STRIDE PROJECT – Steel Risers in Deepwater Environments – Achievements 1999-2001

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The presentation relates to some of the key activities of the STRIDE JIP in the last 2 years. STRIDE has run since 1998 with 2H as initiator and Lead Engineering Contractor, and will be concluding in 2002. Work has focussed on steel simple catenary risers (SCR's) in deepwater. STRIDE participants are listed at the end of this paper.

Allegheny Monitoring Programme

The first set of figures, 1 to 5, relate to the Allegheny monitoring programme. The Allegheny gas export riser presented an excellent opportunity to fit motion loggers onto an SCR likely to see vortex induced vibration (VIV) due to ocean currents. No data was publicly available of this nature, with VIV prediction codes largely relying on data from vertical risers. The riser is welded steel construction, 12-3/4" OD in 3,255 ft water depth in the Gulf of Mexico. The top 580 ft has a helical strake VIV suppression system, designed to reduce VIV but not expected to eliminate it.

Twelve 2H data-loggers were fitted during riser installation in August 1999 as shown in Figures 1 and 2. These measured triaxial linear acceleration for 20 minutes every 6 hours until the memory was full in January 2000. During the logging period, a significant eddy current event occurred producing currents near to 2 knots at Allegheny – Figures 3 and 4.

Figure 5 shows a response summary over the logging period. The riser response has been classified into the following four classes:

<C1> small amplitude response;
<C2> vessel motion induced response;
<C3> VIV induced response;
<C4> "mixed" response.

In general, the riser VIV response can be seen to correlate with the higher and more unidirectional current velocities.

Significant back-analysis and code benchmarking has now been performed on the measured data. It seems that the Allegheny SCR was subject to VIV response, but the measured VIV response was less than has been predicted by available VIV software, both in terms of response amplitude and occurrence. The reasons for this are still under investigation. Current considerations are:

- The strake system may be better at suppressing VIV than was expected
- Due to their shape, SCR's have their own preferred planes of modal vibration. If the current direction is not orthogonal to these, the SCR plane may fight the VIV direction, and suppress VIV.
- Variation in current direction through the water column may cause a damping effect.

Within STRIDE Phase 4, further work is proceeding on this activity:

- Program benchmarking by 5 VIV code suppliers
- Analysis of the Allegheny TLP motions during the monitoring period
- Analysis of a second monitoring campaign at Allegheny, March 2000 to July 2000
- Tank tests on a model SCR, towing at different angles, to establish how the VIV direction reacts with the natural SCR plane direction.

SCR-Seabed Interaction

The second activity presented relates to another area of uncertainty within SCR design – riser interaction with the seabed. Deepwater seabeds are usually very soft clay. ROV videos of installed SCR's show significant seabed trenching in the dynamic riser area, 4 to 5 ft deep, sometimes with back-fill. In April 2000 a test programme was set up to look at whether riser seabed interaction might produce localised stress hot-spots due to soil suction or trench interaction.

Figure 6 shows the riser simulated – a spar SCR in 1000m water depth. Analysis techniques were used to predict riser motions at the touchdown area due to environmental loading on the spar (ignoring soil suction). Then another analysis model was set up of a cut-down riser that could be more easily simulated on test – Figure 7 – and the input motions at the top end were adjusted to produce riser motions at the seabed similar to the full-scale case.

A tidal harbour location was found in the west of England that had seabed properties similar to the deepwater Gulf of Mexico, and this allowed the cut-down model to be set up – Figure 8. An actuator unit at the top end – Figure 9 – provided the required motions simulating spar drift and wave motions. Strain gauges along the riser recorded the local bending moment for different actuator motions – Figure 7.

Figure 10 shows strain gauge readings from a spar fast drift simulation, as might be seen from a failed spar mooring line in a storm. Some of the strain gauge positions show a non-smooth transition from the starting bending moment (spar at “near” position”) to the final (“far” position). There is a suction “peak” in evidence, (actually an inverted peak here, relates to a sag-type bending moment on the riser). This peak is made clearer when the riser is laid down again at exactly the same rate – the lift shows the peak, the laydown does not, and this adds confidence to the conclusion that this is a soil suction effect. Figure 11 shows this comparison for some of the strain gauge positions.

It seems that as the riser is lifted from the seabed, a suction peak races along the riser at ~1 m/s as the soil-riser suction causes a local tightening in the radius of curvature. This peak grows and fades as it passes along the riser. Figure 12 shows an example of this. For this test the top of the pipe was below the mudline and the trench had been backfilled by hand with seabed material to simulate trenches seen offshore. The test then simulated the fast drift as before, and the strain gauge with the highest peak is plotted.

Towards the end of the test programme, tests were also conducted on a simulated rigid seabed, by actuating the riser on top of a steel walkway placed on the harbour floor under the riser. These tests did not show the suction peak identified in Figure 12. Figure 13 shows bending moment traces from strain-gauges at different riser positions along the test pipe. It can be seen that the lift and lay-down strain gauge curves are almost identical. This indicates that the suction peaks seen on other tests were due to soil suction, and not a result of the actuation system or hysteresis/inertia effects.

Work is ongoing within STRIDE phase 4 analysing the data from these experiments. Further tests are being conducted using seabed soil from the harbour on small scale rigs at 2H and NGI Oslo, pushing riser sections of different diameters into the soil to compare uplift and lateral resistance.

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STRIDE Lead Engineering Contractor: 2H Offshore Engineering

STRIDE Phase 3 Sponsoring Participants: Aker, BP, Brown and Root, Chevron, Conoco, Norsk Hydro, SBM, Sofec, Stolt Offshore, Texaco, TotalFinaElf, Statoil, , Vastar

STRIDE Programme manager: Offshore Technology Management

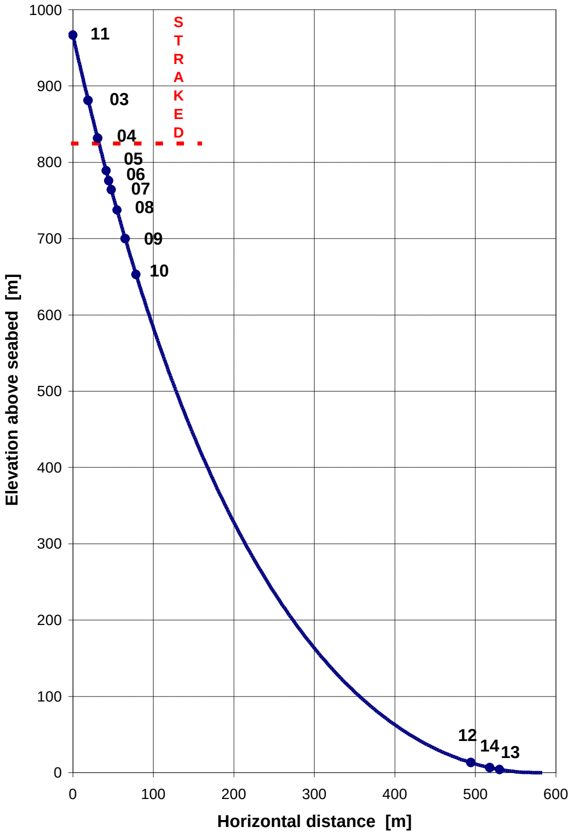


Figure 1 - Data Logger Positions along the Allegheny Gas Export Line

Figure 2 - 2H Accelerometer on the Allegheny SCR

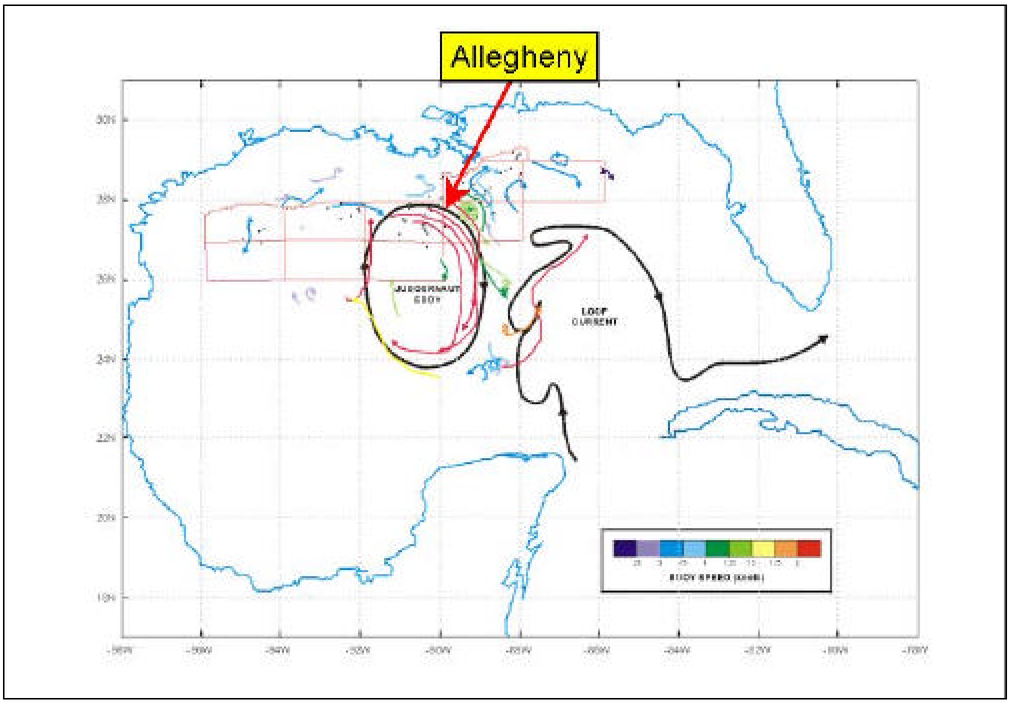


Figure 3 – Eddy “Juggernaut”

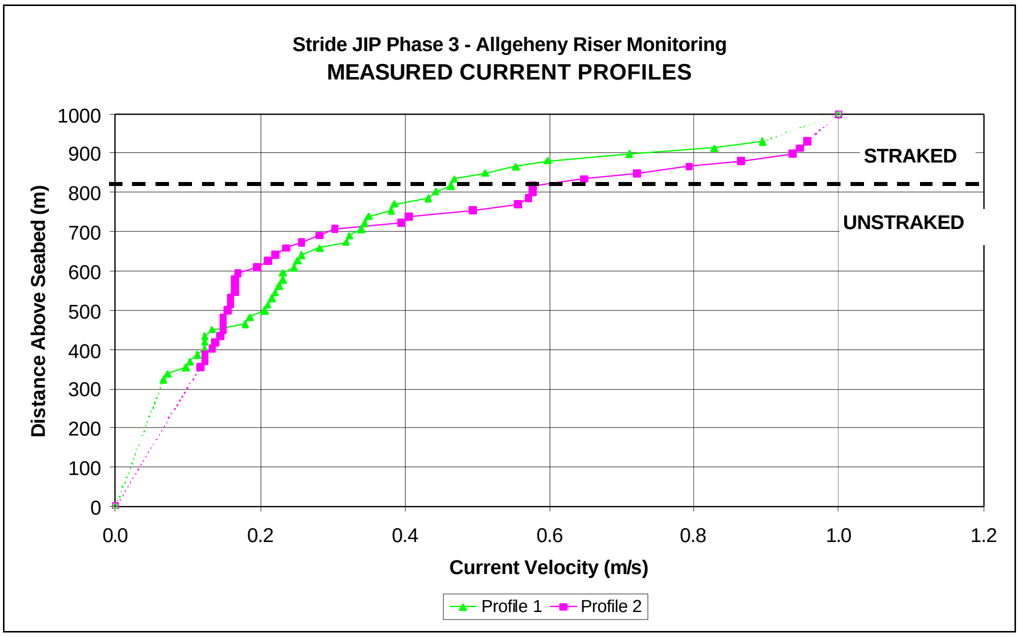


Figure 4 – Measured Currents

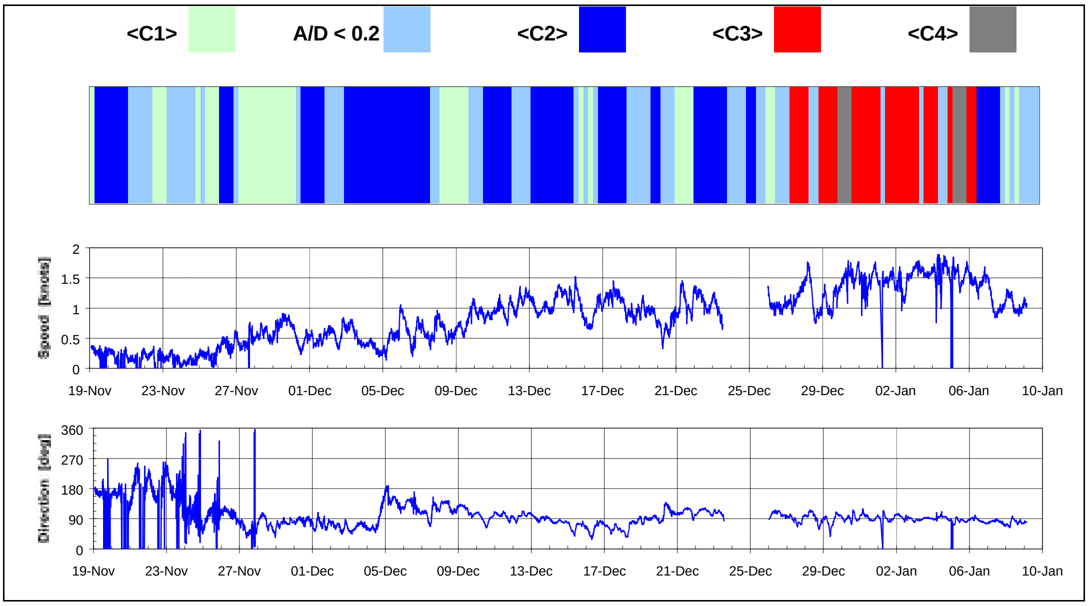


Figure 5 - Response Classification Summary

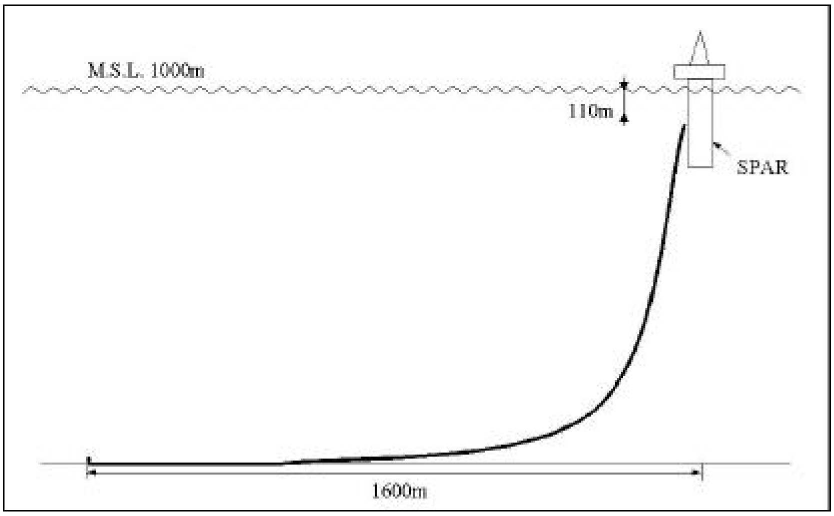


Figure 6 – Full Scale Riser Configuration

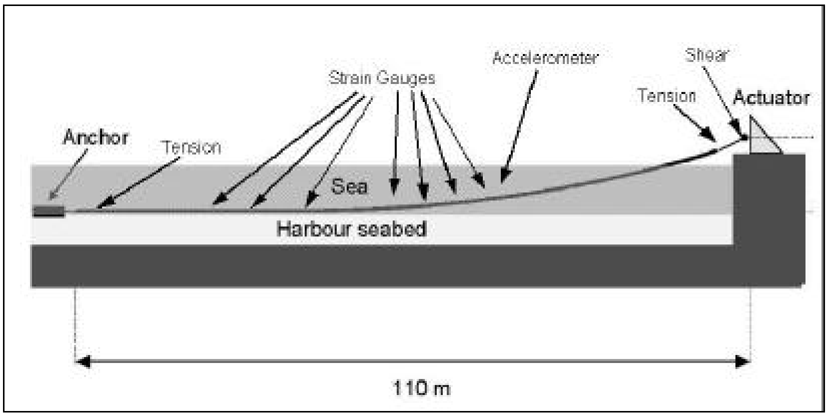


Figure 7 – Harbour Test Set-Up Schematic

Figure 8 – Harbour Test Site at Low Tide

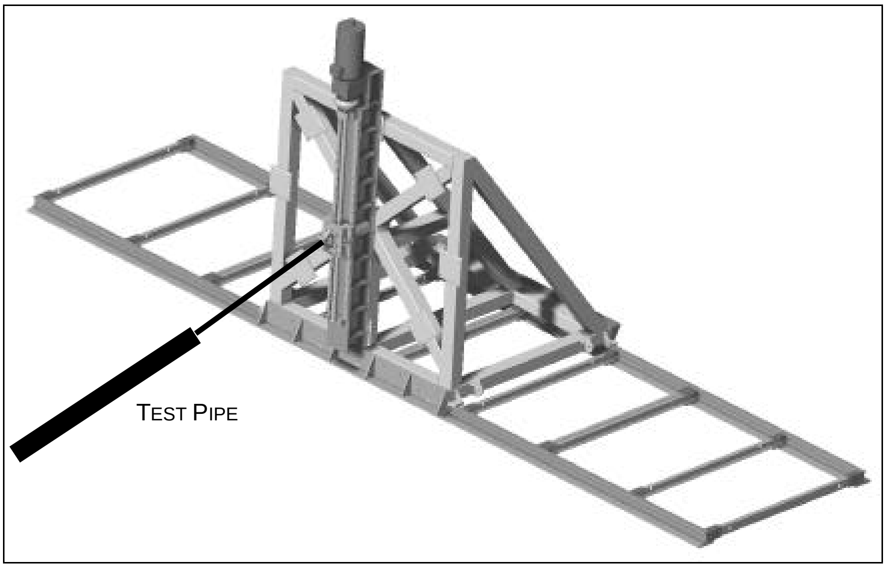


Figure 9 – Actuator Unit and Rails

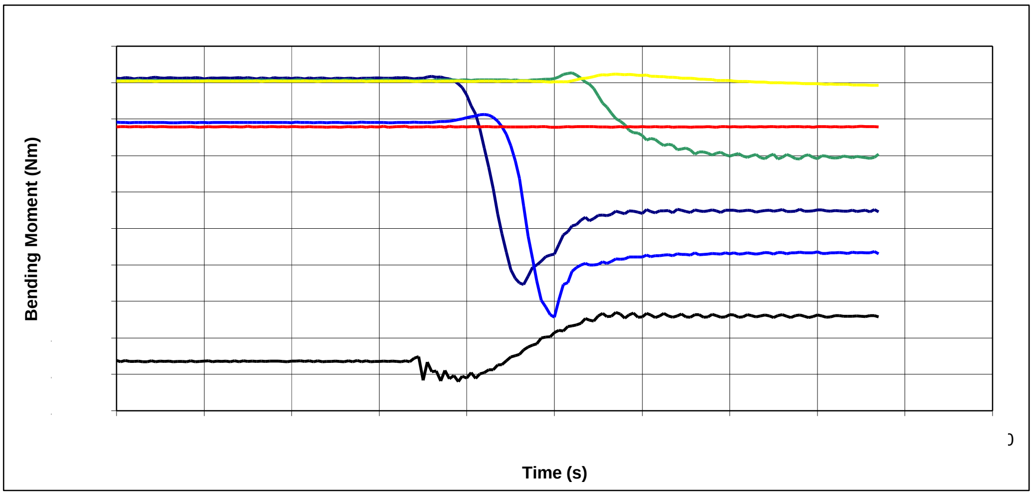


Figure 10 – Bending Strain at Different Riser Positions During a Drift Simulation

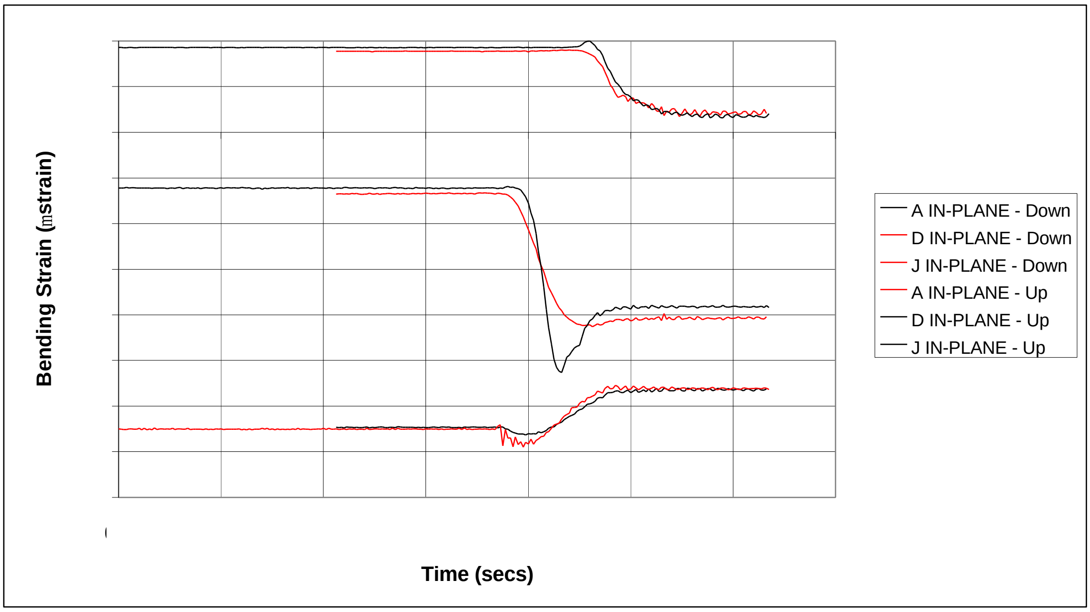


Figure 11 – Comparing Near-Far and Far-Near Bending Traces

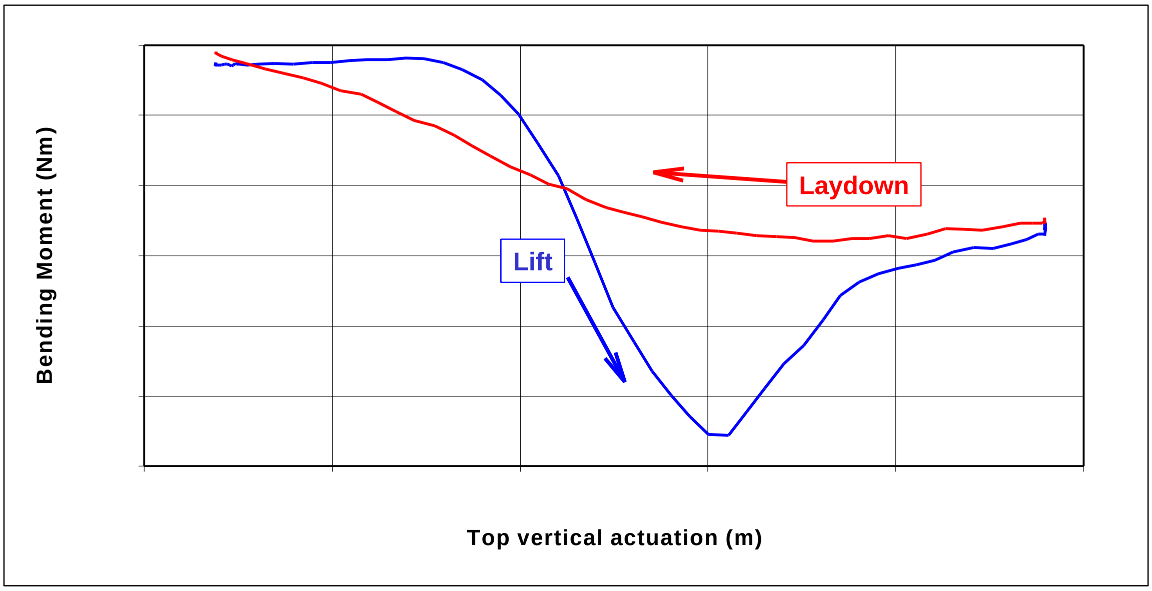
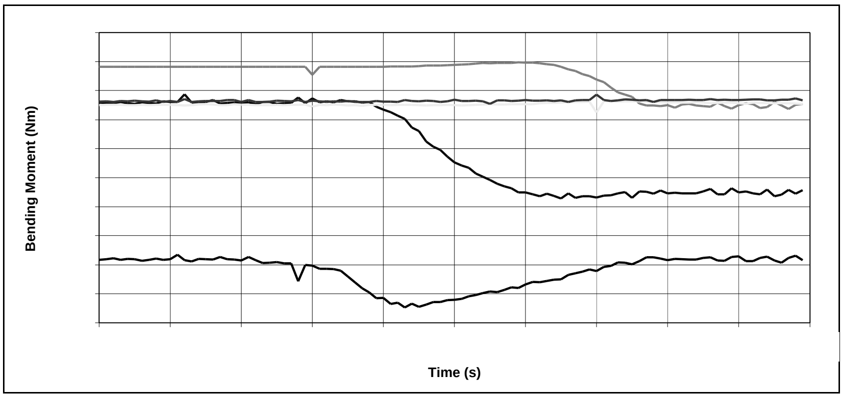
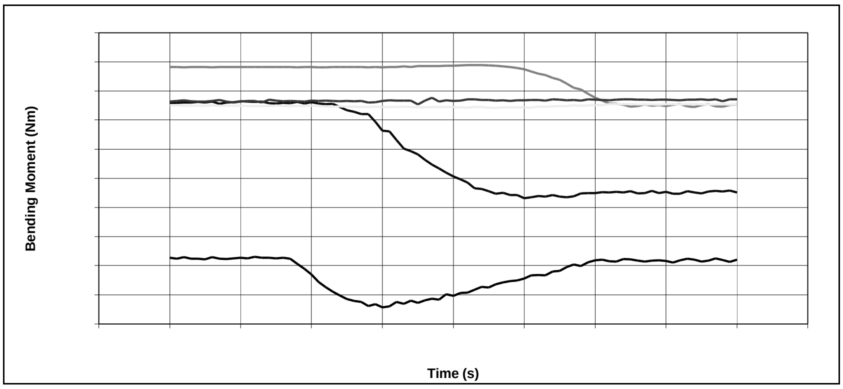


Figure 12 – Suction Peak for Fast Drift Case



(a) Lift (Near to Far)



(b) Lay-down (Far to Near)

Fig. 13 – Strain Gauge Data from Rigid Surface Tests