increased to 6.5 tonne by an increase of equivalent cross sectional diameter to 250 mm. This could be achieved by repair of the piles as described in Alternative 3 in 4.1 above.

5. CONCLUSIONS

The structural capacity of the jetty is limited by the capacity of the existing elements; deck, bearers, steel stringers, steel crossheads and timber piles. The maximum wheel loads available are as summarised in Table 5.1.

Table 5.1 Allowable Wheel Loads

Element	Wheel Load Tonne	Comment
Single deck plank 225 x 75 tallow wood	2.7	Load per plank. Dual wheels would increase this to 5.4 tonne
Cross beam 225 x 150 ironbark	3.0	
Stringer, 4.47 m span, 330 x 125 TFB	4.5	Corroded, drilled hole, two spans
Stringer, 9.35 m span, 330 x 125 TFB	1.0	3.5 m wheelspan, front wheel load 0.6 t
Crosshead, 2 x 300 x 88 channels	7.0	Corroded, one span
Piles 450 diameter timber	140	Based on full diameter, full length (ie new pile)
Piles 200 diameter timber	2.2	Conservatively based on 200 diameter for full length
Piles 250 diameter	6.5	Based on 250 diameter for full length

In summary, for Bents 1 to 26, assuming a dual wheeled vehicle, the cross beam would govern, resulting in a maximum 3 tonne wheel load or 6 tonne axle load.

At two specific locations (Bents 27 and 32) where pile bents are ineffective, the stringer governs, resulting in a maximum 1 tonne wheel load or 2 tonne axle load. This limitation could be removed by repair of the piles.

For Bents 28 - 80, the piles govern generally (except for the steel piles at every fifth bent which are not limiting), resulting in a maximum wheel load of 2.2 tonne or axle load of 4.4 tonne. This could be increased by repair of the piles.

In the machinery bays, the deck and cross beams govern as for the approach jetty. This limitation could be increased or removed by the use of outrigger spreader plates or beams between crossheads.

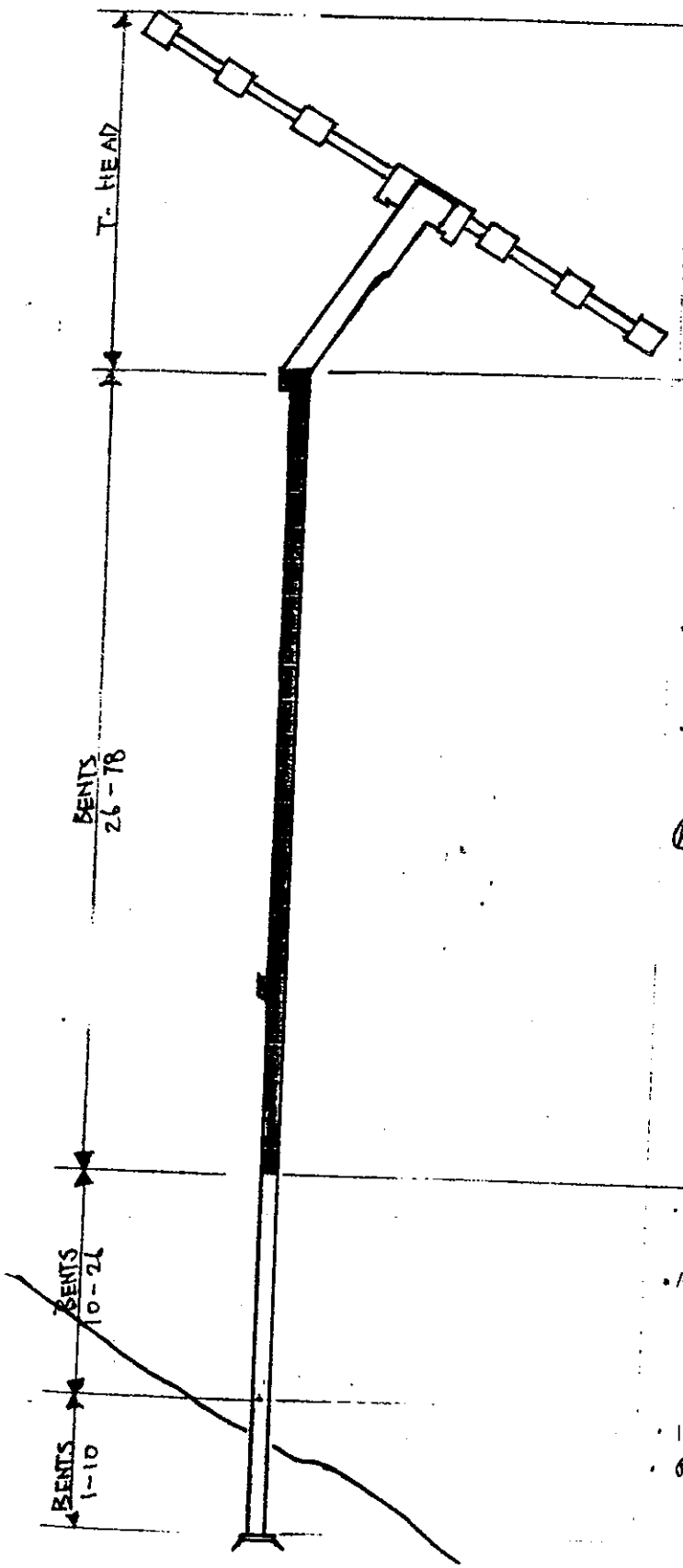
6. REFERENCES

Department of Marine and Harbors, Rapid Bay Jetty Structural Status 1987, Adelaide 1987

Drawings, Rapid Bay Jetty, various by BHP Co. Ltd 1940, 1941, 1965 and 1968 and DMH 1979.

What about reference to 1992 DMH Report Why was this not referred to ???

RAPID BAY JETTY	**Maunsell**	
	JOB No. 10998	
	BY RL.	SHEET No. A 1
SUMMARY OF JETTY CONDITIONS	CHECKED	DATE July '97.



SUBSTRUCTURE	SUBSTRATE
• 79 - 80 → STEEL PILES (No. 3 MOTOR Rm)	• Old decking
• ALL STEEL PILES	
• 28 & EVERY 5TH BENTS → STEEL RAKER PILES	• 30 → v. poor stringer condition
• 37 → 38 → STEEL PILES (No. 2 MOTOR Rm)	
• 70 → TIMBER PILES + STEEL SIDE PILES	
• 76 & 78 → ADDITIONAL STEEL PILE ON EASTERN SIDE	
(NB Very poor condition at Bents 27 & 32)	
• 10 → 26 → STEEL PILES (raking + vertical)	• 17 → v poor Cross Head Condit
• 13, 18, 23 → DOUBLE RAKER PILES	
• 1-7 → TIMBER PILES • 8-10 → STEEL PILES (raking + vertical)	• 8 → v. poor Stringer Condit.

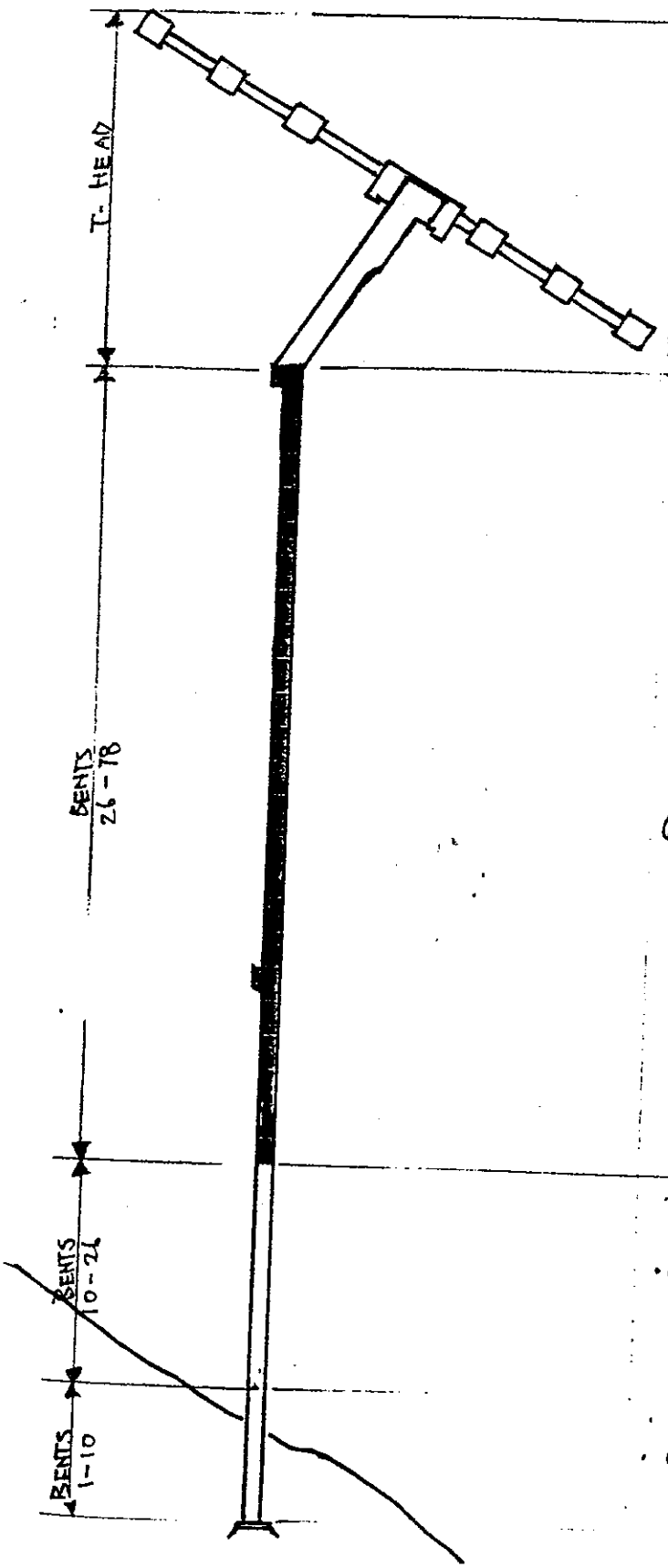
APPENDIX A

CALCULATIONS

RAPID BAY JETTY	Maunsel	
	JOB No. 10998	
APPENDIX A – CALCULATION	BY DL,	SHEET No.
	CHECKED	DATE July '97

CONTENT :

RAPID BAY JETTY	**Maunsell**	
	JOB No. 10998	
	BY TRL.	SHEET No. A 1
SUMMARY OF JETTY CONDITIONS	CHECKED	DATE July '97.



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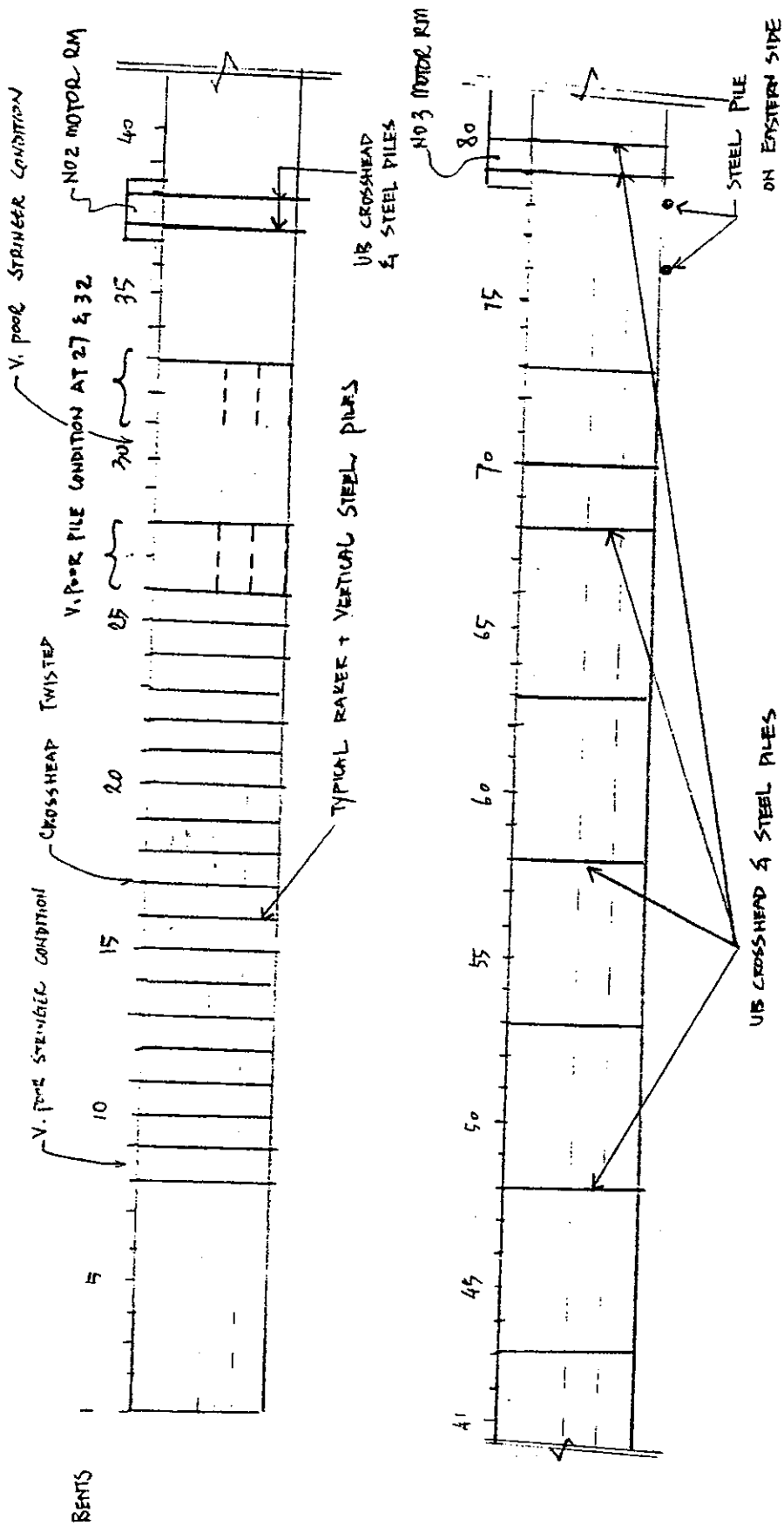
· 13, 18, 23 → DOUBLE RAKER PILES	
· 1-7 → TIMBER PILES · 8-10 → STEEL PILES (raking + vertical)	· 8 → v. poor Stringer Condit.

RAPID BAY JETTY	**Maunsell**	
	JOB No. 10998	
	BY DL.	SHEET No. A 2
SUMMARY OF JETTY CONDITION FROM BENT 1 TO BENT 80	CHECKED	DATE July 97.



RAPID BAY JETTY	Maunsell
	JOB No. 10998
VISUAL INSPECTION	BY D.L. / SHEET No. A 3
	CHECKED / DATE July 97

(A) SUBSTRUCTURE

BENT	PILE		CONDITION
1 - 7	TIMBER		
8 - 26	STEEL	(Raking + Vertical)	GOOD
	TIMBER		OK
27	TIMBER		
28	STEEL	(2x Raking - inside)	27 - V. poor
	TIMBER		
29-32	TIMBER		¢290 - 29-31
33	STEEL		V. poor - 32
	TIMBER		
34-36	TIMBER		
37-38	STEEL	(No. 2 motor Rm)	
39-47	TIMBER		
48	STEEL		
49-58	TIMBER		
58	STEEL		
59-67	TIMBER		
68	STEEL		
69	TIMBER		
70	STEEL	(OUTER)/TIMBER	
71-75	TIMBER		
76	STEEL	(ON EASTERN SIDE)	
	TIMBER		
77	TIMBER		
78	STEEL	(ON EASTERN SIDE)	
	TIMBER		
79-80	STEEL	(NO. 3 motor Rm)	
81 & ONWARDS	STEEL		

RAPID BAY JETTY	Maunsell	
	JOB No. 10998	
VISUAL INSPECTION	BY DL	SHEET No. A 4
	CHECKED	DATE July '99

(B) SUBSTRATE STEELWORK

BENT	GIRDER/STRINGER		CROSSHEAD	REMARKS
1-7				
8	5	(4-5mm flange)	2	
9	1		3	
10	1		2	
11	3	(7-8mm flange)	1	
12	3		4	
13-16	3		4	
17	3		5	crosshead twisted
18	3		4	
19-26	4	(5-6mm flange)	4	girders span from 26-28
27-29	4		4	
30	5		4	
31-36	4		4	girder span from 31-33
37-38				
39-47	4		4	*
48			1	*
49-57	4		4	
58			2	*
59-67	4		4	
68			2	*
69-78	*		4	
79-80			2	*
81 & ONWARDS	2		2	

NB:

- CODE : 1 (GOOD) — 5 (POOR)

- * ~ ADDITIONAL I SECTION CROSSHEAD & STEEL PILING SYSTEM

RAPID BAY JETTY	**Maunsell**	
	JOB No. 10998	
	BY DL	SHEET No. A 6
GIRDER CHECK	CHECKED	DATE July '97

(I) NO CORROSION :

13" x 5" TFR $\Rightarrow$ $Z = 43.63 \text{ in}^3$

$Z_{xx} = 714.8 \times 10^3 \text{ mm}^3$

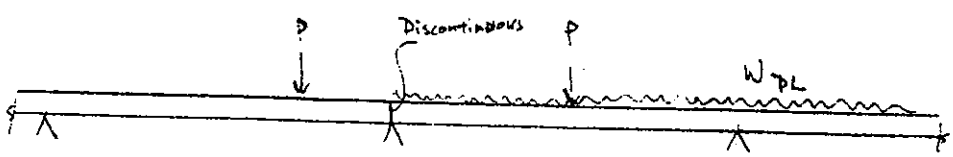
$f_b = 165 \text{ mPa}$

$f_b = \dfrac{M_{all}}{Z_{xx}}$

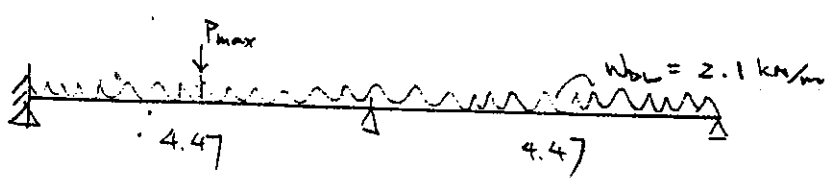
$M_{all} = 165 \times 714.8 \times 10^3 \text{ mm}^3$

$\therefore M_{all} = 118 \times 10^6 = 118 \text{ kN-m}$

WORST CASE :



$\approx$



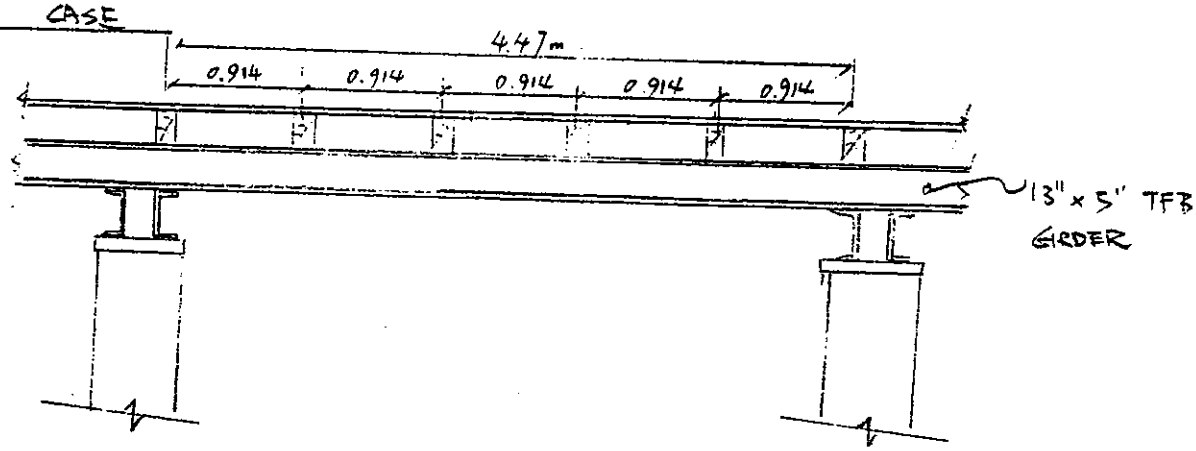
FROM SPREE BASS $P_{max} \approx 120$ kN

ie. 12.2 tonnes / wheel

($M_{max} = 111.6$ kN-m)

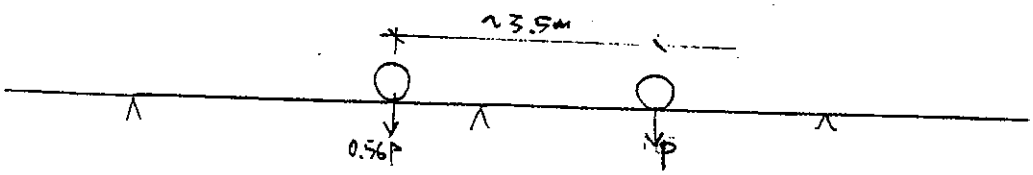
RAPID BAY JETTY	Maunsell
	JOB No. 10998
GIRDER CHECK	BY T.L. / SHEET No. A 7
	CHECKED / DATE July '97

(A) TYPICAL CASE



Assuming a 4t truck load { Single wheel 2 axles

CRITICAL CASE - WHERE LOAD (REAR WHEEL LOAD) AT MID - SPAN



LOADING :

(i) DL : DECK PLANK : $1000\ kg/m^3 \times 0.076 \times \frac{9.81}{1000} = 0.75\ kN/m$

CROSS BEAM : $1100\ kg/m^3 \times 0.178 \times 0.127 \times \frac{6}{4.47} \times \frac{9.81}{1000} = 0.33$

GIRDER S/W $\approx 50\ kg/m \times \frac{9.81}{1000} = 0.5\ kN/m$

$\Rightarrow \Sigma DL = (0.75 + 0.33)\ 1.38 + 0.5\ kN/m$

$= 1.99\ kN/m$

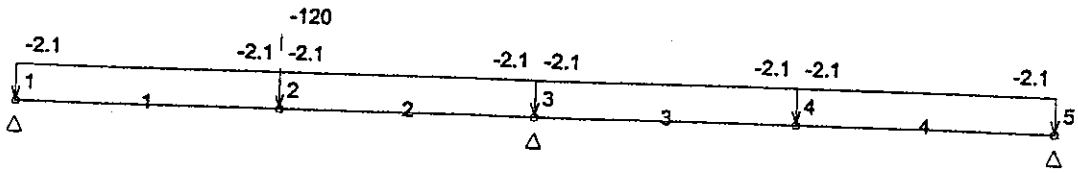
$\approx 2.1\ kN/m$ Including hand rail etc

(ii) L.L. : WHEEL LOAD

SPACE GASS 7.00d(Win) - MAUNSELL PTY LTD

A7

1 DL
2 LL
3 DL+LL



RDER (1) NO CORROSION

5: Unnamed, Designer: DL, Units: m,kN,kNm, Scale: 1:66, Axes: XY
ad: .42 Disp: None Moment: None Shear: None Axial: None
PIDBAY JETTY
998

16 Jul 1997, 11:47 am

SPACE GASS 7.00d(Win) - MAUNSELL PTY LTD
Job name: Unnamed Designer: DL Date: 16 Jul 1997, 11:47 am Page: 1
RAPIDBAY JETTY
10998

MEMBER FORCES AND MOMENTS (kN,kNm)

Load case 3 (Linear): DL+LL

Memb	Node	Axial Force	Y-Axis Shear	Z-Axis Shear	X-Axis Torsion	Y-Axis Moment	Z-Axis Moment
1	1	0.000	52.270	0.000	0.000	0.000	0.000
	2	0.000	47.577	0.000	0.000	0.000	111.579
2	2	0.000	-72.423	0.000	0.000	0.000	(111.579) ←
	3	0.000	-77.117	0.000	0.000	0.000	-55.532
3	3	0.000	17.117	0.000	0.000	0.000	-55.532
	4	0.000	12.423	0.000	0.000	0.000	-22.521
4	4	0.000	12.423	0.000	0.000	0.000	-22.521
	5	0.000	7.730	0.000	0.000	0.000	0.000

NODE REACTIONS (kN,kNm)

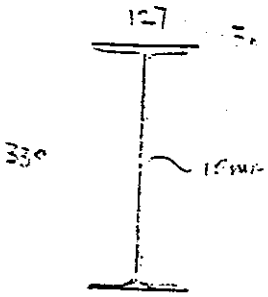
Load case 3 (Linear): DL+LL

Node	X-Axis Force	Y-Axis Force	Z-Axis Force	X-Axis Moment	Y-Axis Moment	Z-Axis Moment
1	0.000	52.270	0.000	0.000	0.000	0.000
3	0.000	94.234	0.000	0.000	0.000	0.000
5	0.000	-7.730	0.000	0.000	0.000	0.000
Load	0.000	-138.774	0.000			
Reac	0.000	138.774	0.000			

RAPID BAY JETTY	**Maunsel**	
	JOB No. 10998	
GIRDER CHECK	BY D.L.	SHEET No. 49
	CHECKED	DATE July '9

(II) CORRODED GIRDER :

Generally corrosion varies at different locations, conservatively, take 5 mm for flange thickness and 10 mm for web thickness.



$$I_{xx} = \frac{127 \times 330^3}{12} - \frac{117 \times 320^3}{12}$$

$$= 60.845 \times 10^6 \text{ mm}^4$$

$$Z_{xx} = I_{xx}/y = \frac{60.845 \times 10^6}{165}$$

$$= 368.76 \times 10^3 \text{ mm}^3$$

$$\therefore Z_{xx\,(COR)} = 368.8 \times 10^3 \text{ mm}^3.$$

$$\approx 52\% \text{ OF } Z_{xx\,(NEW)}$$

$$\Rightarrow M_{all} = 165 \times 368.8 \times 10^3$$

$$= 60.85 \text{ kN-m}.$$

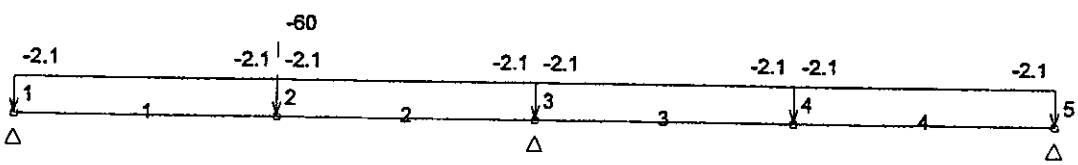
FROM SPACE GASS $P_{max} = 60$ kN

ie 6.1 tonnes / wheel

($M_{max} = 57.1$ kN-m)

SPACE GASS 7.00d(Win) - MAUNSELL PTY LTD

1 ——— DL
2 — — — LL
3 - - - - - DL+LL



GIRDER-CORRODED
Job: RAPBAY, Designer: DL, Units: m,kN,kNm, Scale: 1:66, Axes: XY
Load: .42 Disp: None Moment: None Shear: None Axial: None
RAPIDBAY JETTY
0998
16 Jul 1997, 2:11 pm

SPACE GASS 7.00d(Win) - MAUNSELL PTY LTD
Job name: RAPBAY Designer: DL Date: 16 Jul 1997, 2:12 pm Page: 1
RAPIDBAY JETTY
10998

MEMBER FORCES AND MOMENTS (kN,kNm)

Load case 3 (Linear): DL+LL

Memb	Node	Axial Force	Y-Axis Shear	Z-Axis Shear	X-Axis Torsion	Y-Axis Moment	Z-Axis Moment
1	1	0.000	27.895	0.000	0.000	0.000	0.000
	2	0.000	23.202	0.000	0.000	0.000	57.101
2	2	0.000	-36.798	0.000	0.000	0.000	(57.101) ←
	3	0.000	-41.492	0.000	0.000	0.000	-30.389
3	3	0.000	11.492	0.000	0.000	0.000	-30.389
	4	0.000	6.798	0.000	0.000	0.000	-9.949
4	4	0.000	6.798	0.000	0.000	0.000	-9.949
	5	0.000	2.105	0.000	0.000	0.000	0.000

NODE REACTIONS (kN,kNm)

Load case 3 (Linear): DL+LL

Node	X-Axis Force	Y-Axis Force	Z-Axis Force	X-Axis Moment	Y-Axis Moment	Z-Axis Moment
1	0.000	27.895	0.000	0.000	0.000	0.000
3	0.000	52.984	0.000	0.000	0.000	0.000
5	0.000	-2.105	0.000	0.000	0.000	0.000
Load	0.000	-78.774	0.000			
Reac	0.000	78.774	0.000			

RAPID BAY JETTY	**Maunsell**	
	JOB No. 10998	
GIRDER CHECK	BY DL	SHEET No. 4/12
	CHECKED	DATE July 97

DUE TO THE DRILLED HOLES (ϕ = 20 mm) @ 914 mm CTS, THE MOMENT CAPACITY SHOULD BE REDUCED ACCORDING

Z_{xx} (new) = 714.8×10^3 mm^3

Z_{xx} (hole) = 635.16×10^3 mm^3 (from BHP tables 1961)

= 89 % × Z_{xx} (new)

FOR CORRODED GIRDER:

Z_{xx} (COR, hole) = $0.89 \times 368.8 \times 10^3$

= 327.7×10^3 mm^3

P_{max} ≈ 53.4 kN (= 0.89 × 60 kN)

ie 5.2 tonnes / wheel

IN VIEW OF THE EXTENSIVE CORROSION AND LIMITATIONS ON THIS VISUAL INSPECTION, A SAFETY FACTOR OF 1.15 IS APPLIED.

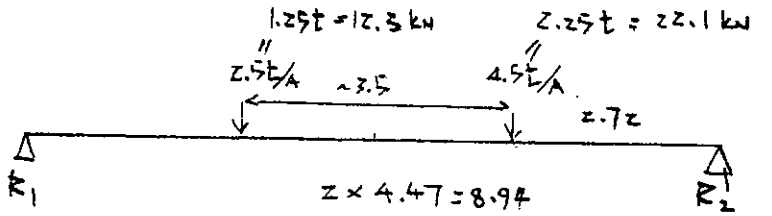
∴ MAX. WHEEL LOAD = $\frac{5.2}{1.15}$

= 4.5 tonnes/wheel

RAPID BAY JETTY	Maunsell	
	JOB No. 10998	
GIRDER CHECK	BY DL	SHEET No. A 13
	CHECKED	DATE JULY 97

(B) CRITICAL CASE.

CRITICAL LOCATIONS OCCUR AT BENTS 27 & 32 WHERE THE TIMBER PILES ARE AT VERY POOR CONDITIONS AND THE GIRDERS ARE ASSUMED TO SPAN TWO SPANS.



Z_{xx} (hole. corr) $= 327.7 \times 10^3 \text{ mm}^3$

$M_{all} = 165 \times 327.7 \times 10^3 \times \frac{1}{1.15}$

$= 47 \text{ kN-m}$

$$R_2 = \frac{12.3 \times 2.72 + 22.1\,(8.94 - 2.72)}{8.94} = 19.12 \text{ kN}$$

$M_{max\,P} = R_2 \times 2.72 = 52 \text{ kN-m}$.

$\gamma L = 2.1 \text{ kN/m}$

$$M_{max\,DL} = \frac{Wl^2}{8} = \frac{2.1 \times 8.94^2}{8} = 21 \text{ kN-m}.$$

$\therefore$ TOTAL MOMENT $= 52 + 21 = 73 \text{ kN-m} > M_{all}$

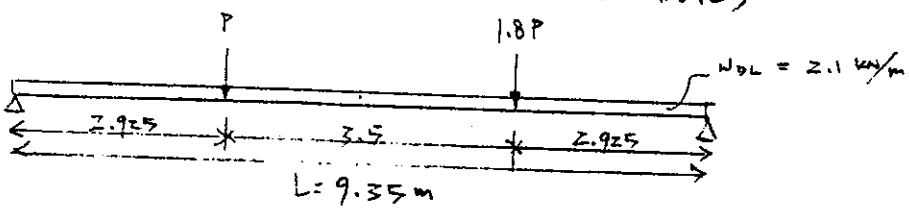
M_{max} due to wheel load $= 47 - 21 = 26 \text{ kN-m}$

Max Mid-Point load $= \frac{4 \times M}{l} = 11.6 \text{ kN}$

≈ 1.18 tonne/wheel

RAPID EXIT JETTY	Maunsell	
	JOB No. 10 998	
GIRDER CHECK	BY DL.	SHEET No. A 14
	CHECKED	DATE July 97

(i) ALTERNATIVE 1 : (LIMITING MAX. WHEEL LOAD)



Z_{xx} (hole, corr.) = 327.7×10^3 mm^3

$$M_{allow} = 165 \times 327.7 \times 10^3 \times \frac{1}{1.15} = 47 \text{ kN-m}$$

$$R_{z,P} = \frac{P \times 2.925 + 1.8P \times (9.35 - 2.925)}{9.35} = 1.55P.$$

$$M_{max,P} = R_{z,P} \times 2.925 = 4.533P.$$

$$DL_{TIMBER} = 2.1 \text{ kN/m}.$$

$$M_{DL} = \frac{2.1 \times 6.425}{2}(9.35 - 6.425) = 19.73 \text{ kN-m (at } x = 6.425 \text{ m)}$$

$\therefore$ TOTAL MOMENT $= M_{max} = M_{max\,P} + M_{DL}$

$$= 4.533P + 19.73$$

$\Rightarrow \therefore M_{allow} > M_{max}$

$\Rightarrow 47 \text{ kN-m} > 4.533P_{max} + 19.73$

$$P_{max} < 6.0 \text{ kN}$$

$\therefore$ Max wheel load = 6.0 kN/wheel

Moment at Mid-span $R_1 = \frac{P(6.425) + 1.8(2.925)P}{9.35} = 1.25P$

$$M_{mid} = 1.25P \times \frac{9.35}{2} - P\left(\frac{9.35}{2} - 2.925\right) + \frac{2.1 \times 9.35^2}{8} \leq 47$$

$\Rightarrow P_{max} = 5.875$ kN/wheel

Max wheel load : 0.6 tonnes/wheel & 1.08 tonnes/axle

RAPID BAY JETTY	Maunsell	
	JOB No. 10998	
GIRDER CHECK	BY D.L.	SHEET No. A 15
	CHECKED	DATE July '97

(ii) ALTERNATIVE 2 : (REPLACING GIRDER)

CRITICAL SECTION AT MID SPAN (AS IN ALTERNATIVE 1)

$$P = 1.39\,t$$
$$= 13.64\ kN$$

$$M_{mid} = 1.25P \times \frac{9.35}{2} - P\left(\frac{9.35}{2} - 2.925\right) + \frac{2.1 \times 9.35^2}{8}$$

$$= 78.8\ kN\text{-}m.$$

$$f_b = \frac{M}{Z}$$

$$Z_{required} = \frac{M}{f_b} = \frac{78.8 \times 10^6}{165/1.15} = 549.12 \times 10^3\ mm^3$$

USE 310 UB 46.2 (OR 360 UB 44.7)

$Z_x = 654 \times 10^3\ mm^3$
$Z_x = 669 \times 10^3\ mm^3$)

FOR 310 UB 46.2

$$\phi M = f_b \times Z = \frac{165}{1.15} \times 654 \times 10^3\ mm^3$$

$$= 93.83\ kN\text{-}m.$$

$$M_{max} = 1.25P \times \frac{9.35}{2} - P\left(\frac{9.35}{2} - 2.925\right) + \frac{2.1 \times 9.35^2}{8} = 93.83$$

$$4.09375\,P + 22.95 = 93.83$$

$$\Rightarrow P = 17.3\ kN$$

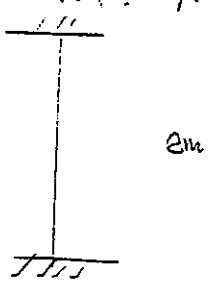
$\Rightarrow$ max wheel load $= 1.8P = 31.2\ kN$

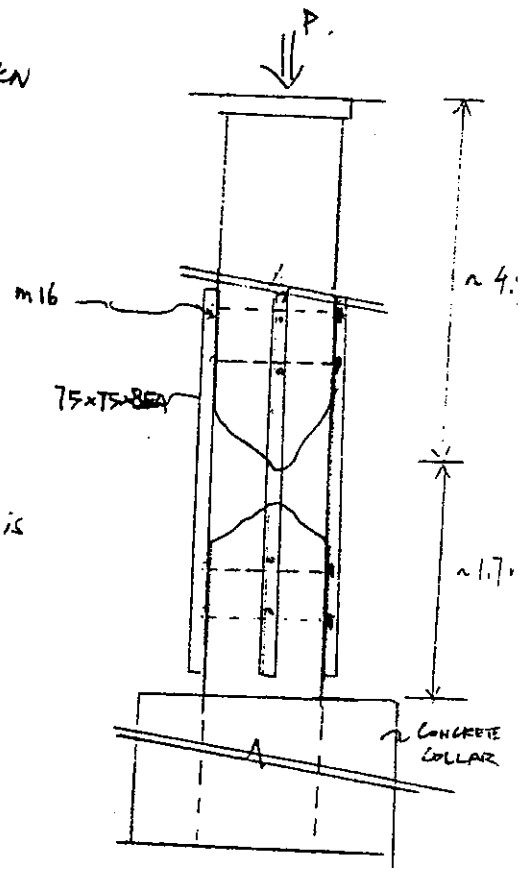
RAPID BAY JETTY	Maunsell
	JOB No. 10998
GIRDER CHECK	BY DL, SHEET No. 16
	CHECKED DATE July '97

(iii) ALTERNATIVE 3 : (FIXING THE BROKEN PILES).

Assuming Max. Load = P = 3 tonnes ≐ 29.4 kN

↓P/4 = 7.4 kN





Moment caused by timber pile buckling is small

$P^* \doteq 2 \times 7.4 \doteq 14.8$ kN

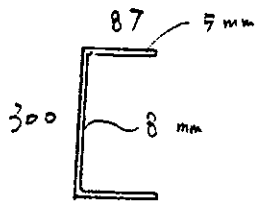
USE 75×75×8 EA $\phi N = 79.5$ kN

V^* on 1 bolt $= 29.4 \times 2/8 = 7.35$ kN

M16 ⇒ $\phi V_{fn} = 28.6$ kN

RAPID BAY JETTY	**Maunsel**	
	JOB No. 10998	
CROSSHEAD CHECK	BY DL	SHEET No. 17
	CHECKED	DATE July '97

CROSS HEADS : $2 \times 12'' \times 3.5'' \times 34 \times 33^{*}$ lb/ft
≈ 28.0 lb/ft



$$I_{xx} \approx \frac{87 \times 300^3}{12} - \frac{79 \times 290^3}{12}$$

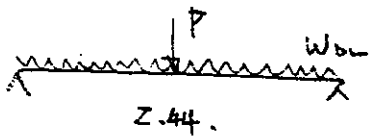
$$\doteq 35.2 \times 10^6 \text{ mm}^4$$

$$Z_{xx} \approx \frac{I_{xx}}{y}$$

$$\approx \frac{35.2 \times 10^6}{150}$$

$$\approx 234.6 \times 10^3 \text{ mm}^3 \quad \text{(Corroded Section)}$$

$$M_{all} = \frac{1}{1.15} \times 165 \times 234.6 \times 10^3 \times 2 = 46.92 \text{ kN.m}$$



$$W_{DL} = (0.75 + 0.33)4.47 + 0.5 \times 4.47 \times 3/2.44 + 0.25 \text{ kN/m}$$
$$= 6.9 \text{ kN/m}$$

$$M_{all} > M_{max} = 6.9 \times 2.44^2/8 + P \times \frac{2.44}{4}$$

$$46.92 > 5.135 + 0.61P$$

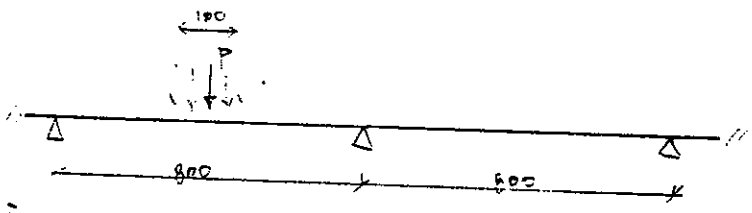
$$\therefore P_{max} = 68 \text{ kN} \approx 7 \text{ tonnes/wheel.}$$

$\gg$ Pmax for girder

$\therefore$ cross head is not critical

RAPID BAY JETTY	Maunsell
	JOB No. 10998
DECK PLANK CHECK.	BY D.L. / SHEET No. A 18
	CHECKED / DATE July '97

PLANK : 254mm × 76mm
10" × 3" Decking - Tallow Wood
Stress grade = F17



BENDING :

$F_b = 17\ mPa$

$k_1 = 1.7 \quad k_2 = 1 \quad k_4 = 1.05 \quad k_5 = 0.65 \quad k_6 = 1 \quad k_8 = 1 \quad k_{11} = 1$

$k_{12} = 1$

$\therefore F_b = 1.7 \times 1.05 \times 0.6 \times 17 = 19.7\ mPa$

Assume double span :

$M = 0.178\ PL$

$\sigma = \frac{0.178\ PL}{Z} \Rightarrow P = \frac{\sigma Z}{0.178 \times L}$

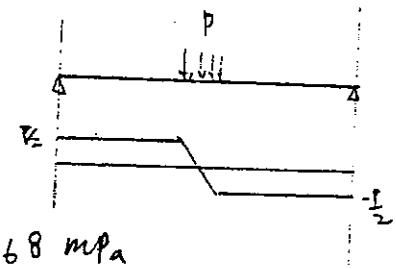
$= \frac{19.7 \times 250 \times 75^2}{0.178 \times 800 \times 6} = 32.424\ kN$

≈ 3.3 tonnes / wheel.

RAPID BAY JETTY	Maunsell
	JOB No. 10998
DECK PLANK CHECK	BY DL / SHEET No. A 19
	CHECKED / DATE July '97

SHEAR :

$F'_s = 1.47 \text{ MPa}$



$F_s = k_1 k_2 k_4 k_5 k_6 F_s'$

$= 1.7 \times 1 \times 1.05 \times 0.65 \times 1 \times 1.45 = 1.68 \text{ MPa}$

$\sigma = \frac{F}{A} = \frac{V}{A}$

$\Rightarrow V = F_s \times A = 1.68 \times 250 \times 75 = 31.5 \text{ kN}$

$\simeq 3.2$ tonnes/wheel.

TO TAKE INTO ACCOUNT OF THE CONDITION OF TIMBER PLANK (ESPECIALLY TRUE FOR AREA NEAR JETTY HEAD), A FACTOR OF SAFETY OF 1.15 IS APPLIED

$\therefore$ MAX. WHEEL LOAD $= 3.2 \times \frac{1}{1.15}$

$= 2.78$ tonnes/wheel

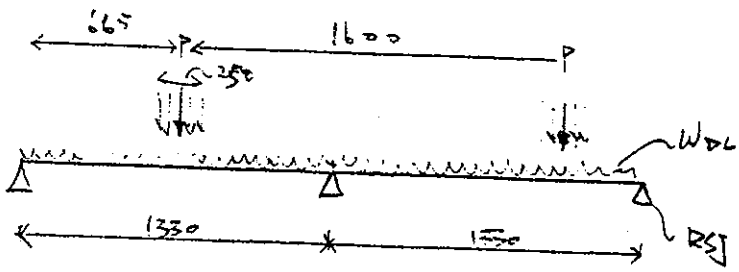
RAPID BAY JETTY	Maunsell	
	JOB No. 10998	
CROSS BEAM CHECK	BY D.L.	SHEET No. A 20
	CHECKED	DATE July 97.

CROSS BEAM :

178mm 127mm

7" × 5" Ironbark

Stress grade : F17



BENDING :

$$F_b = k_1\, k_2\, k_4\, k_5\, k_6\, k_8\, k_{11}\, k_{12}\, F_b'$$

$$= 1.7 \times 1 \times 1 \times 0.62 \times 1 \times 1 \times 1 \times 1 \times 17 = 17.92 \text{ MPa}$$

Due to Deck + S/W $W_{DL} = 0.75 \text{ kPa} \times 0.914 + 0.25$

$= 0.94 \text{ kN/m}$

$$M_{max} = 0.07 \times 0.94 \times 1330^2 + 0.15\, P \times 1330$$

$$P = \left(17.92 \times \frac{175^2 \times 125}{6} - 116\,393.62\right) \frac{1}{0.15 \times 1330}$$

$$= 51.73 \text{ kN}$$

$$\approx 5.8 \text{ tonnes/wheel}$$

SHEAR :

$$F_s = 1.7 \times 1 \times 1 \times 0.62 \times 1.45 = 1.53 \text{ MPa}$$

$$V_{max} = 1.53 \times 178 \times 127 = 34.5 \text{ kN}$$

≈ 3.5 tonnes/wheel

max wheel load $= 3.5 \frac{1}{1.15} = 3$ tonnes/wheel

⇒ LESS CRITICAL THAN DECK PLANK.

RAPID BAY JETTY	Maunsell
	JOB No. 10998
	BY TL / SHEET No. A 21
	CHECKED / DATE July 97

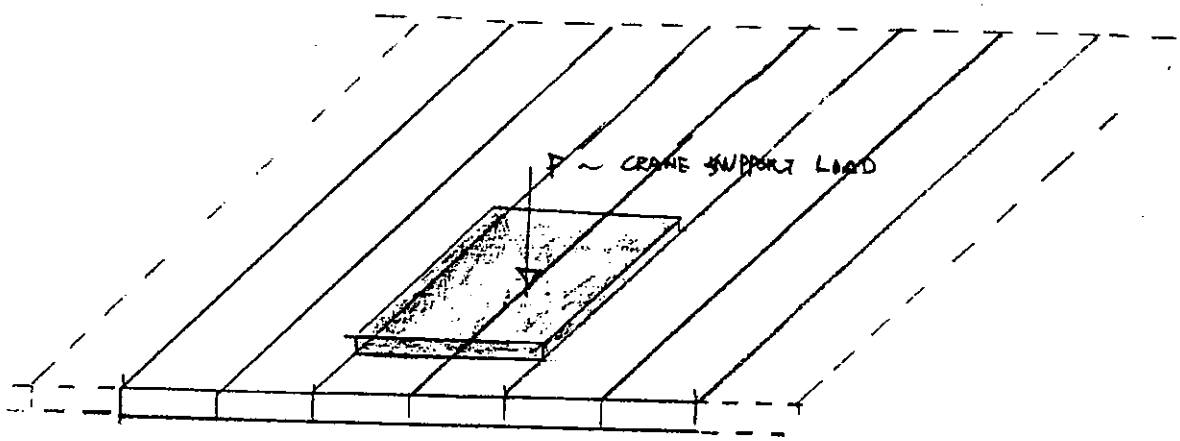
SUMMARY OF PERMISSIBLE WHEEL LOAD FOR SUBSTRATE

	STRUCTURAL MEMBER	PERMISSIBLE WHEEL LOAD (tonnes/wheel)
1.	GIRDER (TFB)	4.5
2.	CROSSHEAD (DOUBLE CHANNEL)	7
3.	DECK (TIMBER PLANK)	2.78
4.	CROSSBEAM (TIMBER)	3

* CRITICAL LOCATION AT BENT 26 - 28 & BENT 31 - 33.

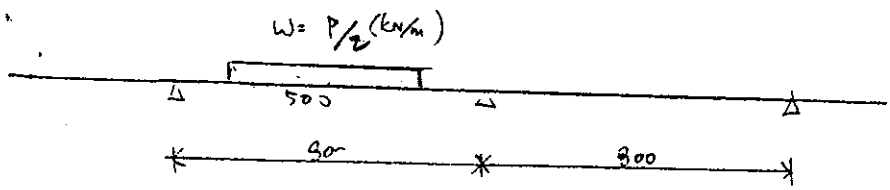
RAPID BAY JETTY	Maunsell	
	JOB No. 10998	
DECK PLANK CHECK - STEEL PAD DESIGN	BY D.L.	SHEET No. A 22
	CHECKED	DATE July '97

IN ORDER TO REDUCE CRANE SUPPORT PRESSURE, STEEL PADS ARE PLACED UNDERNEATH THE SUPPORTS FOR SPREADING LOADS TO LARGER DECK AREAS.



ASSUME THE PAD AREA IS 500 x 500 mm²

FOR 1 PLANK :



$M_{max} = 0.096 \times \frac{P}{2} \times 0.8 \times 0.8 = 0.0307\,P$ (kN-m OR $\times 10^6$ N-mm)

$F_b = 19.7$ mPa

F.O.S = 1.15

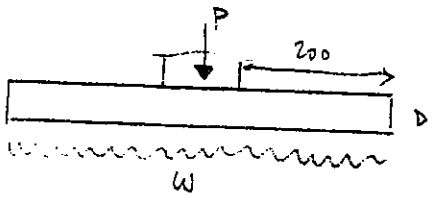
$\Rightarrow F_b = 17.13$ mPa

$\sigma = \frac{M}{Z} \Rightarrow 17.13 = \frac{0.0307 \times P \times 6 \times 10^6}{250 \times 75^2}$

$\Rightarrow P = 130.7$ kN

≈ 13.3 tonne.

RAPID BAY JETTY	Maunsell	
	JOB No. 10998	
DECK PLANK - STEEL PAD DESIGN	BY D.L.	SHEET No. A 23
	CHECKED	DATE July '97



$$w = 130.7 / 0.5 \times 0.5 = 522.8 \text{ kPa}$$

$$w^* \approx 784.2 \text{ kPa}$$

$$M^* = 522.8 \times 0.5 \times 0.2 \times \frac{0.2}{2} \doteqdot 5.3 \text{ kN-m}.$$

$$\sigma = \frac{M}{Z}$$

$$280 \text{ mPa} = \frac{5.3 \times 10^6 \text{ N-mm}}{Z}$$

$$Z = 18929 \text{ mm}^3 = \frac{BD^2}{6}.$$

$$\Rightarrow D_{min} = \sqrt{\frac{18929 \times 6}{500}}$$

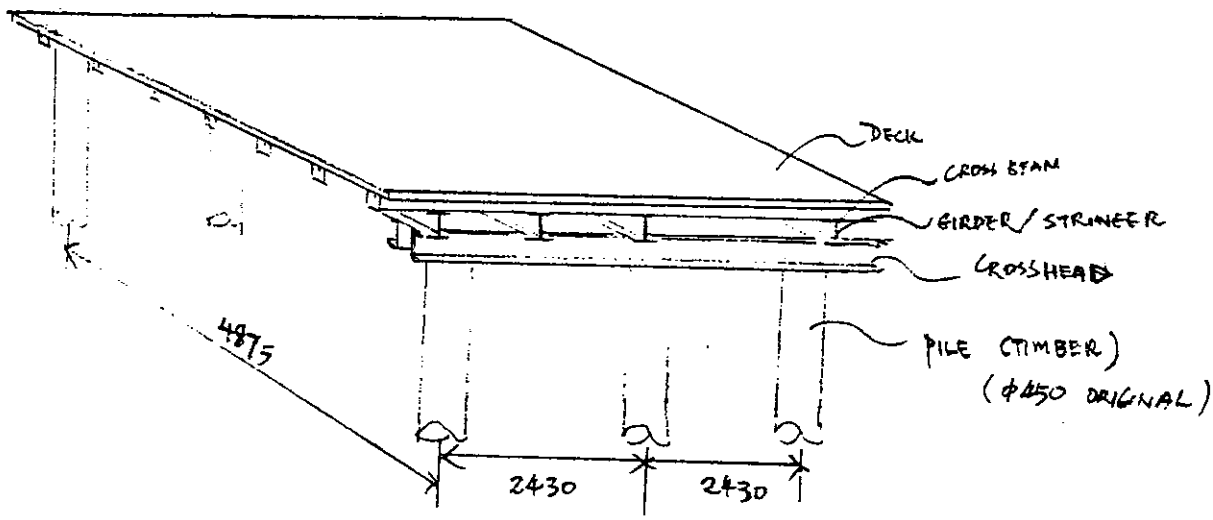
$$= 15 \text{ mm}$$

$\therefore$ CHOOSE $D = 20$ mm.

$\therefore$ PAD : 500 × 500 × 20 thk

P allow depends on the point of application.
(PLANK IS NOT CRITICAL)

KAPID BAY JETTY	Maunsell	
	JOB No. 10998	
TIMBER PILE CHECK	BY DL	SHEET No. A. 24
	CHECKED	DATE July 97



FOR BENTS 1-7, the timber piles are generally in good conditions. From BENT 8 onwards, timber piles are subjected to different degrees of corrosion / degeneration with steel piles replacing timber piles from Bent 8-26 which are non-functional due to their poor conditions. Additional steel piles are located at every fifth bent from bent 28 to Jetty head where the Platform and Motor Room is supported by steel I section piles.

Critical locations shall be at the timber piles without steel pile supporting.

RAPID BAY JETTY	Maunsel	
	JOB No. 10998	
TIMBER PILE CHECK	BY D.L.	SHEET No. A 25
	CHECKED	DATE July '97.

AT Bents 29 - 31, the remaining timber pile diameter is about 200 mm just above sea level.

Original diameter = 450 mm.

$$\% \text{ of area remaing} = \frac{100^2}{225^2} \times 100\,\%$$

$$= 20\,\%$$

DL : $(\overset{\text{DECK}}{0.75\ kPa} + \overset{\text{CROSS BEAM}}{0.33\ kPa} + \overset{\text{GIRDER}}{0.5 \times 4 / 6.47}) \times 4.88 \times 2.44 + \overset{\text{CROSSHEAD}}{1.25 \times 2.44}$

$= 16.54 + 0.61 = 17.15\ kN$

LL : P_w due to wheel load

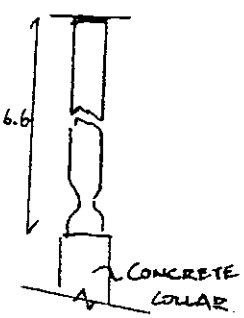
<u>For t = 450 mm</u>

$F_c = k_1 k_2 k_4 k_7 k_6 k_8 k_{12} F_c'$ (Hard wood from SA → F11)

where $\begin{cases} \rho = 1.22 \\ g_{13} = 1.0 \ ; \quad l = 6.6 \end{cases}$ $\Rightarrow S = \frac{1 \times 6.6}{0.45} = 14.7$

$\Rightarrow \rho S = 17.9$

$k_{12} = 1.5 - 0.05 \rho S = 0.605$



$\therefore F_c = 1.7 \times 1 \times 1 \times 1 \times 1 \times 1 \times 0.605 \times 8.4 = 8.64\ MPa$

$F_c = P_{all} / A_e \Rightarrow P_{all} = 8.64 \frac{N}{mm^2} \times \pi\, 225^2\, mm^2 = 1375\ kN$

$= 140$ tonnes/piles

RAPID BAY JETTY	Maunsell	
	JOB No. 10998.	
TIMBER PILE CHECK	BY DL	SHEET No. A 26
	CHECKED	DATE July '97

FOR BENTS 29 - 31 , $\phi = 200mm$

$$S = \frac{1.0 \times 6.6}{0.2} = 33$$

$$\rho S = 1.22 \times 33 = 40.26$$

$$k_{12} = 200/(\rho S)^2 = 0.123$$

$$F_c = 1.7 \times 0.123 \times 8.4 = 1.76 \text{ MPa}$$

$$P_{all} = 1.76 \times \pi\, 100^2 = 55.3 \text{ kN}$$

$$\therefore P_{all} = DL + LL$$

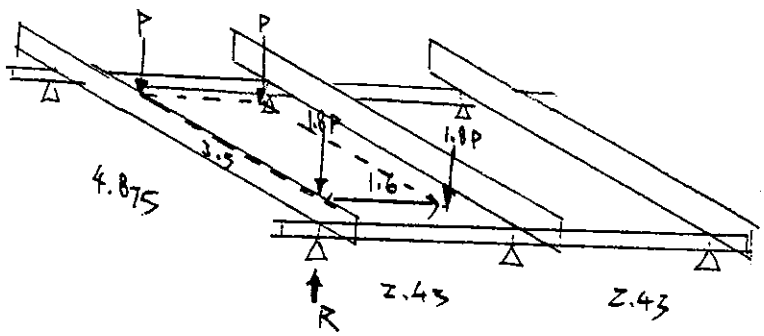
$$P_{LL} = 55.3 - 17.15 = 38.15 \text{ kN}$$

$$= 3.9 \text{ tonnes}$$

USING FACTOR OF SAFETY OF 1.15

ALLOWABLE LOAD = 3.38 tonnes

RAPID BAY JETTY	**Maunsell**	
	JOB No. 10998	
TIMBER PILE CHECK	BY DL	SHEET No. A27
	CHECKED	DATE July '97



$$R = 1.8P + 1.8P \times \frac{0.83}{2.43} + \left(P + P\frac{0.83}{2.43}\right)\left(\frac{1.375}{4.875}\right)$$

$$= P\,(2.793)$$

$$\Rightarrow \quad R = 3.38 \text{ tonnes} = P\,(2.793)$$

$$P = 1.21 \text{ tonnes}$$

$\therefore$ MAX WHEEL LOAD $= 1.8P$

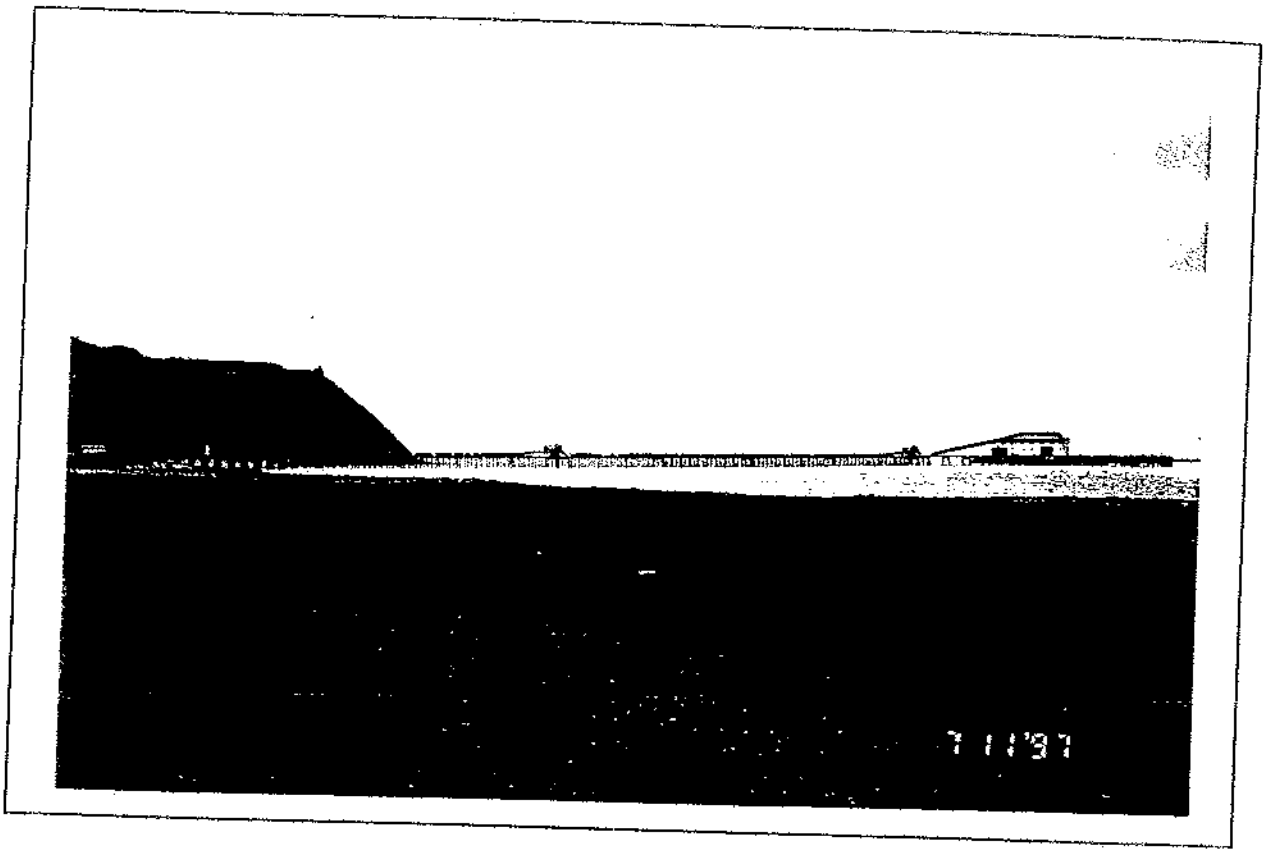
$= 2.2$ tonnes/wheel

Appendix B

Photographs

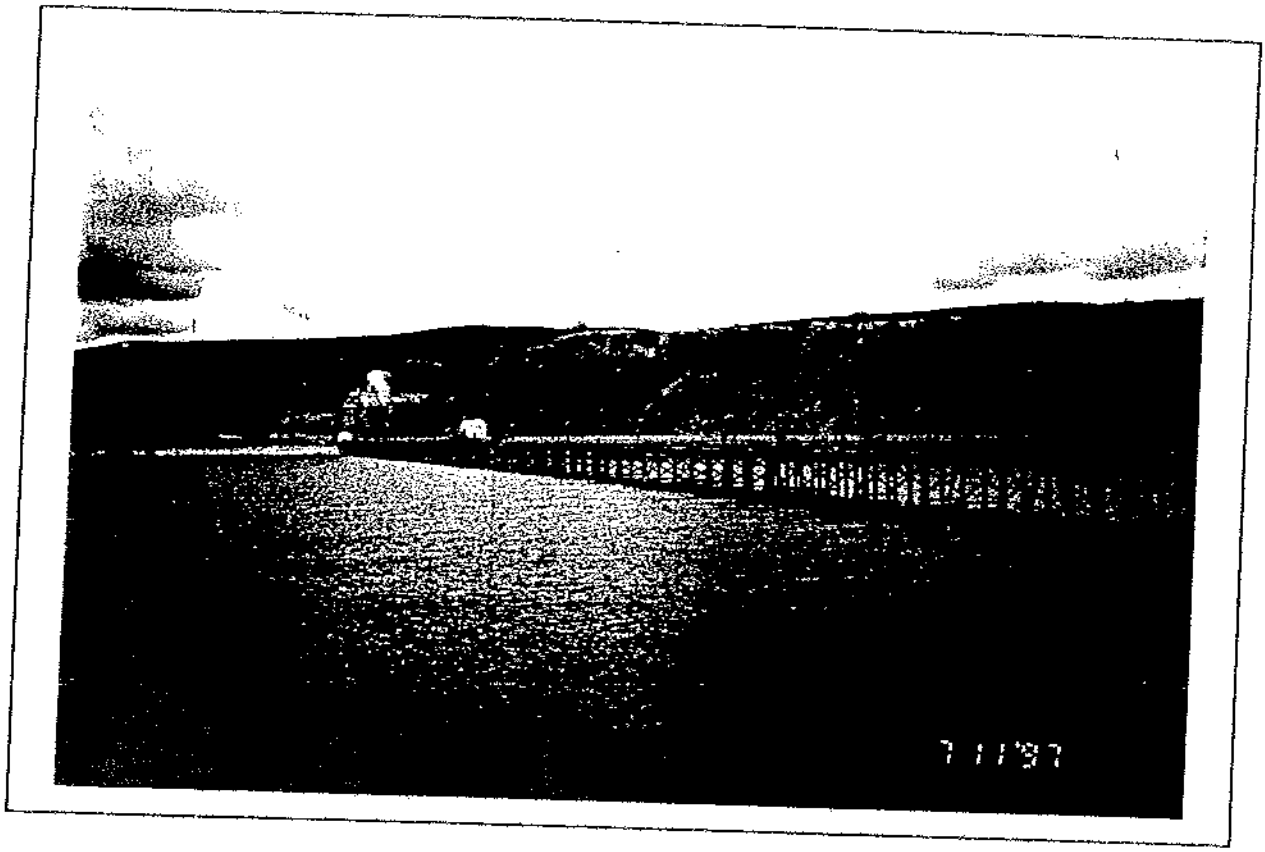
APPENDIX B

PHOTOGRAPHS

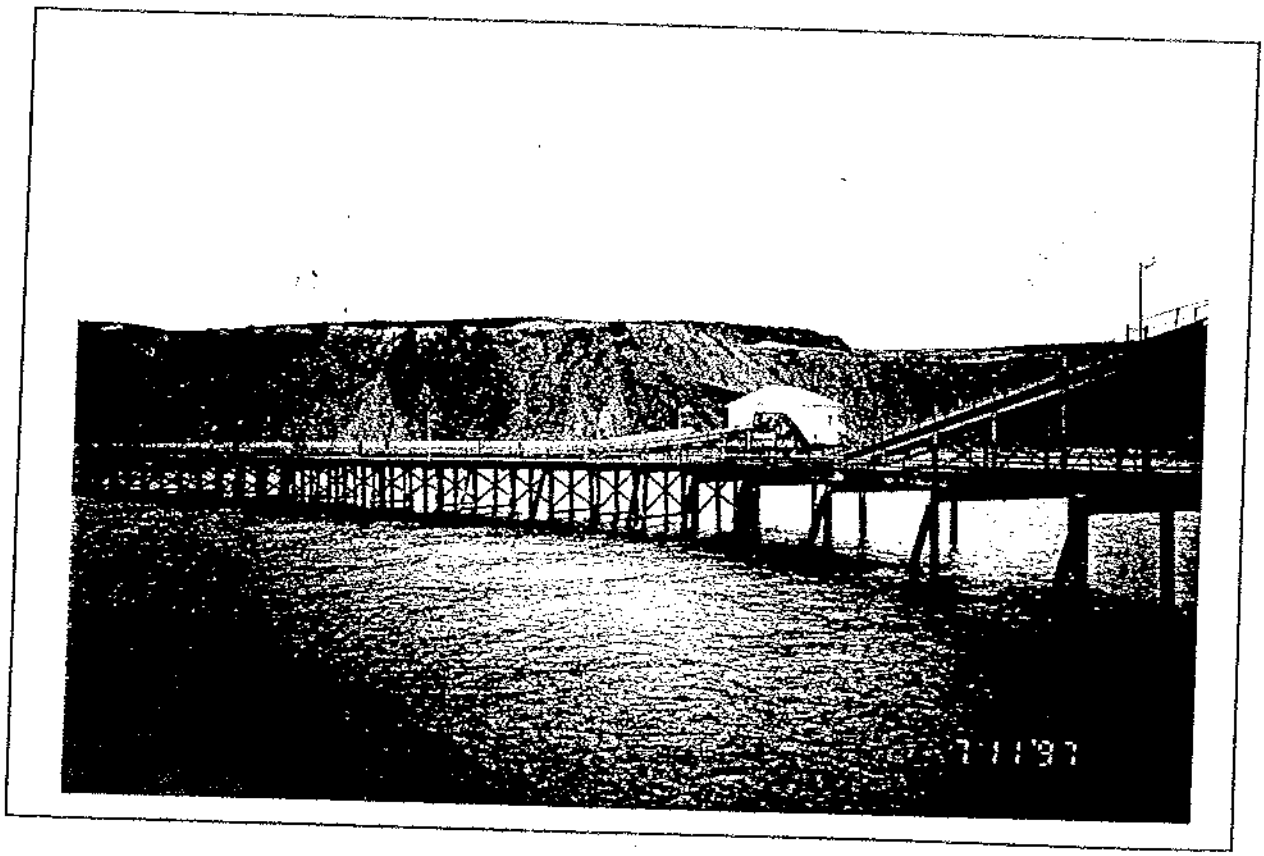


1. View from shore

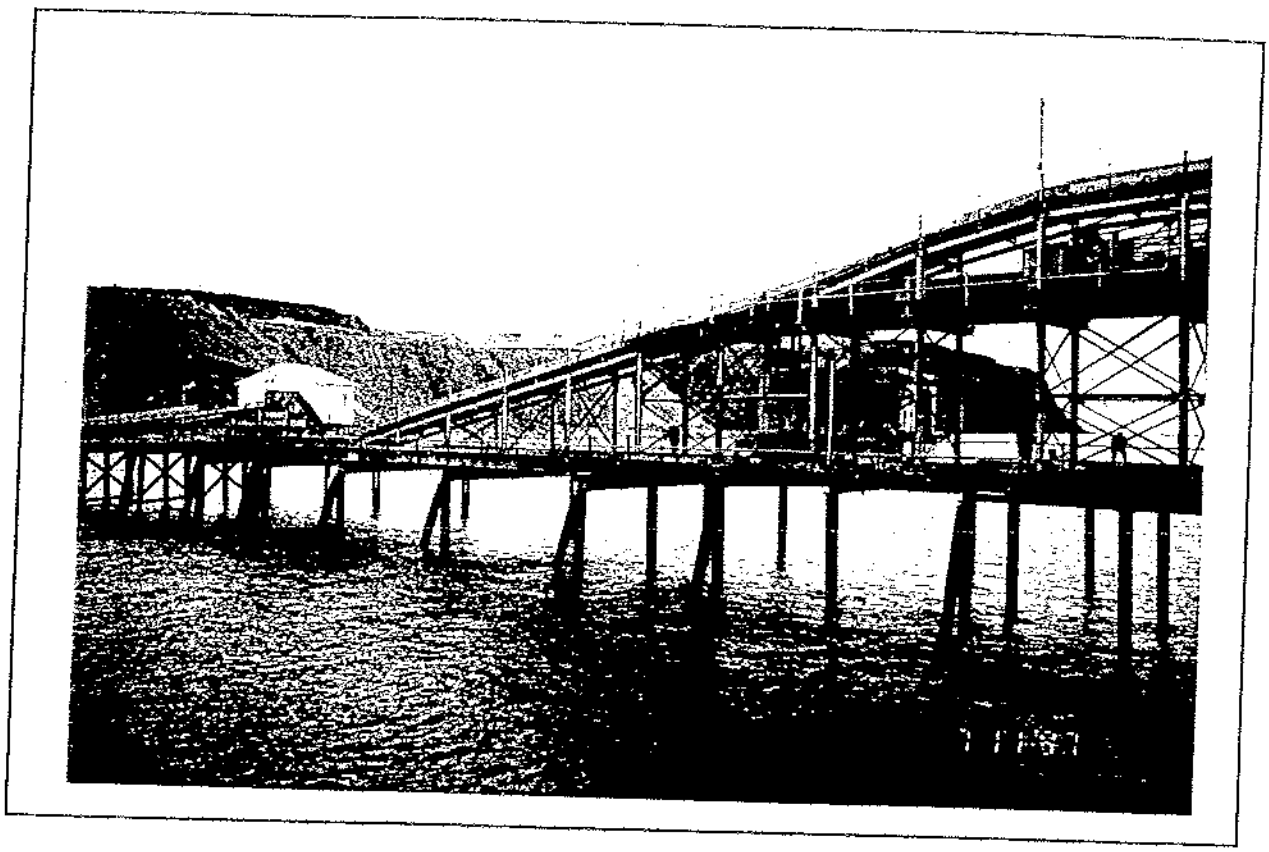
2. View from shore



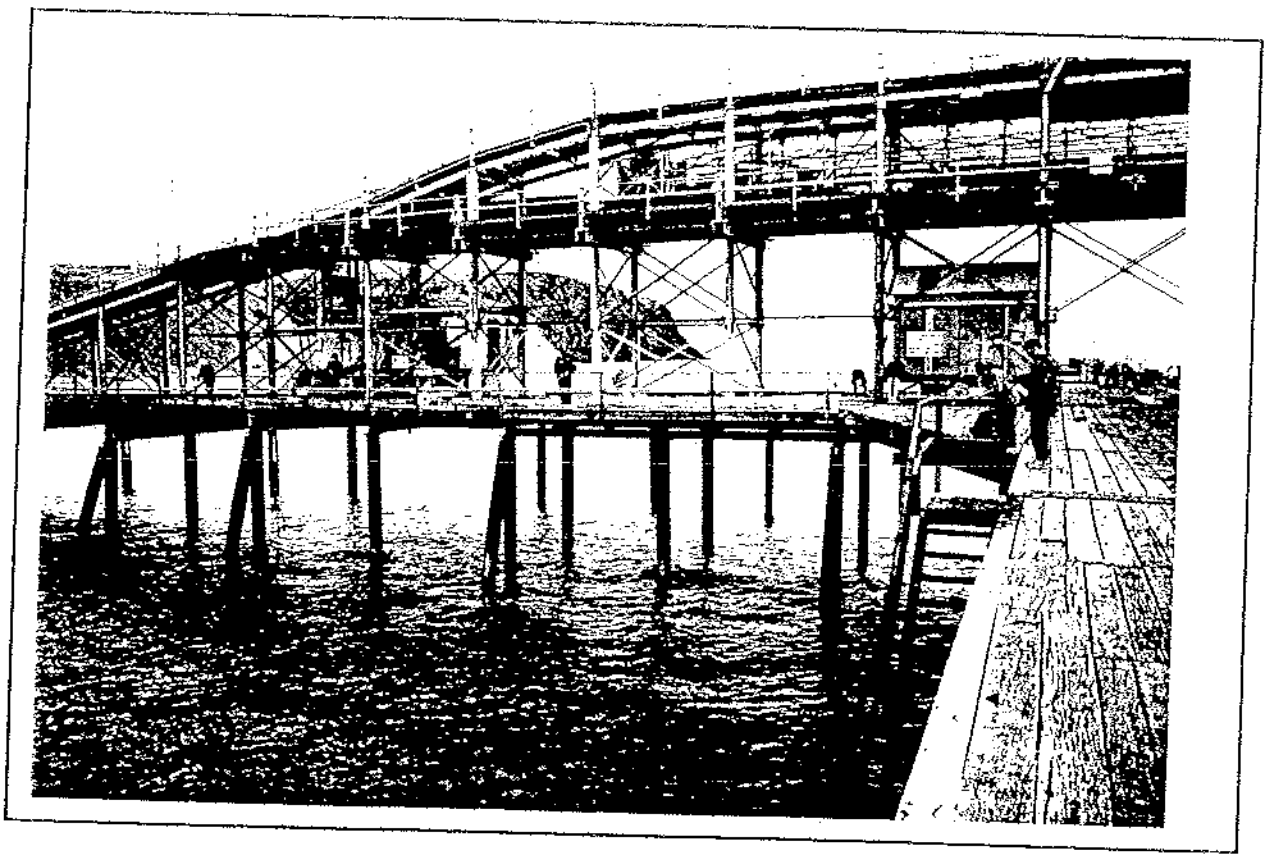
3. View from loading head - inner section



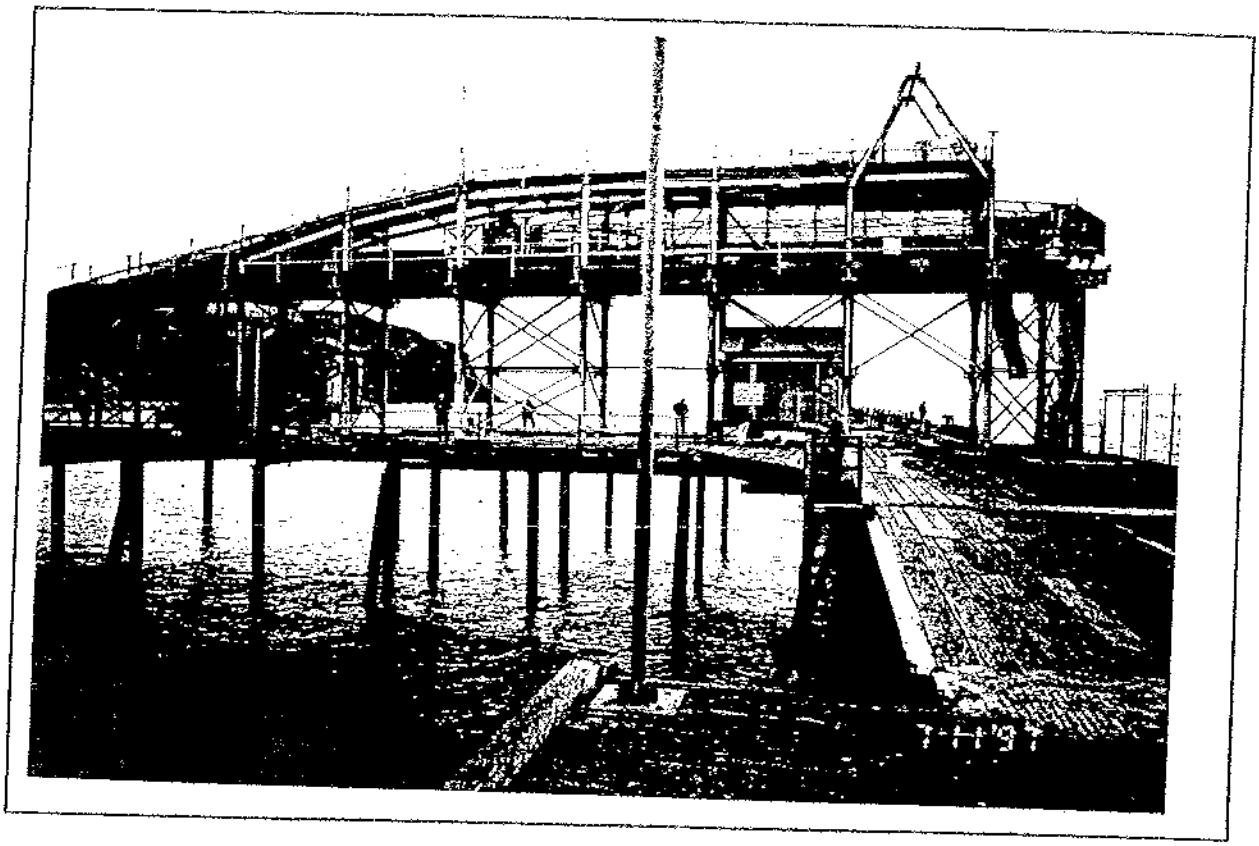
4. View from loading head - outer section



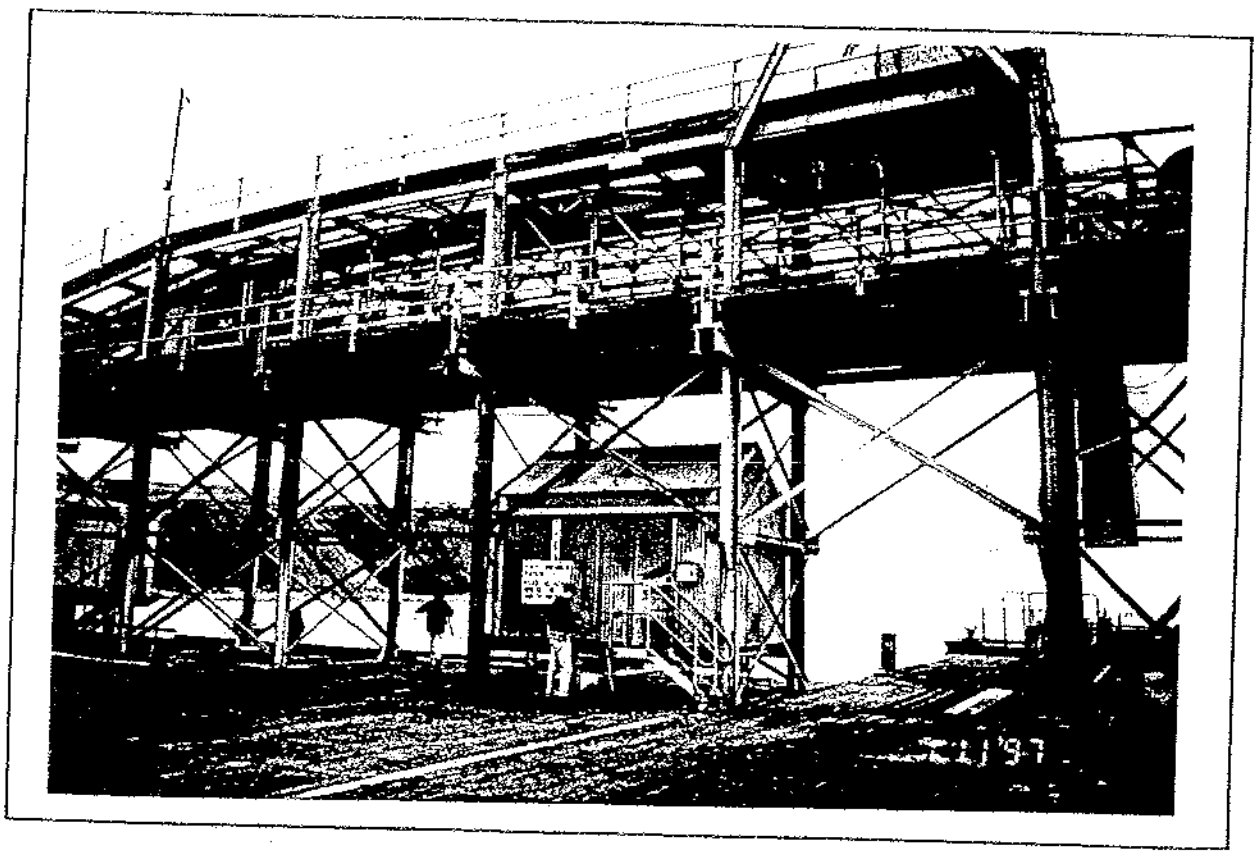
5. Motor room 2 and inner end of loader



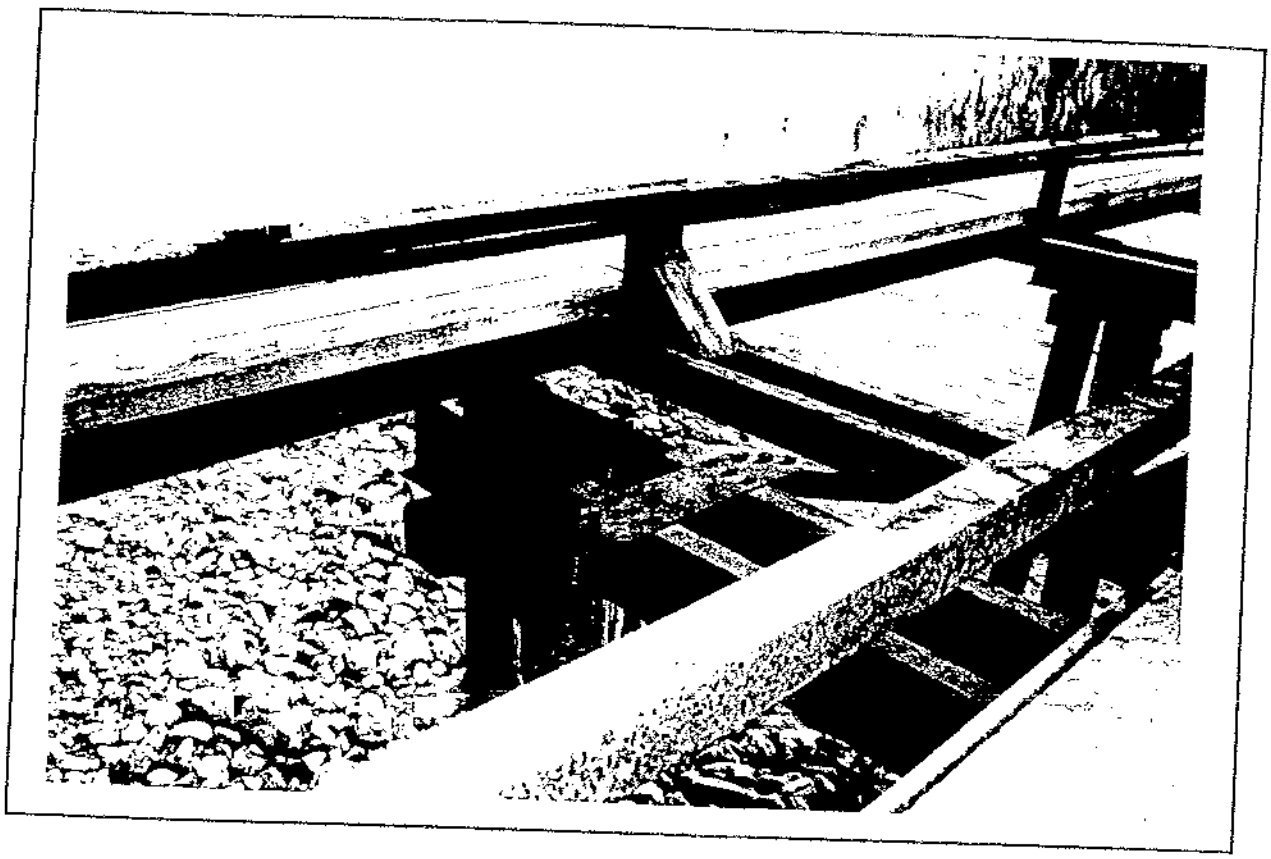
6. Loader and steel piles at jetty head



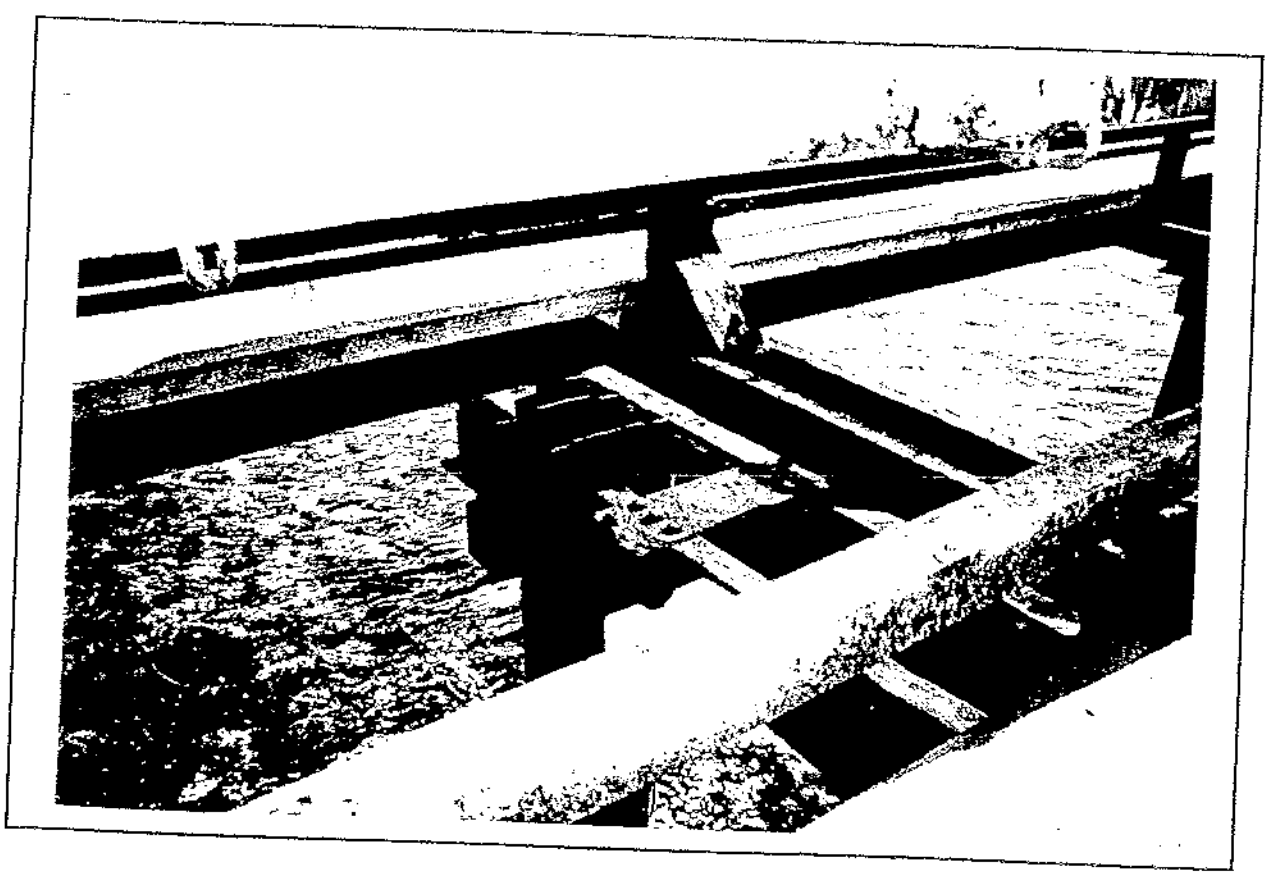
7. Tee head and loader



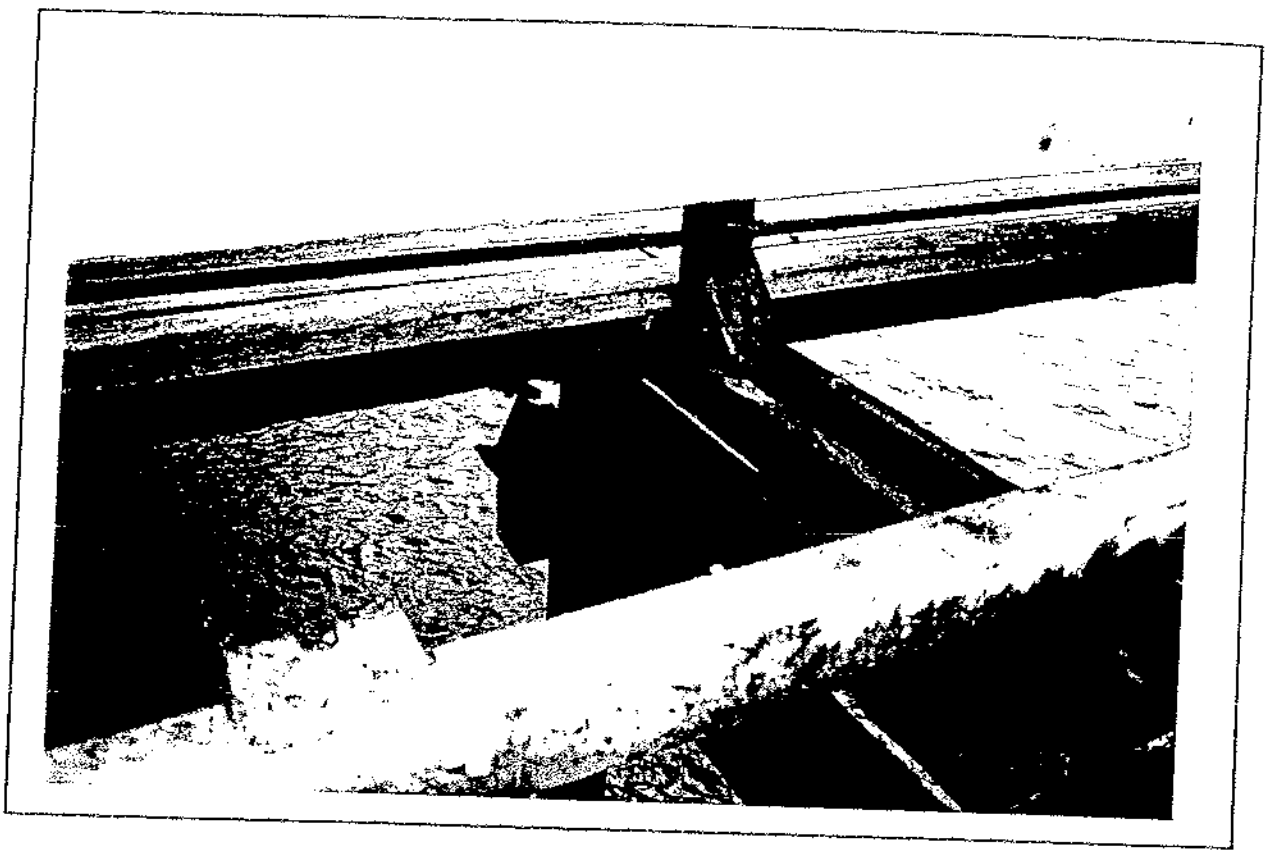
8. Jetty head and loader



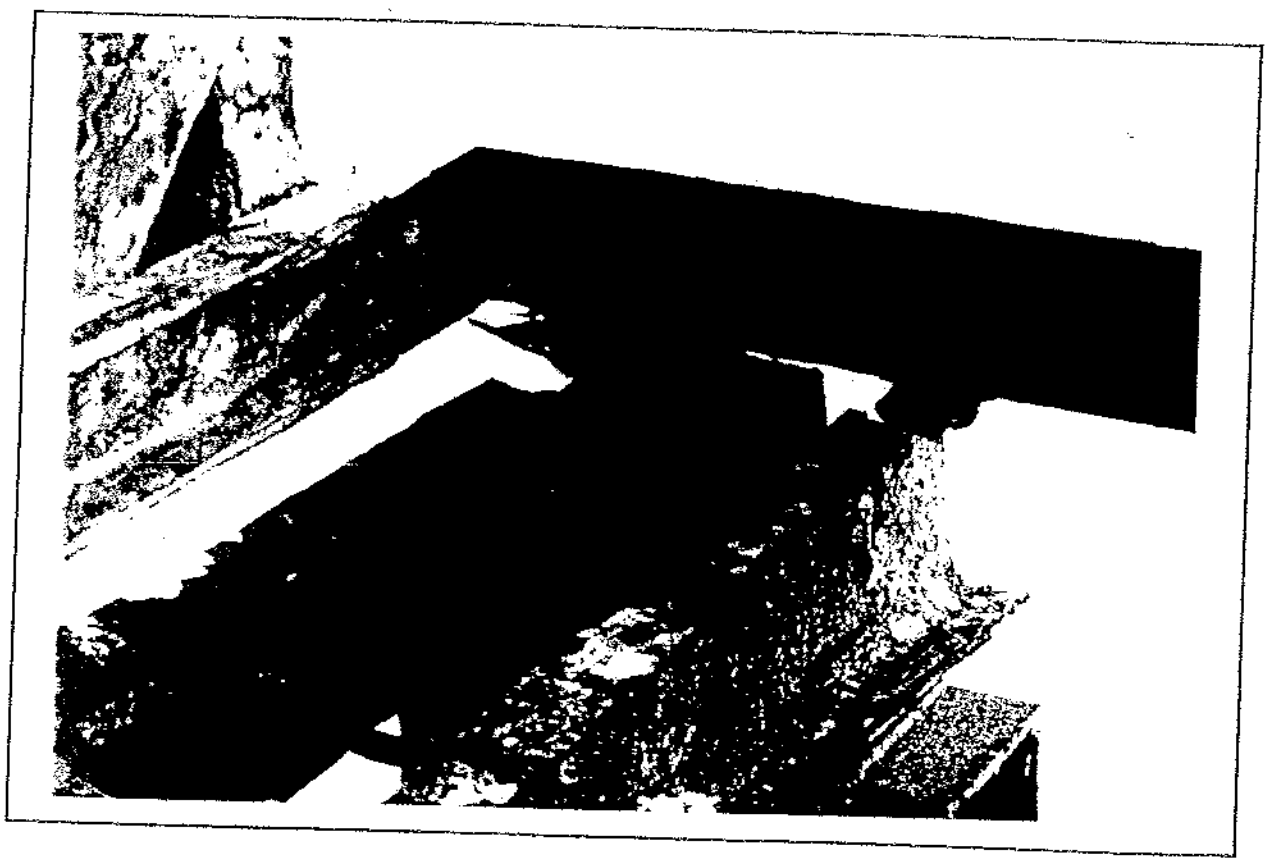
9. Crosshead Bent 9



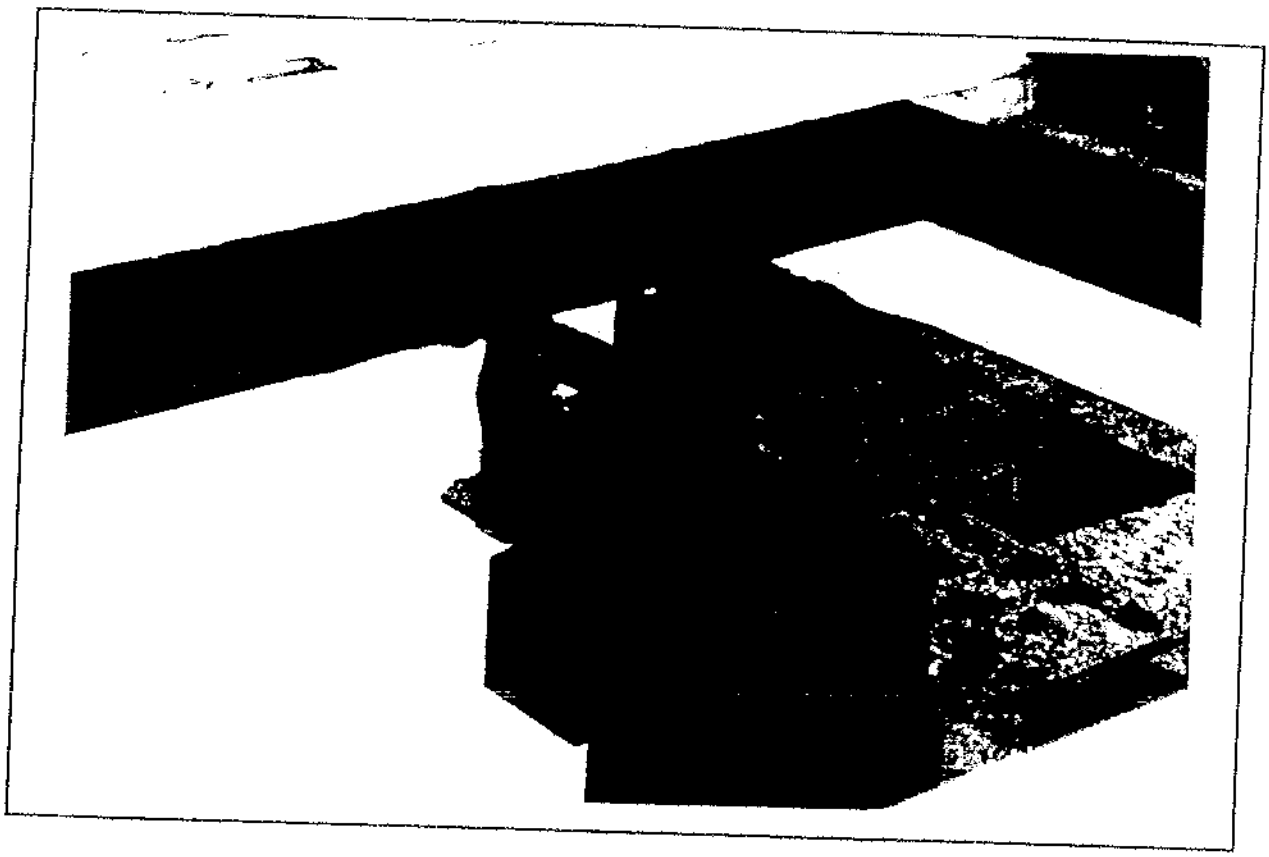
10. Crosshead Bent 12



11. Crosshead Bent 17

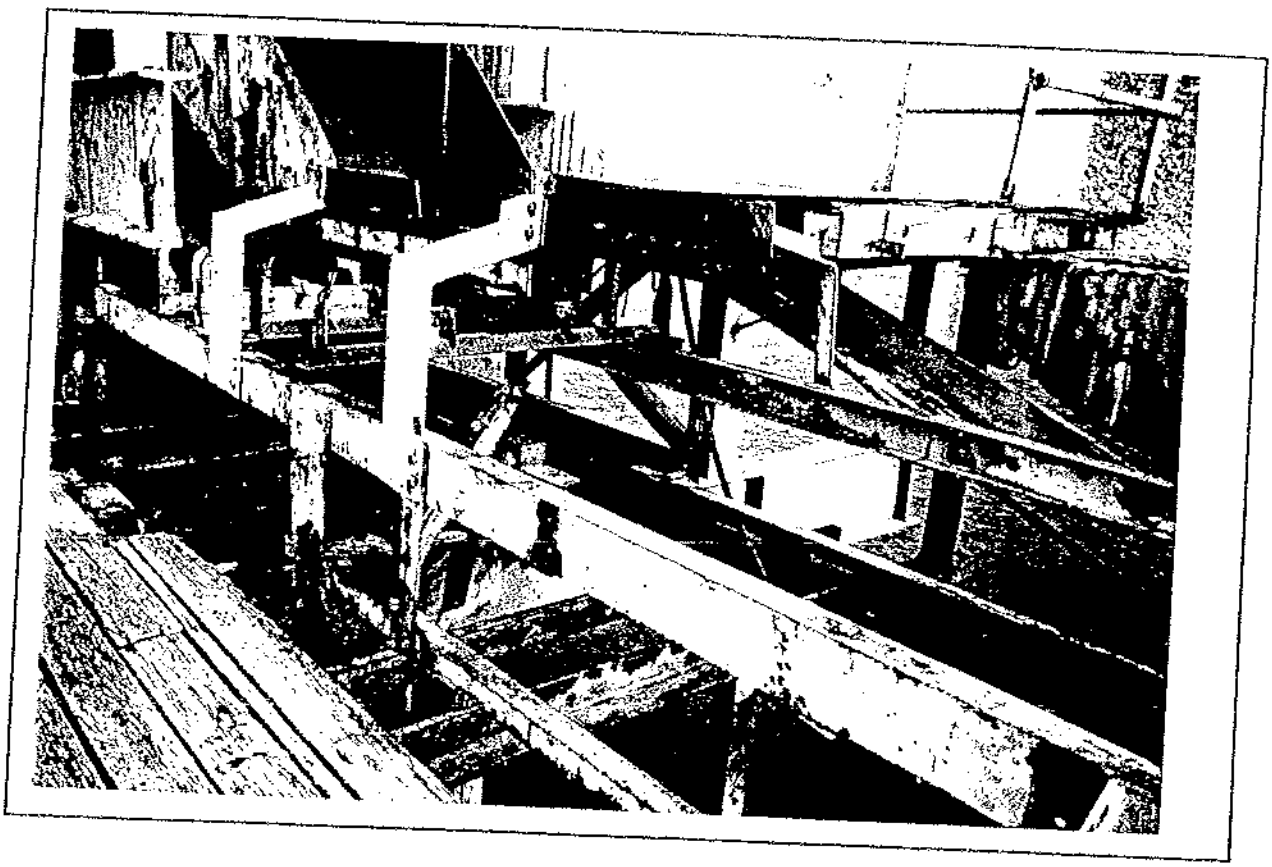


12. Crosshead Bent 17

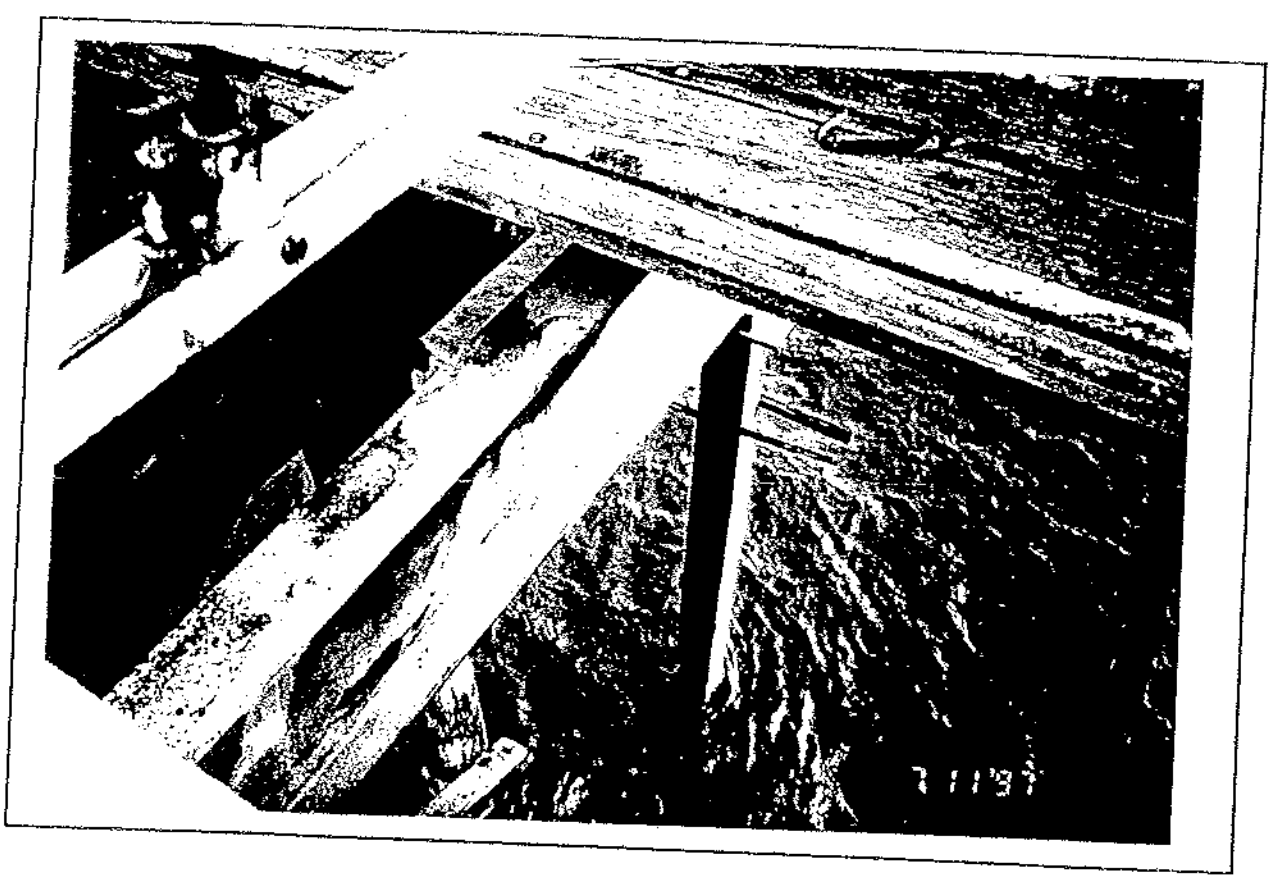


13. Crosshead Bent 19

14. Pile at Bent 27



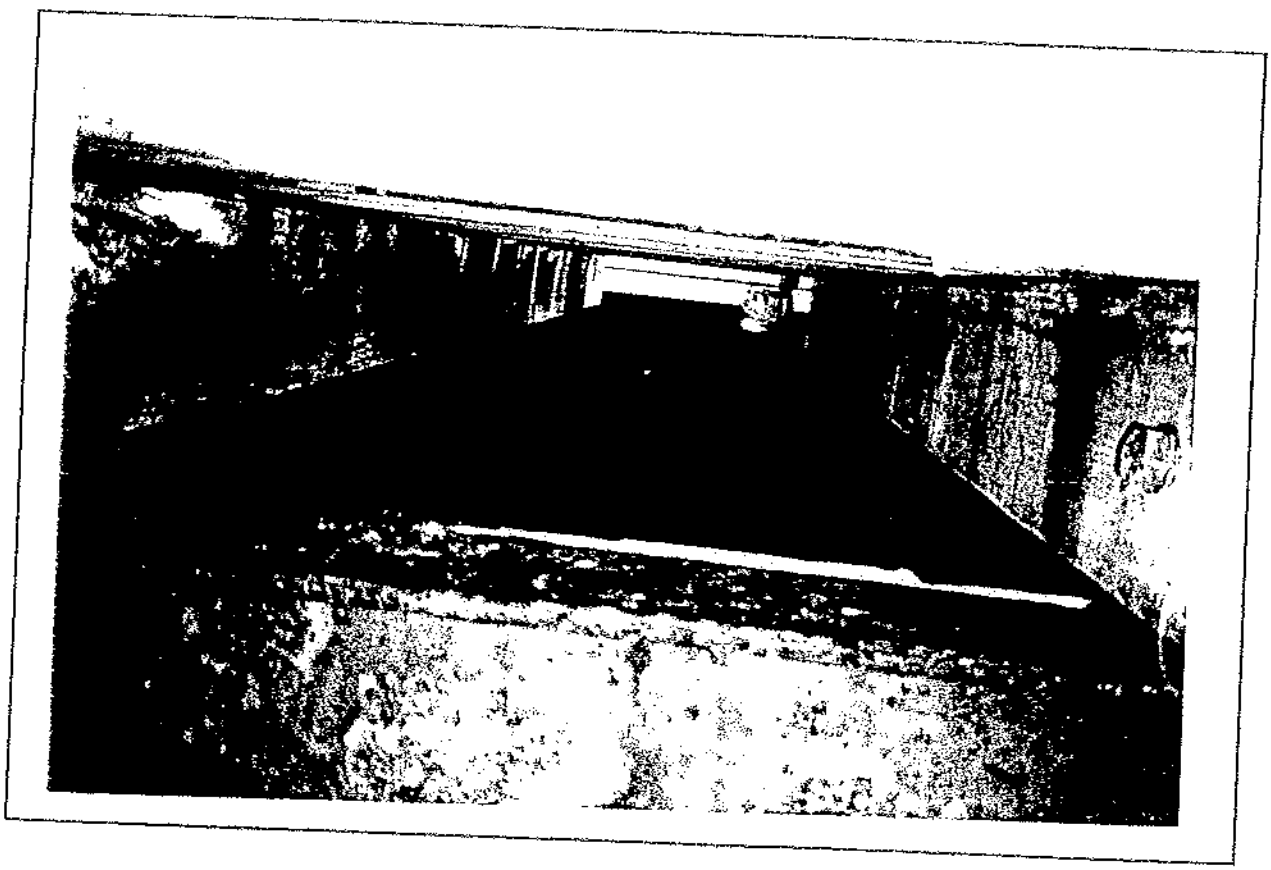
15. Steel piles at crosshead at Bent 38



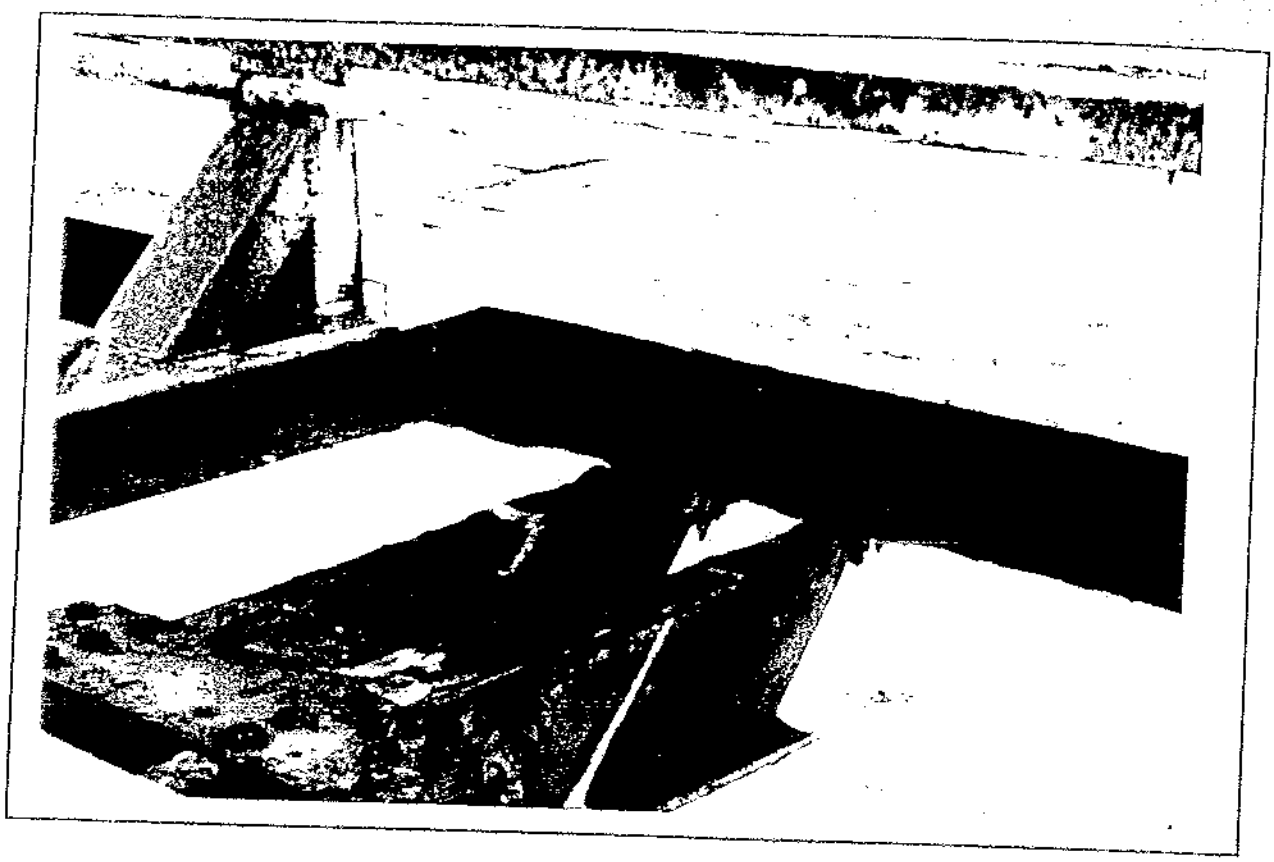
16. Steel piles at crosshead at Bent 48

17. Steel pile at Bent 70

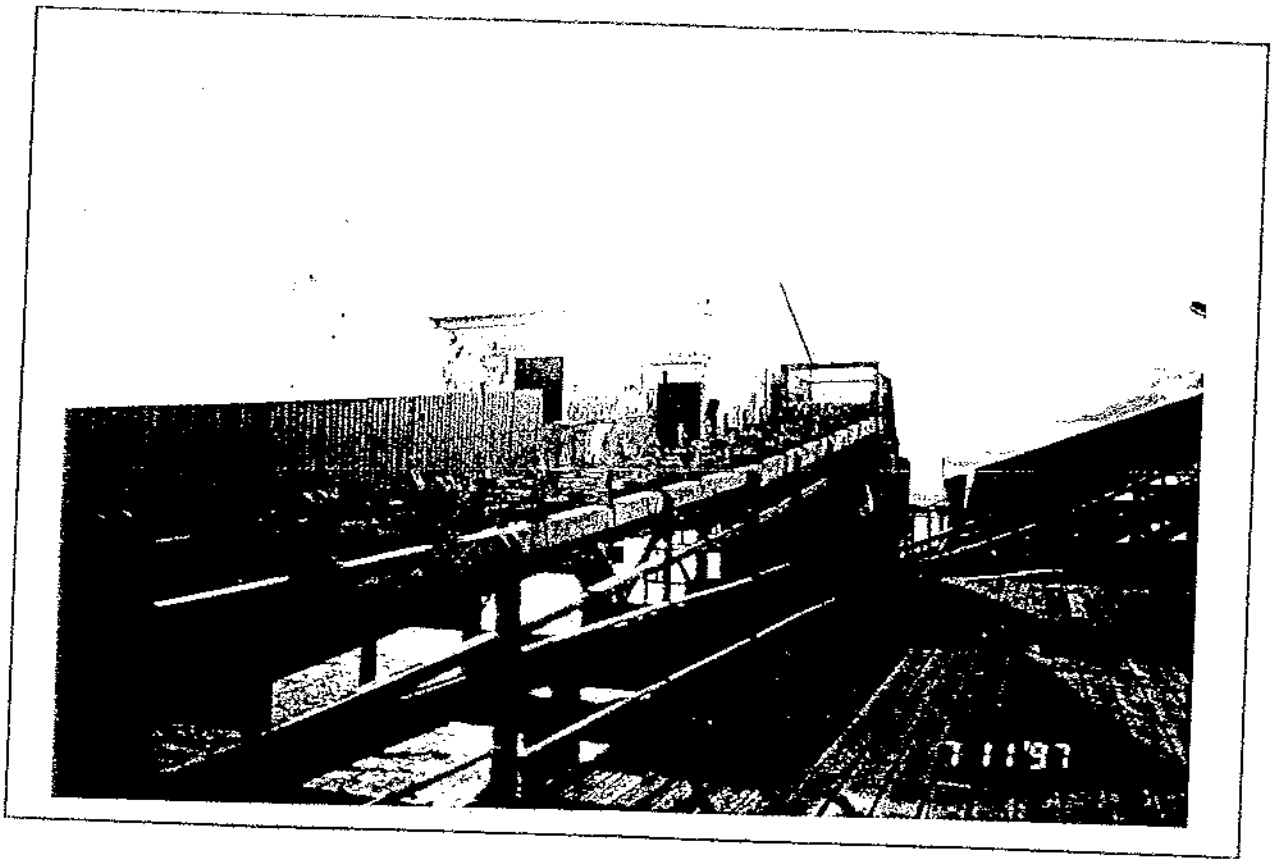
18. Stringers between Bents 73 and 74



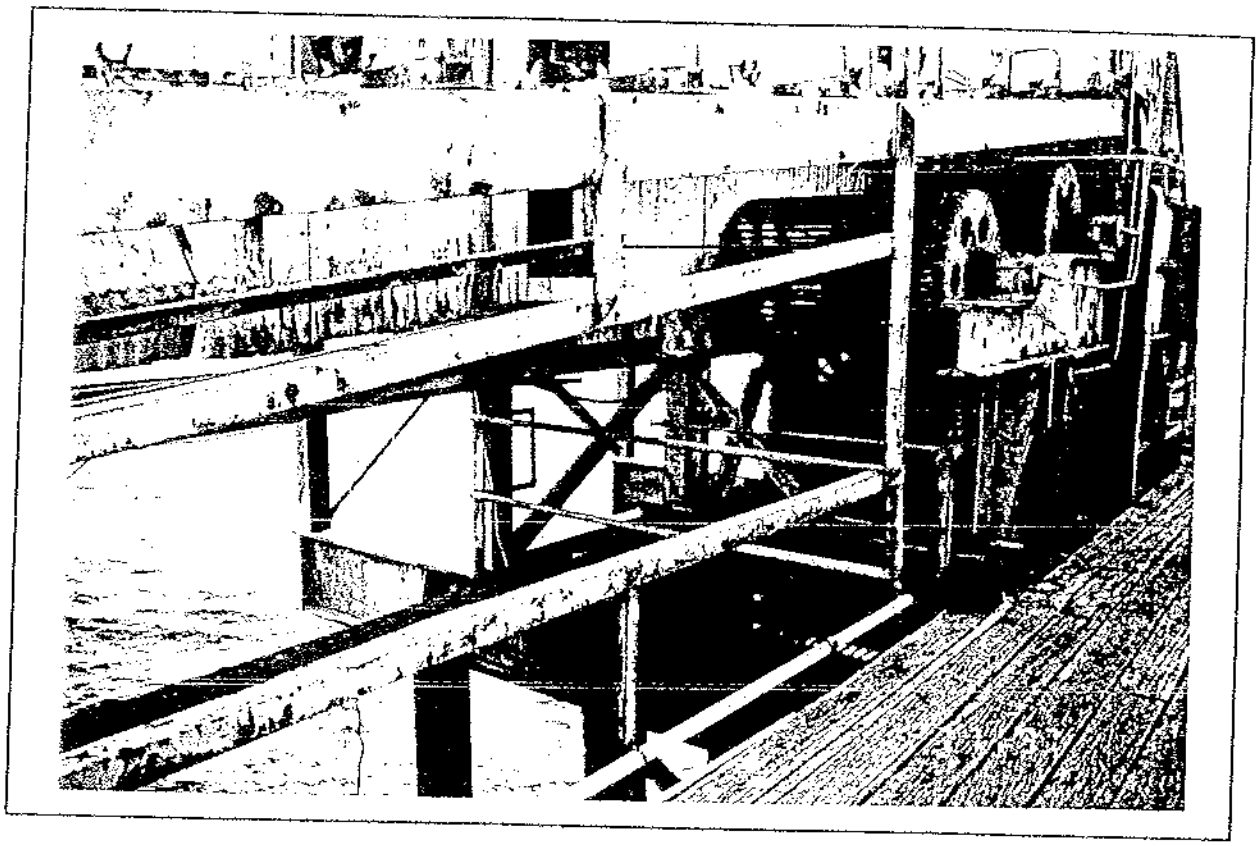
19. Stringer and bearers between Bents 73 and 74



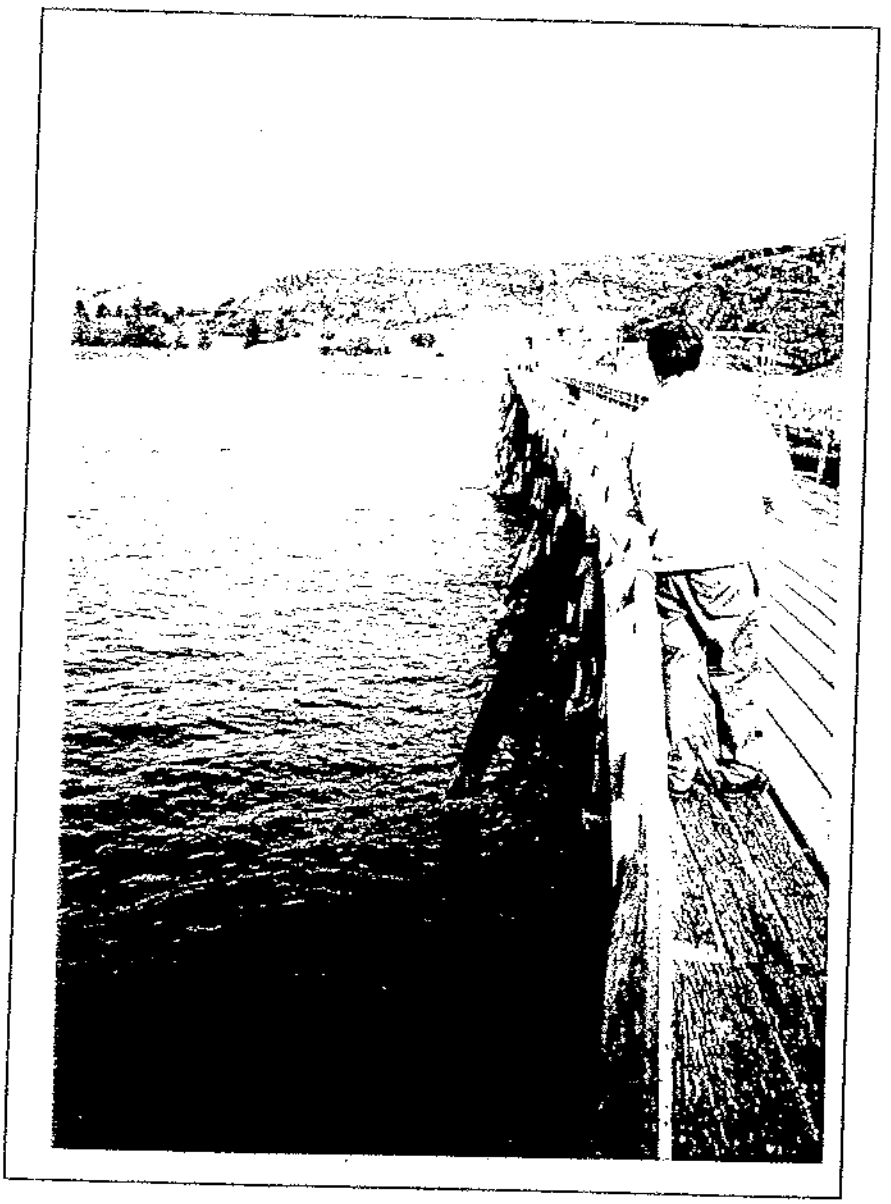
20. Girder 4 at Bent 73



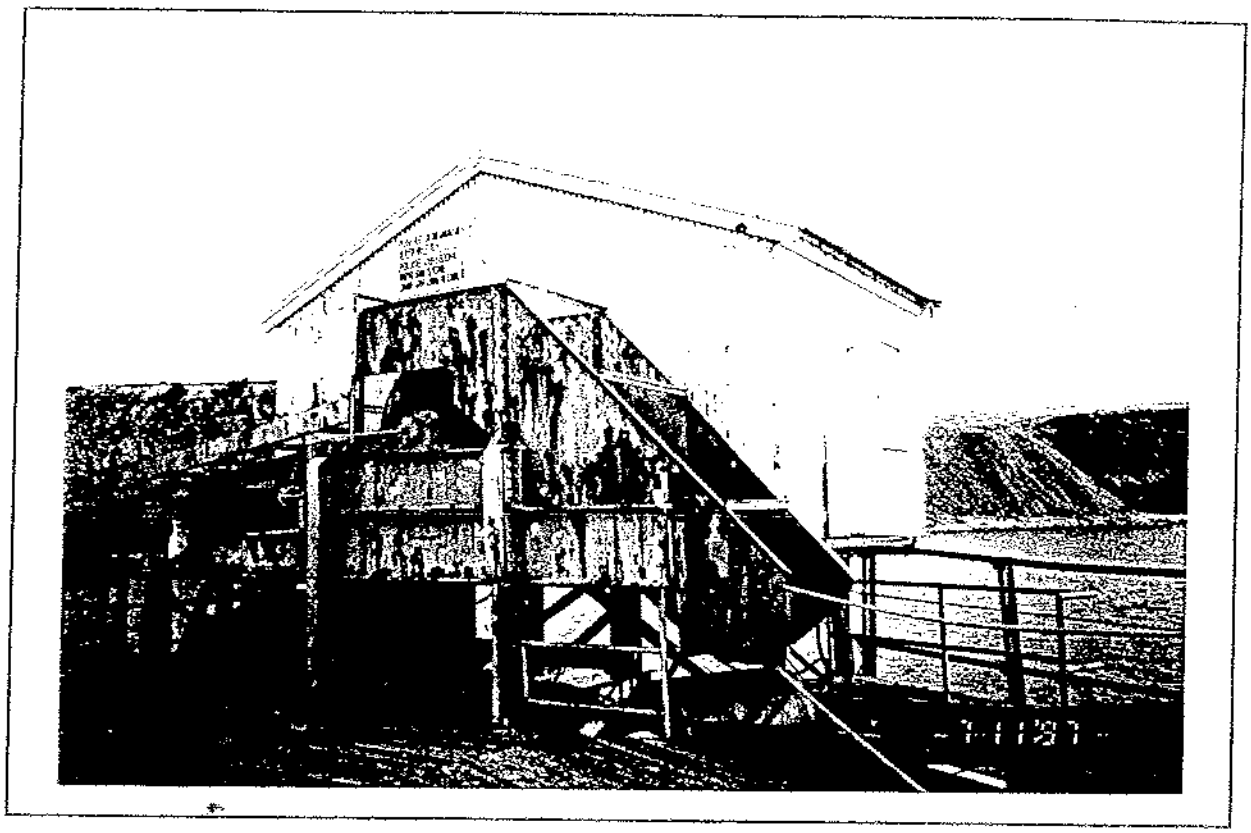
21. Motor Room No. 3



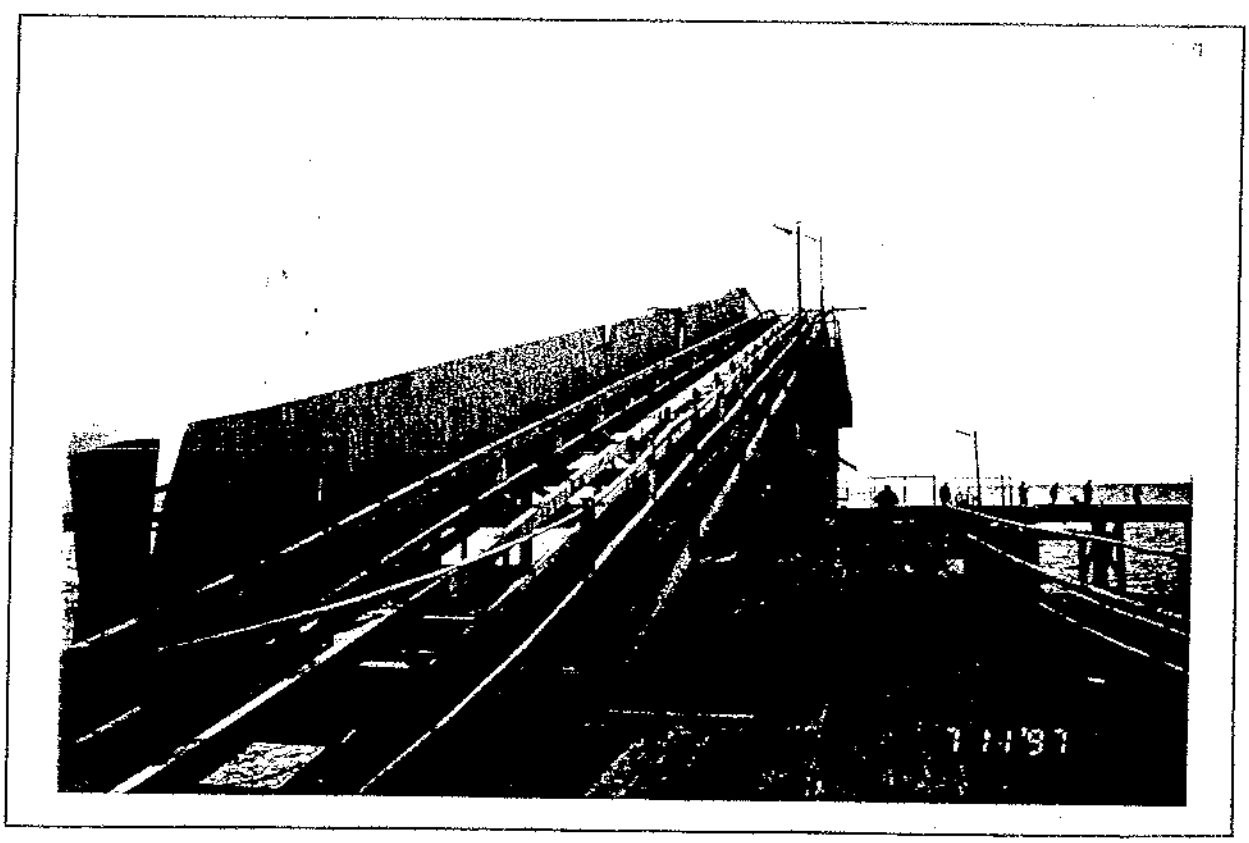
22. Steel piles and crossheads at Bent 79 and 80



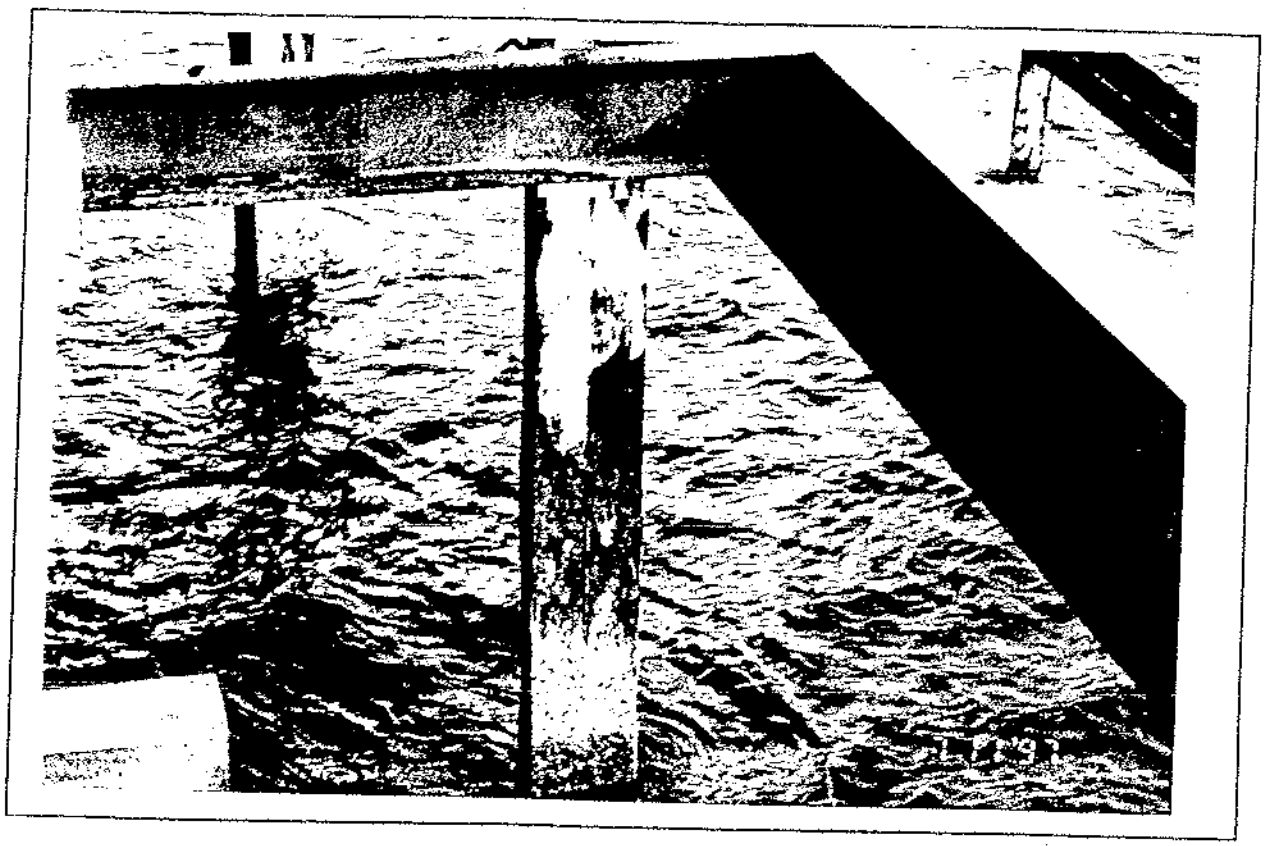
23. Raking steel pile at Bent 76



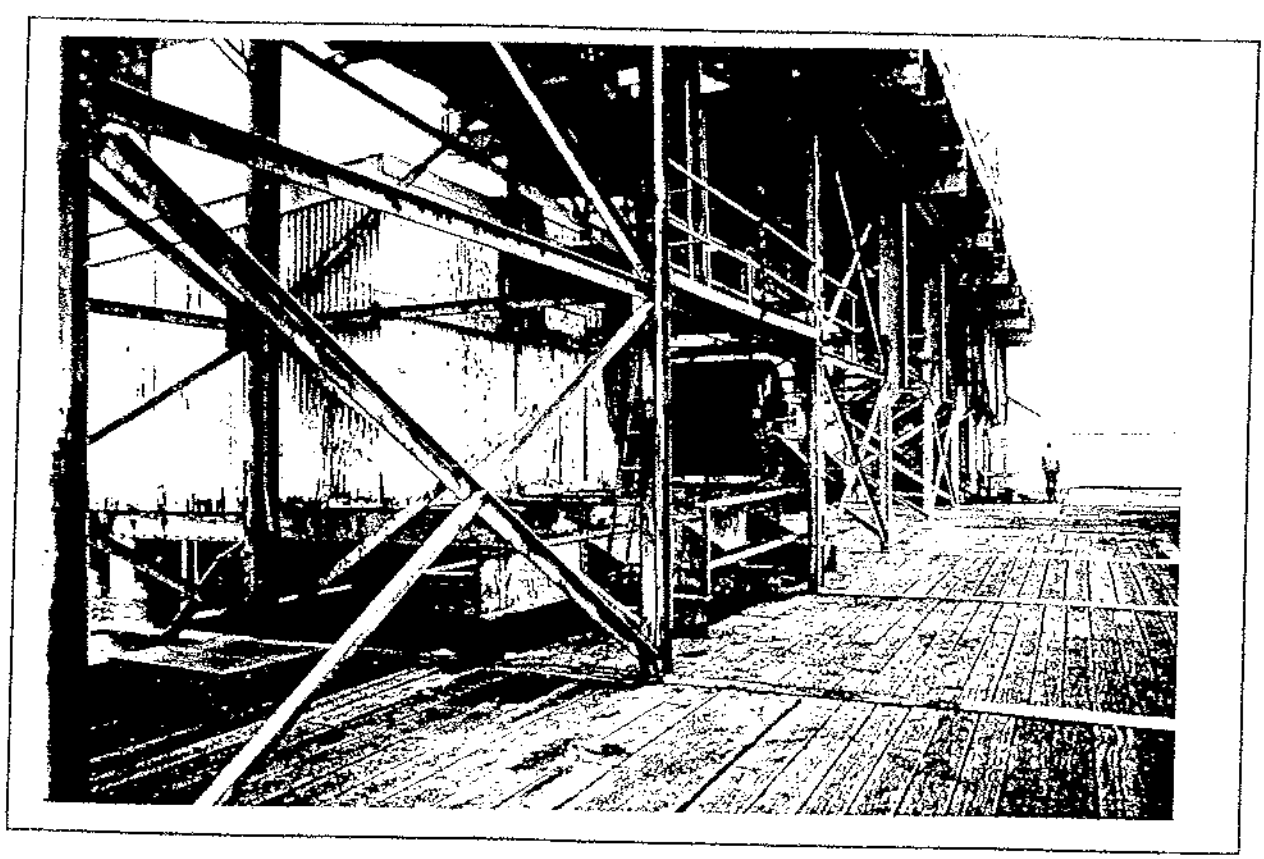
24. Motor Room No. 3



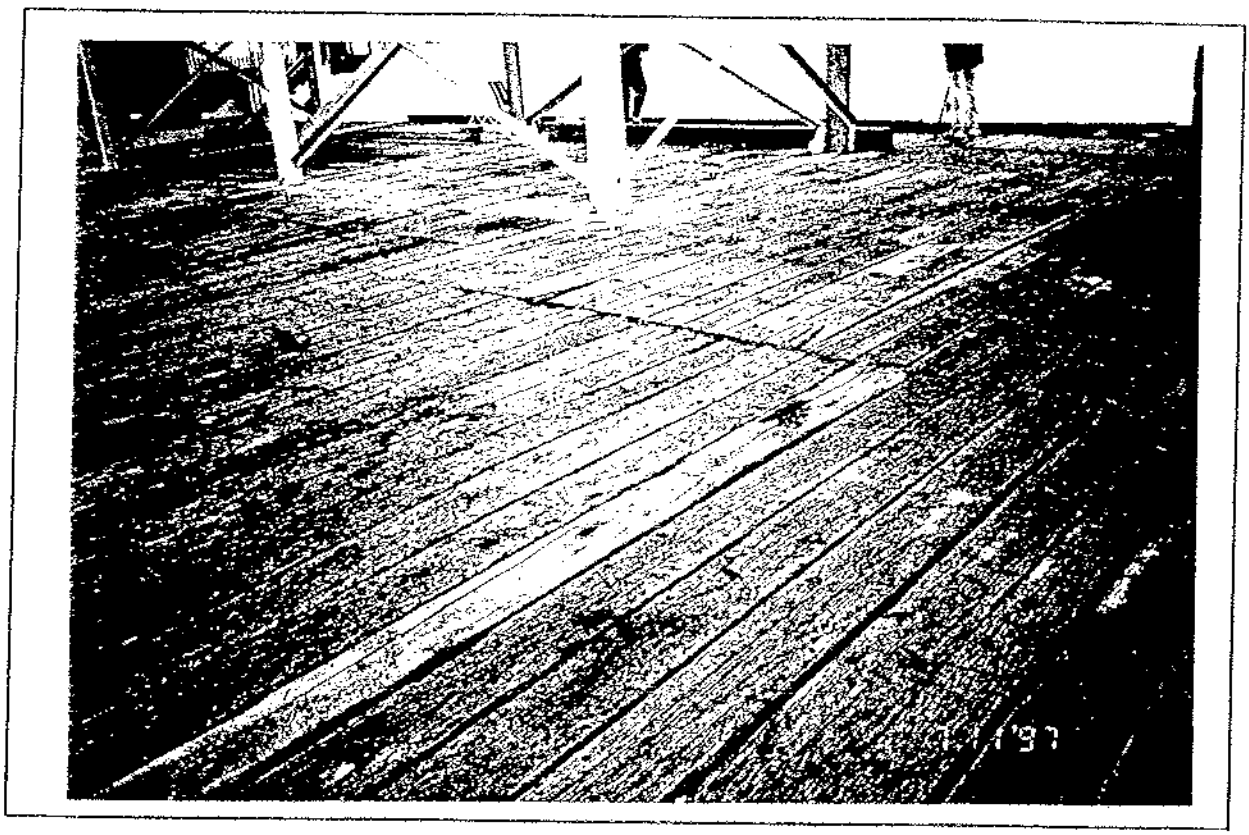
25. Jetty head platform at Tee head



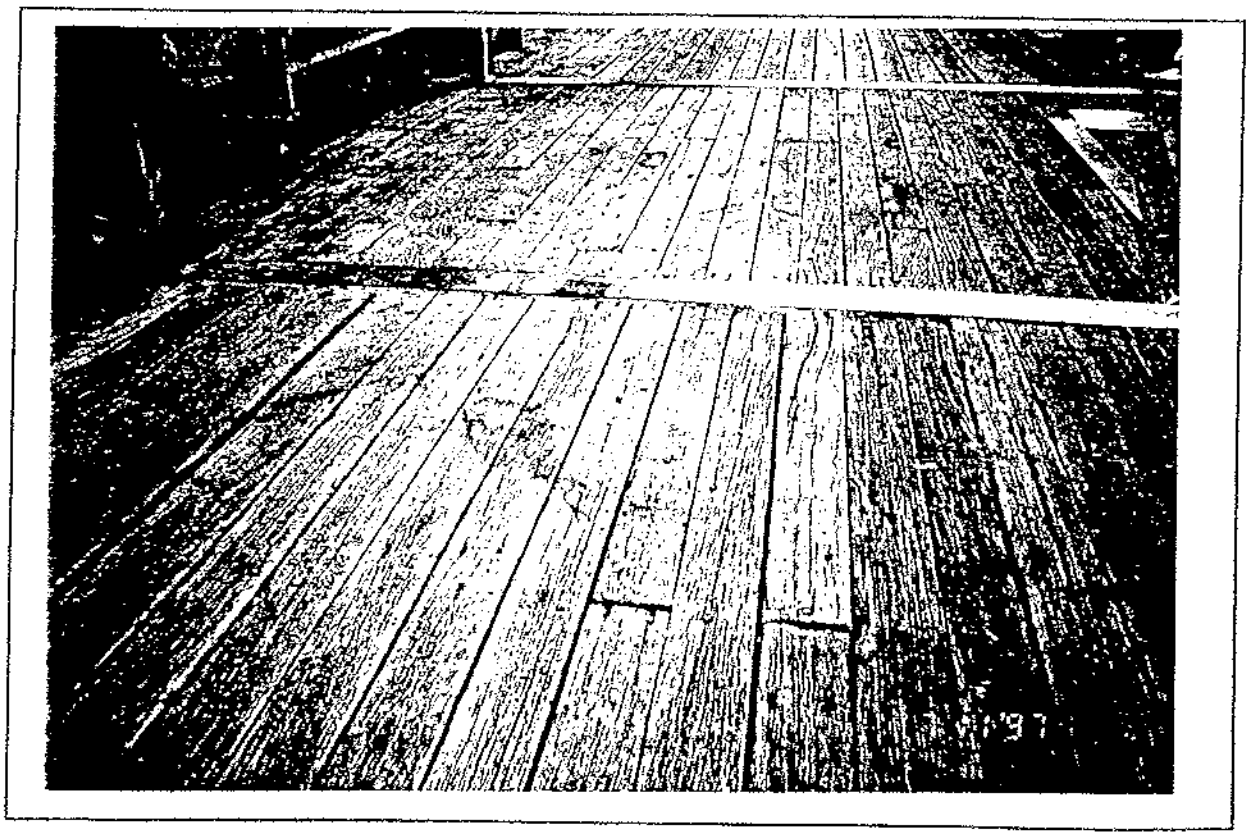
26. Tee head steel piles peeling off at 1 m above sea level



27. Jetty head and loader

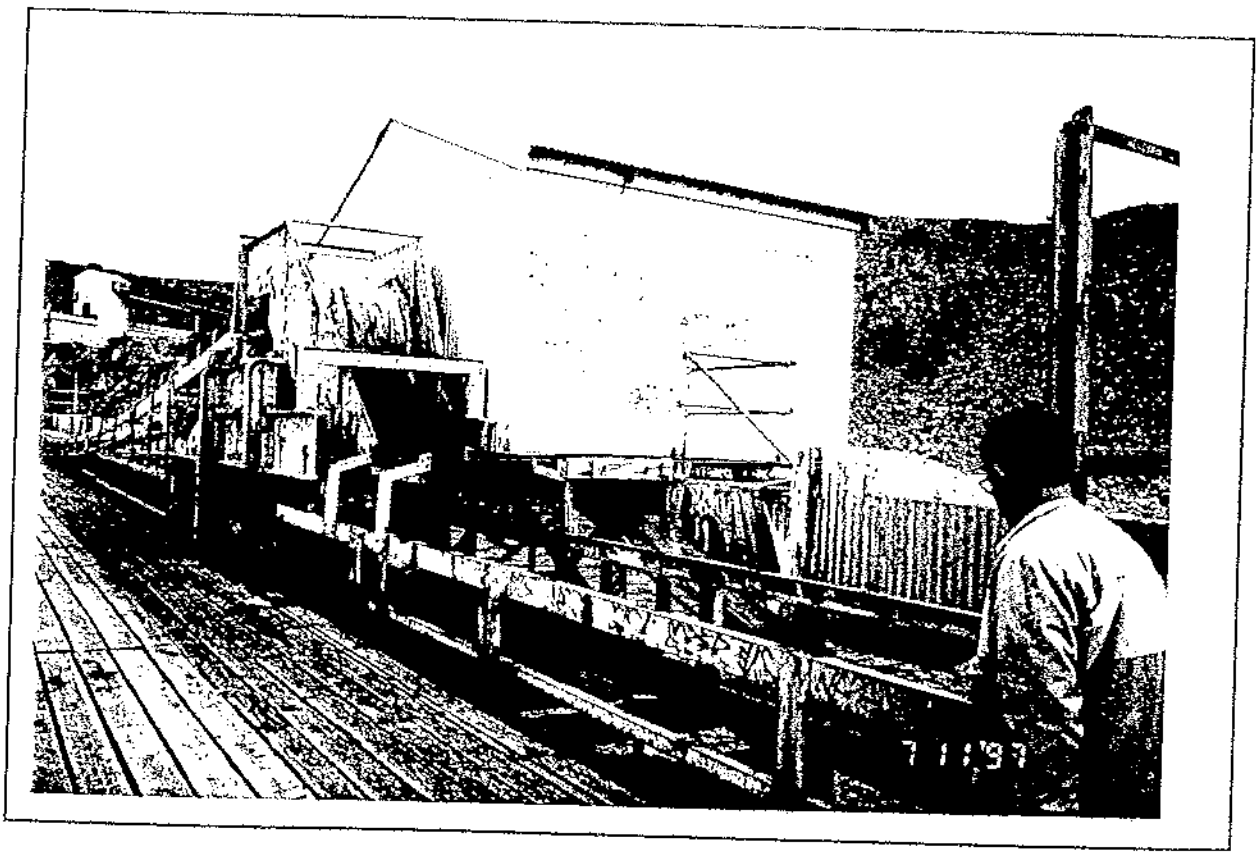


28. Deck at Tee head



29. Deck beyond Bent 81

30. Deck between Motor Room Nos. 2 and 3



31. Motor Room No. 2