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RAPID BAY JETTY

REPORT ON THE TESTING OF TIMBER PILES TO THE RAPID BAY JETTY, SOUTH AUSTRALIA

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APPENDICES

1 INTRODUCTION

We were commissioned by Transport-SA, and in particular Mr Nadio Correani to carry out pile tests to the Rapid Bay jetty, South Australia.

The object of the testing to determine the condition of the piles and there need for repairs if required. We proposed the use of our exclusive "Mod-Shock™" system for the testing and this was accepted by the Client. Data capture was carried out on the 21st September 2000 and interim reports were issued on the 10th November 2000.

This is the final report and contains the analysis of the data captured on the 21st September 2000.

2 TEST METHODOLOGY

For the testing of the timber piles we used our exclusive "Mod-Shock™" system and rather than go into lengthy descriptions of the test and its methodology, we attach as Appendix A, a paper by JS Higgs & DJ Tongue on the methodology of the Modified Shock Test and Its Usage's.

3 TEST METHODS

For the data capture we used a small workboat and moored along side the piles, identified each pile with an EAR tag as a permanent identification of each pile and each pile was photographed.

For the data capture we used a horizontal transducer placed on the flat surface of the pile and then the pile was struck in the same horizontal direction 3 to 4 times with a 2kg lump hammer. The resultant seismic wave being captured by the transducer and via a cable stored into a "notebook" computer for later analysis.

We commenced our numbering system from the start of the jetty, then as instructed we jumped from row 7 to row 27. We numbered the piles as 30A, this being the pile in the centre of the jetty and 30B, this being the pile on the West side of the jetty. In some locations we tested all three piles and numbered them 80 for the East side pile and then 80A and 80B as described before.

4 ANALYSIS OF RESULTS

Attached as Table 4.1, is a summary table of the results including the most important aspects of the data and full test results are included as Appendix C.

Summary Table 4.1
The summary table comprises the following information.

Pile Test No.
This is the reference number given to the pile at the time of testing and as seen on the EAR tag.

Length of Pile (m)
For the timber piles we have used a standard velocity of 2,500 m/sec longitudinally and 833 m/sec in the horizontal direction. This is our standard velocity for this type of pile and it has proved to be correct in the past. We would consider that the length recorded is within 10% of the actual length of the pile. We were fortunate in that the pile lengths in feet had been blazed onto some of the piles and our lengths corresponded quite well with these.

Pile Head Stiffness
This is the "E" prime of the pile measured as a direct measurement of the first part of the "mechanical admittance plot", and is similar to a load/deflection graph for a dead weight load test. This is not always an accurate result as we would desire and as such is only used to determine the overall assessment of the pile. The "pile head stiffness (t/mm)" is compared to the two model stiffness values "E" min and "E" max. "E" min is a pile model with the pile pinned at its toe but with no clamping along its length. "E" max is a pile model with an infinite rigid base and clamped along its length. These models are based on the work carried out by Davis & Dunn (refer paper, Appendix A). In this instance the pile head stiffness for a good or even minor defective pile should be above the "E" min, but closer to the "E" min than the "E" max. For medium to defective piles the "pile head stiffness" would always be less than the "E" min model. The reduction in stiffness being due to the defects in the shaft of the pile effecting large reductions in the diameter or load bearing potential of the pile.

Total Elastic Load (tonnes)
This is the "design" load for the pile, derived by the solution of the wave equation of motion obtained from the "mechanical admittance plot" (refer paper, Appendix A).

In the solution, two points of deflection against the load are plotted and we have used the first point on the load deflection graph. The second point is determined as the "maximum elastic load" and as such is too close to the pile mobilisation to be used for design purposes or even SAFE working load. The first point agrees very well with results from piles tested in Sydney (refer paper, Appendix A).

We would recommend that for any structural calculations, the load is viewed as the maximum elastic load for each pile and this is the value used in this column.

Loss of Section (m)
As detailed earlier, this is the depth from the top of the pile to the smallest diameter of the pile, measured using a velocity of 2,500 m/sec for timber piles.

Remarks
A simple "remark" to pinpoint any defects or to determine whether it is a structurally acceptable pile.

Category
To assist with possible repair programs, we have devised a simple category system for the piles described below.

Category 1	Good pile, minor defects, usually reduction of section, but good design loads, generally in excess of 20 tonnes for timber piles
Category 2	Good pile, but with more significant defects, but not drastically reducing the design load. Once again, design loads in excess of 20 tonnes for timber piles
Category 3	Defective piles, with major defects but still capable of design loads generally between 15 to 20 tonnes for timber piles. Candidate for repairs in the next 2 to 3 years.
Category 4	Either structurally redundant or with sufficient defects to the pile to be replaced immediately.

These categories can are amended to reflect local soil and environment conditions.

Minimum Diameter Reduction (mm)
This is the smallest diameter of the pile based on a velocity of 833 m/sec for sound timber.

Therefore, we believe the summary table is a good basis for both use the structural consultant to check the structural capability of the pile as well as a database for a long-term maintenance program. Re-testing at a later date gives the amount of reduction in mm over the time period as well as loss of "design" load over the same time interval. With this type of information long term asset management systems can be adapted. This reduced diameter is an equivalent diameter the remaining structural area of pile.

Full Test Results
The full test results are attached as Appendix C. The first sheet gives a photograph of the pile and a summary of the vital information, all of which is found in the summary table. The second sheet gives volumes of information, all of which is not pertinent in this case. A 2D model of the pile is shown on the right hand side of the page, the model starts at 0m at the top of the pile to the toe of the pile in the mud. On the pile is marked the sea level, this being measured from the top of the pile.

We also mark the sea bed and this was determined as a length from the top of the pile to the sea bed, we were given the water depths by the clients representative and as such are only mean levels.

On the right hand side below the 2D model is a list of parameters and they are as follows:-

MSL	Mean Sea level for this project as measured below the top of the pile
Sea Bed (m)	The depth from the top of the pile to the Sea bed, minus the MSL, so a Sea bed of 8.0m is in fact the 1.5m to MSL plus the depth of water giving a depth of 9.5m sea bed depth.
Diameter (mm)	This is the diameter measured at the hit point and used in the calculations.
Length (m)	This is the total length of the pile using the standard velocity of 2,000 m/sec for timber piles.
Long V ms & Trans –V ms	This is the velocity in the longitudinal and transverse direction used in the calculations. Generally in this case 2,000 m/sec for timber piles longitudinally and 833 m/sec horizontally for timber piles.

Opposite this parameter is the admittance plot, named the Shock Test. As a general guide a symmetrical wave form indicates a good pile. Any large peaks or numerous peaks indicate reductions or enlargements to the pile. At the top left of the report sheet is the load/deflection graph derived from the solution of the wave equation of motion of the pile, with settlement in mm as the "Y" axis and load (kN) in the "X" axis. Below the graphs are the values from the load/deflection graph and as discussed in this chapter we have adopted the first point on the graphs as the "Design Load".

Finally, there is a table below, which gives the smallest diameter as "diameter m" in relation to the length (m), which is the depth from the top of the pile. Bending moments are calculated but as yet these values have not been verified and we only include them at this stage of interest purposes only.

At the bottom Left hand side of the form is a graphical plot of the measured stiffness compared to the model stiffness's of the Max and Min models. We also include a simple comment on this result such as caution.

4.1 Summary Table of Results

5 CONCLUSION

As can be seen from the results in Table 4.1, the majority of the piles have been adjudged as being category 3 or 4. The reason for this Category 3 being that the piles have all deteriorated below the cross bracing well in the tidal zone. We believe the reductions are due mainly from worm attack, but also by attrition from the severe weather conditions prevalent in this area.

It is our considered opinion that the majority of the piles are in need of repairs or replacement or serious redundancy of the jetty could occur in the near future.

Rapid Bay

Pile Test No.	Category	Length of Pile (m)	Pile Head Stiffness (t/mm)	"E" max (t/mm)	"E" min (t/mm)	Total Elastic Load (tonnes)	Loss of Section Depth (m)	Remarks	Diameter (mm)	Diameter at W/Line	Min. Dia. Red. (mm)
P01A	2/3	8.3	3.6	11.0	2.8	22.0	1.1	Reduced	410	380	280
P01B	2	8.3	3.3	10.5	3.1	19.2	1.2	Reasonable pile	400	360	330
P02A	2	9.0	3.9	10.7	1.9	25.3	0.3	Reasonable pile	400	370	270
P02B	2/3	8.3	3.4	11.5	3.5	20.9	2.9	Splits	400	360	230
P03A	2	9.0	2.9	10.4	3.8	17.2	1.0	Reasonable pile	420	380	380
P03B	2	9.0	3.2	10.0	3.2	17.8	4.5	Reasonable pile	380	350	330
P04A	2	9.0	3.3	9.9	2.6	19.3	4.6	Reasonable pile	410	340	310
P04B	2	8.2	3.4	10.9	3.1	20.4	1.3	Reasonable pile	420	400	370
P05A	2	11.1	2.6	8.7	3.5	13.8	2.1	Reasonable pile	430	400	350
P05B	2	10.0	2.9	10.2	4.4	15.7	3.1	Reasonable pile	400	380	380
P06A	2	11.1	2.3	10.1	3.9	16.3	2.0	Reasonable pile	410	370	320
P06B	2	11.1	2.5	7.9	3.2	20.2	2.0	Reasonable pile	420	400	310
P27A	3	12.5	1.8	10.7	4.4	16.8	6.2	Concrete collar	420	360	320
P27B	3	11.1	2.2	8.3	3.7	12.5	6.6	Concrete collar	400	370	330
P28A	3	12.6	2.3	10.2	3.0	18.8	1.3/3.4	Reduced	400	330	310
P28B	3	12.5	2.1	9.7	4.1	14.9	3.0	Reduced	430	400	330
P29A	2/3	12.4	2.3	10.6	4.8	15.8	4.3		440	400	350
P29B	3	12.5	1.8	10.5	3.6	18.1	5.5	Reduced	420	420	270
P30A	3	12.0	3.9	22.2	7.4	21.2	3.7	Reduced	420	420	270
P30B	3/4	12.5	1.4	8.6	3.7	13.0	1.1/4.0	Reduced	400	330	260
P31A	2/3	14.2	1.9	8.5	2.9	14.7	2.9	Reduced	400	390	350
P31B	2/3	14.0	1.8	10.3	4.1	16.4	3.5	Reduced	430	400	330
P32A	2/3	11.1	1.8	9.7	3.9	15.5	3.0	Reduced	400	380	320
P32B	3	12.5	2.2	7.2	3.1	11.1	3.2	Reduced	460	400	300
P33A	3/4	12.0	1.8	5.9	3.5	7.8	4.3	Reduced/Splits	400	400	240
P33B	3/4	12.5	2.1	10.2	4.5	15.5	4.5	Reduced	400	400	270
P34A	4	12.3	1.4	5.9	2.0	10.2	3.8	Reduced	350	350	260
P34B	3	12.5	1.5	8.3	2.7	14.5	1.1/3.8	Reduced	400	400	280
P35A	4	12.3	1.3	6.7	2.4	11.3	4.5	Severely reduced	350	350	280
P35B	3	12.5	2.7	9.7	3.6	15.9	2.6	Severely reduced	400	380	280
P36A	4	12.5	1.0	8.8	2.8	8.8	2.5	Severely reduced	410	360	260
P36B	3/4	14.2	1.2	5.2	2.0	8.5	5.5	Reduced	420	380	310
P37A	3	12.6	2.8	8.7	2.9	14.9	2.8	Reduced	400	380	330
P37B	3	12.5	2.9	7.9	3.2	12.3	1.5/6.2	Splits	400	370	320
P38A	3	12.6	2.8	8.5	3.6	13.2	2.8	Reduced	420	380	280
P38B	3/4	12.0	2.8	6.8	2.9	10.4	1.2/2.9	Reduced	410	370	270

Pile Test No.	Category	Length of Pile (m)	Pile Head Stiffness (t/mm)	"E" max (t/mm)	"E" min (t/mm)	Total Elastic Load (tonnes)	Loss of Section Depth (m)	Remarks	Diameter (mm)	Diameter at W/Line	Min. Dia. Red. (mm)
P39A	4	12.6	1.5	9.0	3.0	7.8	1.4/5.8	Reduced	450	450	270
P39B	3/4	12.0	1.3	8.0	3.0	13.0	3.8	Reduced	400	370	280
P40A	4	12.6	1.9	6.7	2.3	11.5	5.2	Reduced	360	360	270
P40B	4	12.6	2.3	4.7	1.9	7.4	3.2	Severely reduced	380	330	230
P41A	3	12.8	2.6	7.7	3.1	12.3	3.8	Reduced	420	400	330
P41B	3	13.0	3.4	8.9	2.8	15.9	4.5	Reduced	410	400	310
P42A	4	12.9	1.5	7.0	1.3	8.0	2.7/4.5	Severely reduced	400	400	190
P42B	3	12.5	3.0	7.6	2.8	12.5	4.6	Reduced	460	400	300
P43A	3/4	12.9	3.2	7.0	2.5	11.8	3.3 to 5.5	Worms	450	450	280
P43B	4	13.8	1.3	4.9	2.5	6.9	1.0/1..8/3.0	Severely reduced	460	360	210
P44A	3	13.0	2.7	7.4	3.0	13.9	1.7/4.1	Worms	450	380	330
P44B	3	13.2	2.6	10.0	3.7	16.4	3.7	Reduced	410	400	290
P45A	3	13.4	2.7	7.8	3.2	12.2	3.1	Reduced	450	400	320
P45B	3	12.5	2.7	9.2	3.4	15.2	3.8 to 6.6	Worms	430	380	320
P46A	3/4	13.6	3.5	5.6	1.6	11.9	3.3	Severely reduced	400	370	280
P46B	4	13.6	2.7	7.9	2.7	9.7	1.1/3.3	Severely reduced	420	320	220
P47A	4	13.7	2.5	7.5	2.6	12.8	1.74/4.1	Severely reduced	450	400	280
P47B	4	12.5	2.7	6.4	2.2	11.0	1.1/3.0	Severely reduced	420	360	270
P48A	4	12.5	1.9	7.1	2.2	12.8	4.5	Severely reduced	360	360	220
P48B	4	12.5	1.9	7.7	2.8	12.6	3.8	Severely reduced	400	400	240
P49A	4	12.6	1.9	6.2	2.0	11.1	1.0/3.7	Severely reduced	410	330	170
P49B	4	12.0	1.5	11.1	4.6	8.3	3.4	Severely reduced	450	350	220
P50A	3	12.5	2.9	6.5	2.2	11.3	3.8	Reduced	400	360	300
P50B	4	13.0	1.4	4.5	2.1	6.7	3.5	Severely reduced	450	410	220
P51A	3	13.6	2.4	9.0	2.6	14.0	3.9	Reduced	410	400	280
P51B	3/4	12.5	2.4	8.6	2.8	15.3	4.3	Reduced	400	300	280
P52A	4	12.6	2.8	6.2	2.9	9.2	4.5	Reduced	400	400	270
P52B	3/4	12.0	2.7	8.6	3.4	13.7	3.9	Reduced	430	390	300
P53A	3	12.8	2.5	7.4	2.0	14.4	3.7	Concrete collar	460	400	310
P53B	4	13.0	1.5	5.0	2.8	6.9	3.2	Concrete collar	380	360	270
P54A	3/4	12.5	2.7	7.4	3.4	11.0	3.3	Concrete collar	410	390	310
P54B	4	13.6	1.6	5.8	3.2	7.9	3.5	Concrete collar/Hollow	420	370	190
P55A	3	12.5	2.5	6.0	1.7	11.1	2.9	Concrete collar	400	380	300
P55B	3	12.6	2.8	6.5	2.0	11.7	3.3	Reduced	450	450	390
P56A	4	13.5	2.5	8.2	2.3	10.2	2.9	Concrete collar	400	360	240
P56B	4	14.0	1.4	4.8	2.5	6.7	0.9/3.4	Hollow	420	360	210

Pile Test No.	Category	Length of Pile (m)	Pile Head Stiffness (t/mm)	"E" max (t/mm)	"E" min (t/mm)	Total Elastic Load (tonnes)	Loss of Section Depth (m)	Remarks	Diameter (mm)	Diameter at W/Line	Min. Dia. Red (mm)
P57A	3	12.5	2.4	8.4	3.1	14.0	4.5	Reduced	420	380	310
P57B	3	12.3	2.7	6.0	2.7	10.2	3.7	Reduced	410	370	300
P58A	3	13.8	2.3	7.6	2.0	14.8	5.0	Concrete collar	420	360	320
P58B	3	12.3	2.5	7.9	2.9	13.0	2.8	Concrete collar	420	420	300
P59A	4	12.6	2.7	6.7	2.7	10.5	3.0 to 6.0	Worms	450	380	270
P59B	4	12.0	2.0	10.1	3.6	7.3	3.7	Worms	380	330	170
P60A	3/4	12.3	2.7	7.1	1.8	14.0	1.4/4.1	Worms	400	350	280
P60B	3	12.5	2.4	5.9	1.7	11.0	4.7	Worms	410	350	300
P61A	3/4	12.3	2.6	7.0	2.5	11.8	3.7	Worms	420	360	280
P61B	3	12.2	2.9	8.1	2.8	13.7	5.2	Concrete collar/Worn	420	360	310
P62A	3	12.0	2.7	8.1	1.9	16.5	3.7	Worms	420	370	310
P62B	3	12.2	3.0	8.0	2.7	13.8	2.1/5.2	Worms	420	350	300
P63A	3	12.3	2.6	8.1	2.6	14.3	1.0/5.0	Worms	400	380	320
P63B	3	14.0	3.0	9.0	3.3	14.8	2.7 to 5.2	Worms	450	420	310
P64A	3	12.3	2.6	8.0	2.0	16.1	3.3	Worms	420	420	330
P64B	4	12.0	1.8	7.4	2.6	12.4	4.1	Worms	420	420	280
P65A	4	12.5	2.5	9.4	2.6	13.2	0.9/5.3	Worms	500	460	180/280
P65B	4	12.2	2.9	7.1	3.4	10.3	4.7	Worms	380	360	260
P66A	3	12.0	2.6	10.0	3.9	16.3	3.8	Worms	420	400	310
P66B	3/4	12.3	2.8	7.5	2.8	12.1	0.5/4.0	Hollow/Worms	400	350	250/340
P67A	3	12.5	3.7	9.5	2.0	18.2	2.9	Reduced	420	370	340
P67B	3	12.5	2.6	10.5	3.9	17.4	4.3		420	400	310
P068	4	12.3	1.9	7.1	3.2	10.8	2.4 to 5.8	Worms	400	350	220
P68A	3	12.5	2.6	9.0	2.6	16.8	2.9 to 6.0	Worms	400	350	310
P68B	4	12.4	2.6	10.1	3.7	13.2	2.0 to 6.0	Worms	400	350	200
P069	4							Sheared off			
P69A	4	12.0	1.9	7.6	3.0	12.1	4.5	Worms	400	350	290
P69B	4	12.0	2.6	7.9	3.1	12.5	1.1/3.7	Worms	400	350	280
P070	4	12.0	2.2	6.4	1.9	11.6	4.0	Worms	420	390	270
P70A	4	12.5	3.0	7.8	1.6	8.0	3.3 to 5.0	Worms	420	340	250
P70B	3/4	12.3	2.6	7.3	2.7	12.1	5.3	Worms	420	340	270
P071	3	12.0	2.6	9.1	3.2	16.0	3.2	Worms	420	350	340
P71A	4	12.3	2.5	8.4	2.4	12.4	4.1	Worms	420	350	250
P71B	3	12.3	2.6	8.4	3.1	13.9	3.0	Concrete collar	420	340	320
P072	4	12.0	2.7	7.3	3.2	11.1	1.4/5.2	Worms	400	350	270/300
P72A	3	12.5	2.9	8.9	3.7	15.0	4.7	Worms	480	390	310
P72B	4	12.0	2.6	9.8	3.8	8.8	5.5	Worms	400	200	200
P073	4	12.0	1.8	6.0	2.1	10.3	4.1	Worms/Reduced	420	250	200

Pile Test No.	Category	Length of Pile (m)	Pile Head Stiffness (t/mm)	"E" max (t/mm)	"E" min (t/mm)	Total Elastic Load (tonnes)	Loss of Section Depth (m)	Remarks	Diameter (mm)	Diameter at W/Line	Min. Dia Red. (mm)
P73A	4	11.7	1.7	7.0	3.1	10.6	1.8/4.0	Worms	420	400	210
P73B	4	12.2	1.9	8.3	3.3	11.2	4.7 to 6.0	Worms	420	400	270
P074	4	12.5	2.6	8.4	3.6	12.9	4.3 to 5.2	Severely reduced	420	180	180
P74A	4	12.2	2.1	6.9	2.5	11.5	3.4	Worms	420	400	240
P74B	4	12.5	2.6	8.7	3.2	13.2	5.5	Worms	420	400	280
P075	4							Sheared off			
P75A	4	12.5	2.5	6.4	1.7	10.6	4.7	Worms	480	450	290
P75B	4	12.0	2.5	9.9	3.2	9.6	4.1	Worms	400	320	200
P76A	4	12.0	2.1	8.4	3.3	12.2	5.0	Worms	420	400	240
P76B	3	12.5	2.8	9.4	3.6	15.2	4.3	Worms	410	400	310
P77A	3	12.5	2.6	9.5	3.7	14.4	4.4	Worms	400	380	310
P77B	4	12.0	1.5	8.0	1.9	8.9	5.8	Worms	400	320	250
P78A	4	12.2	2.6	9.1	3.4	10.2	4.5	Severely reduced	400	220	220
P78B	3/4	13.0	2.7	10.7	3.2	13.3	5.3	Worms	400	350	320