OMAE-91-512 / AQ-305-90 / 24.9.1990

IN SERVICE EXPERIENCE OF FIXED OFFSHORE STRUCTURES IN NORWAY

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ABSTRACT

The paper descibes several occurances of storm damages, collisions, fabrication and metallurgical problems, fatigue and operational errors on fixed offshore platforms in the norwegian continental shelf.

KEYWORDS

Structures, damage, collision, storm, marine fouling, fatigue, cracks, dents, corrosion, scour

INTRODUCTON

The paper describes reported incidents on Norwegian fixed offshore structures. The paper is restricted to inservice experience in a 10 year period from 1980 to 1989. Incidents related to problems during design, fabrication and offshore installation of the platforms are not included. We have restricted ourselves to the structural damages.

CODAM

NPD possess a computer system called CODAM (Tesdal, 1985) in which incidents and damages on structures, risers and pipelines on fixed platforms are registered. All in-service inspection reports from the Norwegian Continental Shelf are reviewed by NPD and the damages are reported on CODAM.

The cause of the damages are reported randomly from the operators. For the majority of the damages no particular cause is given.

During 1990 NPD started receiving information from operators on a specified computer readable format.

STORM DAMAGES

The following storm damages have been reported :

ELDFISK 2/7 Bravo - jacket - 24.11.1981 at 12.20 o'clock.

The northern wall of the "New Maintenance Shop" was damaged by a wave. The damage occurred at 20 m above LAT. The damage was small.

EKOFISK 2/4 Tank - concrete Doris-type - 3.1.1984 at 10. o'clock

A container of 2x2x3 meter with an estimated weight of 200 kg was moved 10m on the 20 m cellar deck. The seafastening devices were destroyed. A 20 feet container was thrown into the sea. Because of subsidence the wave height was approximately 17 m above LAT at that time.

EKOFISK 2/4 Alfa - jacket - 3.1.1984 at 13 o'clock.

A 2 mm corrugated iron plate was destroyed at 22 m above LAT on the cellar deck. The force to cause such a damage did not have to be high. In addition the corrugated plate was heavily corroded. Horiontal deflections were reported on 4 girders at 15 m above LAT. In addition the webs of the beams were deformed. The wave also caused water flooding in the control room and the platform was shut down. No personnel was hurt.

EKOFISK 2/4 Tank - 28.-29.2.1988.

A deckplate was buckled upwards under the firepump area. It happened on the 20 m deck which at that time was 15.8 m above LAT. The largest wave measured in the area was 21.8 m.

EKOFISK 2/4 E - jacket - 1988.

A crack in HAZ 23 mm long 2 mm deep. Probably caused by fabrication welding defects and wave forces.

Several cases of damage on secondary structures such as hand rails and stair ways have been reported.

Most storm damages have occurred on platforms which have been subject to subsidence. No major storm induced damages have occured. Several of the wave damages have occured higher that ordinary wave theories would predict. Most probably this is due to freak waves.

SHIP COLLISIONS

The following ship collisions are reported:

EKOFISK 2/4 C - jacket - 1981

It was probably caused by a ship collision. No cracks were seen until after a storm. Water was noted escaping from a member in a wave trough.

EKOFISK 2/4 D - jacket - 12.1.1982

Crack in weld between riser protector and doubler plate. Doubler plate was torn loose.

EKOFISK 2/4 H - jacket - 13.4.1982

Collision with survey vessel Seaway Falcon. Several nodes and braces got cracks, deflections and dents.

VALHALL QP 1.7.1982

Collision with supply boat Tender Turbot in boatlanding area. Insignificant damage.

STATFJORD-C-SPM - Single Point Mooring Platform - 23.1.1985.

Collision with the tanker Poly Viking caused a torsional moment exceeding the design limit. Draintube at column and host deformed.

COD 7/11A - jacket - 25.5.1986.

Structural damage on horizontal brace (140 mm tear). Secondary damage to support beams, stairway and stairway landing platform.

ODIN - jacket - 24.12.1986.

Dent 700 mm long and 120 mm wide. No influence of overall integrity of the structure.

STATFJORD-B-SPM - 1986.

Access platform extensively damaged by tanker collision during loading operation.

EKOFISK 2/4 A - jacket - 1.12.1987.

Boat landing east side pushed against member during collision with the supplyboat "Nor Truck".

STATPIPE 16/11-S - jacket - 1988

Collision with stand-by vessel Geo Boy. 12 scratchmarks with average size 100 * 10 mm and max depth 2 mm.

OSEBERG B - jacket - 6.3.1988.

Submarine collision with brace. The deflection was 194 cm long, 90 cm wide and 26 cm deep. For more details reference is made to Sveen (1989).

Damage caused by collisions is a frequent situation. The reported collisions have had an annual probabily of approximate 2% pr platform year. UEG (1983) and Amdal (1985) have studied the number of damages on platforms as a function of the location on the platform. Based on their observations a conclusion must be that there are also a high number of small non-reported ship collisions. A ship collision probability of 2% every platform year must be a lower limit estimate of the total number of events. Figure 1 gives the number of dents as a function of location on the platform. Most of the dents in the splash zone are probally caused by ship collisions. Some of them also come from falling objects.

FABRICATION AND INSTALLATION PROBLEMS

From 1983 several cracks were observed on the Statfjord A - Articulated loading platform. Because of cracks the platform was moved to shore in 1984. Investigations on the shipyard exposed severe cracking on the platform, and the repair work was stopped. A new offshore loading system has replaced this platform.

Material testing showed no evidence of fatigue. The reason for cracking was belived to be poor quality structural steel. A large majority of the defects was a result of external attachments welded to the structure.

A total of 28 cracks are in CODAM directly related to bad workmanship during fabrication. These cracks have been discovered on different platforms during a long period of time. The real number is probably significantly higher. An indication can be found by reviewing the number of cracks. Figure 2 gives the number of cracks on norwegian platforms as a function of the location on the platform.

A total of 60 cases with burnmarks are reported, mainly dating from the time of transportation and installation phases. This includes temporary attachments which have been removed later. Grinding have been used to remove the burnmarks on several platforms.

FATIGUE

In CODAM the following incidents are reported as caused by fatigue :

On two jackets fatigue is reported as the cause of cracks: Frigg DP2 with two cracks and Ekofisk 2/4-R with one crack.

Undercut in welds from fabrication is believed to be the starting point for fatigue on DP2. The cracks were small, and were removed by grinding.

Several fatigue cracks have been observed in secondary structures. These are structures where fatigue cracks were not included in the design:

a) Ekofisk 2/4-D in 1981 - conductor guide frame

b) Frigg DP2 in 1982 - conductor guide frame

For more details reference is made to UEG (1983), case study number 6.

c) Ekofisk 2/4-F in 1987 - boatbumper support brace

d) Albuskjell 1/6-A-F1 in 1988 - drainpipe support.

The total number of reported incidents with fatigue have been small.

CORROSION

A total of 311 cases of structural corrosion have been reported in CODAM. Of these registrations 282 cases are reported to be corrosion pittings. All the reported corrosion cases were small with no significant effect on the integrity of the structure. Figure 3 show the number corrosion of location on the platform.

The general corrosion were in several cases caused by damaged coating. Burnmarks close to connections have high frequency corrosion rate. Repair have been carried out on several structures with grinding and sandblasting.

OTHER PROBLEMS

Crack in lightweight concrete Statfjord C-1989 because of maloperation of the ballast system. Thus a cell experienced too high internal pressure. A 12 m crack in the lightweight concrete occurred. Aproximately 15 m^3 with oil was also spilled into the sea.

Vortex shedding vibrations of flarebooms are reported by Kvitrud and Dalsgaard (1990). The Heimdal and Statfjord A flarebooms had problems with vortex shedding vibrations. The problem was partly related to design errors and to high damping values in the design.

As reported in several conferences there has been subsidence in the Ekofisk and Valhall area causing severe problems and expensive corrective actions.

13 damages in CODAM are reported caused by falling objects: boyancy tank, pile hammer, boat bumper and seawater pump.

Scour are reported on several platforms, but it has never exceeded the design values.

Marine fouling has been reported exceeding the design limit in 8 cases. On two occations cleaning have been carried out. In one case structural reanalysis was performed.

Several cracks in Ekofisk 2/4 H aluminum helideck of the "safedeck" type was discovered in 1989. The cracks were up to 5 m in length and always in the extrusion zone. Phillips concludes that all cracks are inhibided by galvanic corrosion. A 1 m crack in the Statfjord B "Safedeck" are by Statoil concluded to be termal expansion by freezing of the firewater in the profiles.

FULL SCALE MEASUREMENTS

The geotechnical performance of gravity structures are reported by Lunne and Kvalstad (1982). Platform specific report is made by SINTEF for Statfjord A, Statfjord B and Frigg TCP 2. A general conclusion is a reasonable good prediction of foundation behavior. Only Ekofisk 2/4 H has been instrumented to measure pile behaviour. The conclusion (Lieng, 1984) showed a very conservative behaviour compared to design calculations.

Statfjord A-ALP (an articulated loading platform) was instrumented for full scale measurements of platform behaviour in 1979-1980. A comparison between model test results and the offshore measurements do not show significant differences (Bloch, 1976 and Spitsøe and Brathaug, 1983 a and b).

Several jackets (Valhall QP, Ekofisk 2/4H, Frigg QP and Oseberg B) and gravity structures (Statfjord A, Statfjord B, Frigg TCP2, Oseberg B and Gullfaks C) were instrumented to evaluate their dynamic behaviour. The summary shows that the design gave a conservative prediction of the behaviour (Spitsøe and Hilmarsen, 1983 and Langen and Spitsøe, 1983)

CONCLUSION

Reviewing these reports of problems and accidents there is not much that can be related directly to design codes as such.

One problem is subsidence which is hardly mentioned in any design code at all.

Secondary and temporary structures have not always been designed and fabricated to the same standard as main structures, which later has caused expensive repair work.

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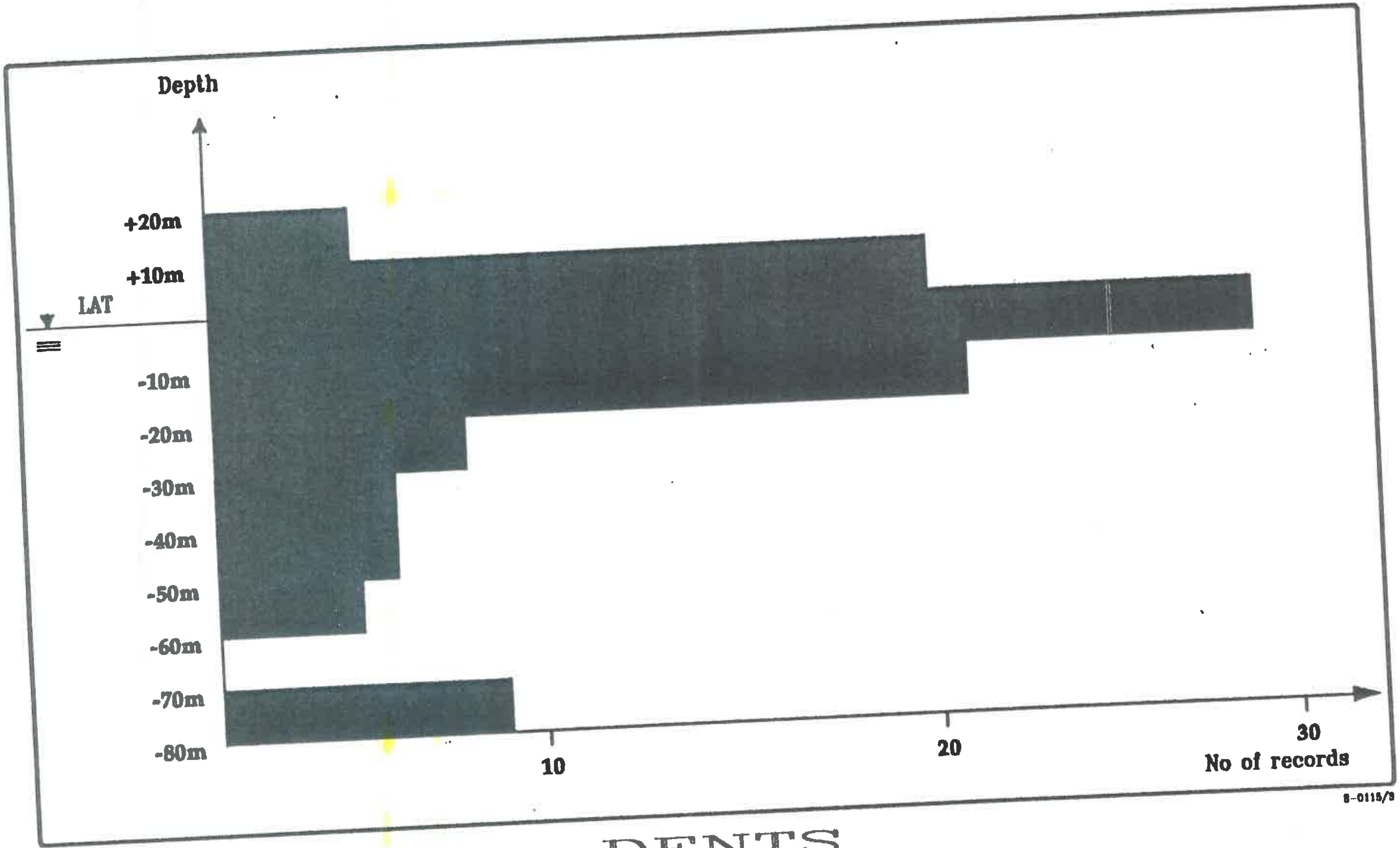
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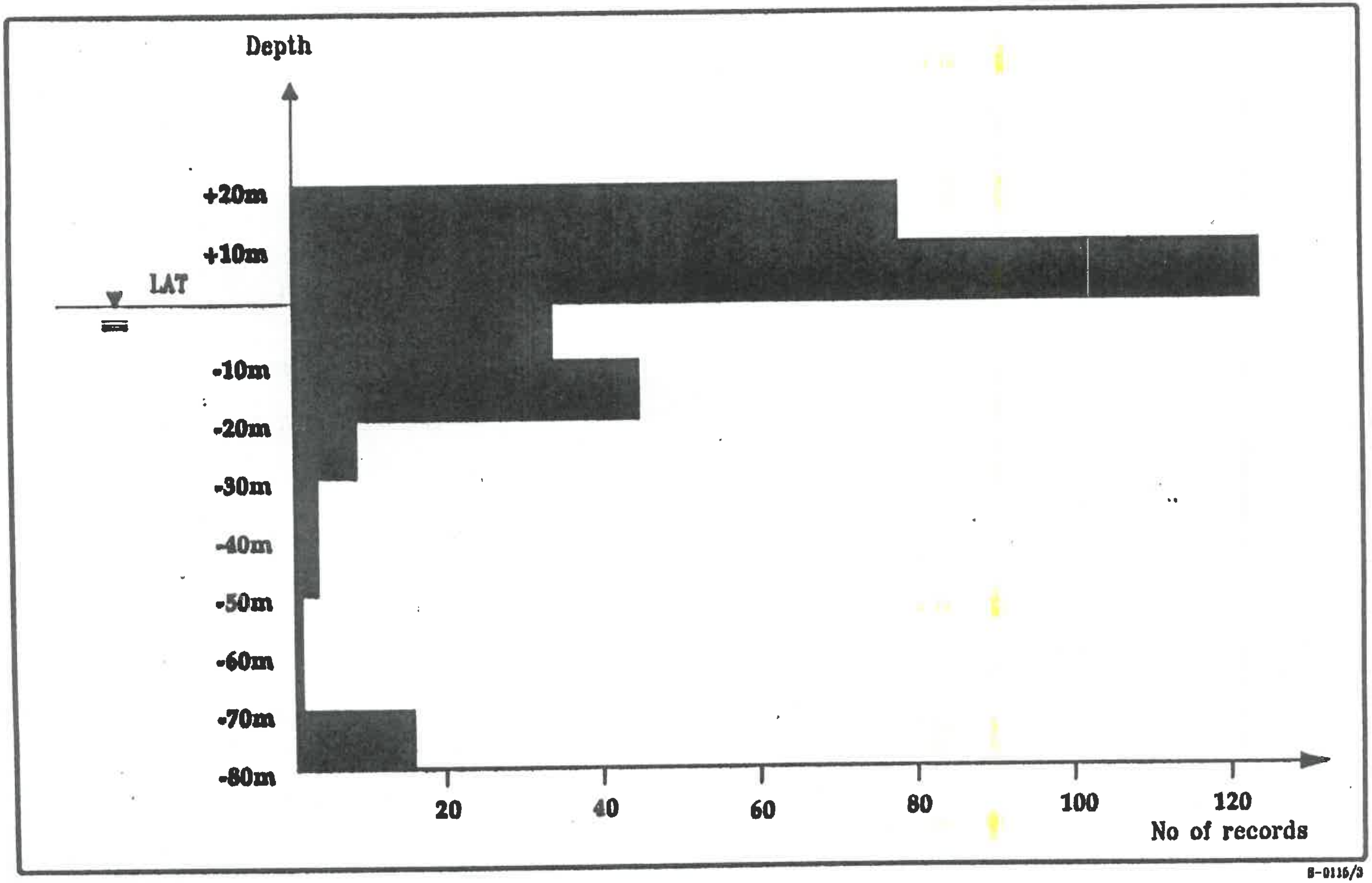
Figure 2



CRACKS