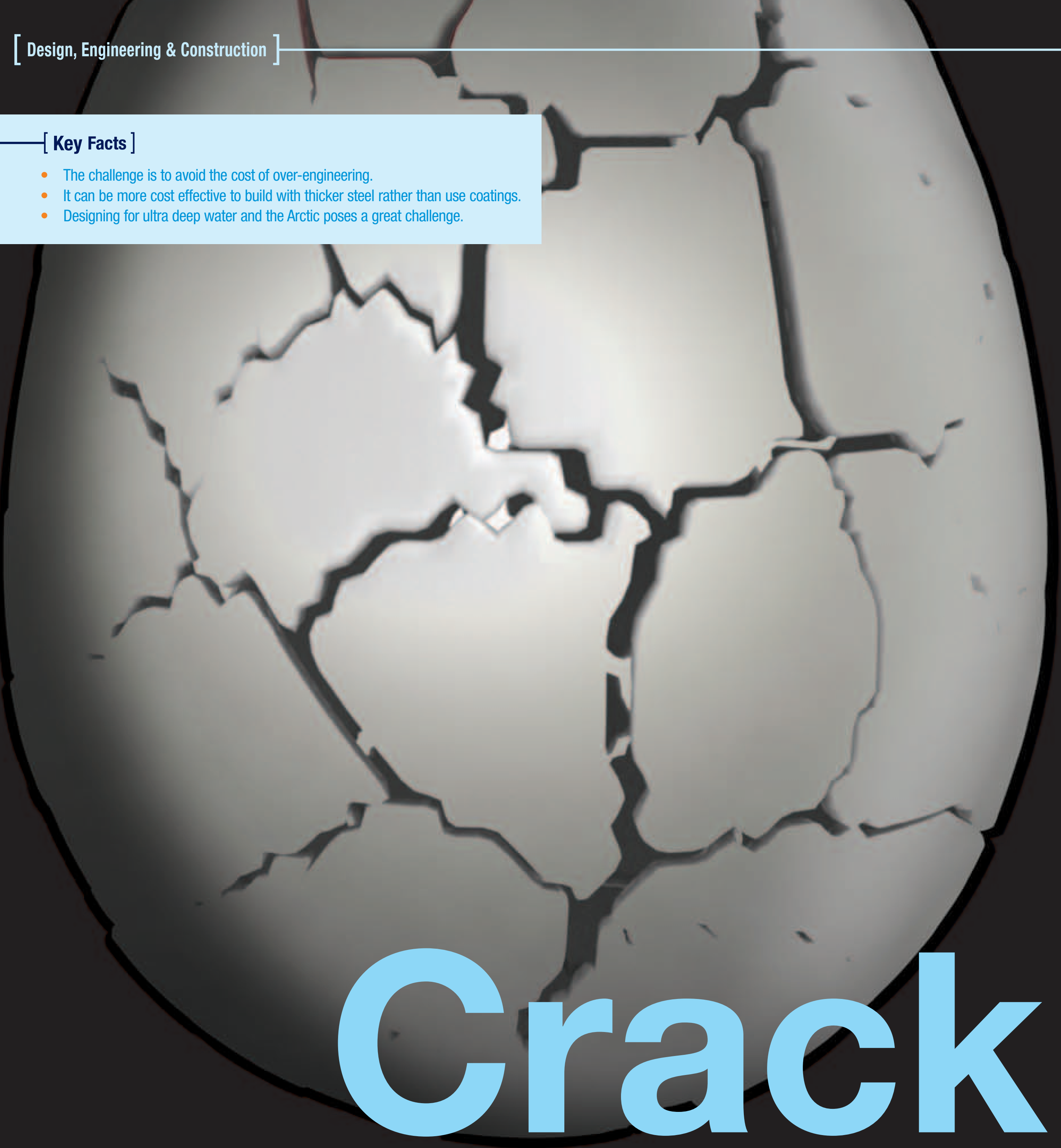
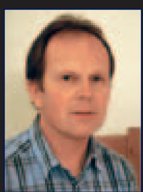


[Key Facts]

- The challenge is to avoid the cost of over-engineering.
- It can be more cost effective to build with thicker steel rather than use coatings.
- Designing for ultra deep water and the Arctic poses a great challenge.

Crack in the system



Tougher standards in corrosion control and fracture risk analysis were put in place following an incident in 1980, in which one of the legs of the semi-submersible Alexander L Kielland rig fell off. Nigel Ash speaks to Professor Bernt Leira (far left) of the Norwegian University of Science and Technology, and Jan Inge Delane (left), the chief engineer of platform technology at StatoilHydro about what remains to be done in this area.

It was only a relatively small hole, drilled in a massive horizontal brace to take a hydrophone to assist the rig's positioning. But the fracture that developed from that hole caused the whole brace to fail in a North Sea gale. In 1980, one of the five legs of the semi-submersible Alexander L Kielland rig fell off. It was an accident that not only claimed 123 lives but also the urgent attention of design engineers. The event resulted in more stringent standards.

'Designing for accidental loads, not simply the hundred year loads and seeking to ensure that that the structure will be able to withstand the 10,000-year wave, wind or an earthquake is now a given', says Professor Bernt Leira of the Norwegian University of Science and Technology, Trondheim. Even if the specification, say for collision resistance, is lowered because a platform will be worked well away from shipping lanes, the need for the structure to withstand large deformation without collapse is absolute.

'With progressive collapse design you design the structure to withstand extreme, worst case loads. Although it will deform, it will remain intact, survive, be load-carrying and also take care of the people who are onboard,' says Leira.

The weakest link

The weak link he admits is estimating loads due to collision, fire and explosion, when the energies involved are uncertain. 'If you have the load right, then the method of calculation is usually quite good within ten percent, except of course in localised areas, where you have stress build ups. But then you have quite good methods to design for the high stresses in those regions. However, when it comes to freak waves, the problem is to find the right wave height or the right wave shape to put a load on the structure. For extreme environmental loads, the uncertainty is on the loading side, not on the stress calculation.

> "With progressive collapse design you design the structure to withstand extreme, worst case loads."

'Operators continue to give serious considerations to having enough safety built into the platforms. Of course, as time passes there may be some relaxation but the basic consideration remains that you should look at the accidental loads that could occur and that you should design for them.' The challenge says Leira is to avoid the cost of over-engineering. "There is always the possibility that you underestimate or overestimate the loads. So the average is hopefully on the right level.'

It is a point borne out by Jan Inge Delane, the chief engineer of platform technology at StatoilHydro. 'The most important challenge is to make sure that you have a good model of the environmental loading and that you have a good model to calculate the response. Then you also need a good detailed knowledge of the hot-spot stresses in the structure.'

'I think it is fair to say that normally we do not detect many fatigue cracks. However, when we do find them, it is very often something to do with the design, an error which has happened during the design phase or alternatively fabrication defects. These latter are classically on the welds and these are the defects that could develop into fatigue cracks.'

[Carte blanche]

Design engineers no longer have to wrestle the money men when planning new rigs.

'I personally haven't experienced major challenges over the cost of a normal design structure,' says Delane. 'The reason for that I am sure is that design is already well defined within the standards and the performance criteria, both with respect to functionality and also to safety performance. Here there are well-defined regulations and standards to meet. Therefore it costs what it costs.'

The challenge comes, he says, as engineering design moves into new areas such as the Arctic. 'We are more uncertain in these areas and as a result it is good design practice to work on conservative assumptions. At this point, finance will often wish to debate conservative assumptions.' Delane considers this an inevitable challenge.

'For any new area where the standards and concepts have not yet matured, the cost of design may turn out to be a larger issue.'

Corrosion and fatigue, though they can come together in deadly combination, remain two distinct materials and design disciplines. Coating is still the most common corrosion inhibitor, now largely water rather than oil-based, followed by cathodic protection, most common on fixed platforms. However, as Leira points out, given that coatings last only between five and ten years and are expensive, it is sometimes more cost effective to build with thicker steel.

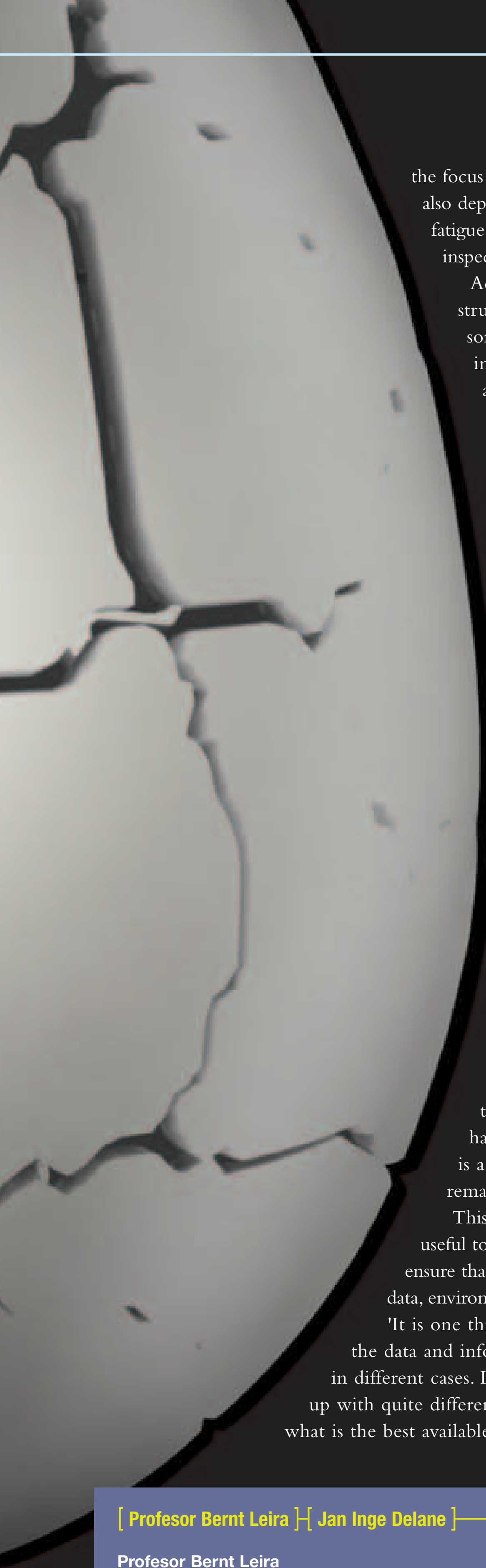
'You have "corrosion allowance". First, you design the structure to a certain thickness that makes it strong enough and then you put down some extra thickness to take into account that it will corrode. In some circumstances steel is cheaper than the coating. If you do it right you still have enough structural strength after 20 years,' he says.

The corrosion resistant properties of alloys, particularly chromium, says Delane, seemed initially to promise a solution. However there remain technical challenges in welding these alloys and such welds appear more prone to fracture. The complexities multiply when alloys have to be welded in Arctic conditions, with difficult pre-heating and post-weld temperature control.

Corrosion prediction has been inhibited by a lack of data of metal deterioration rates in marine environments, says Leira but in the last ten years the work of the Australian Robert Melchers (complemented by that of Carlos Soares in Lisbon) has opened new opportunities.

'Melchers is building probabilistic models for corrosion. You have a mean value for the corrosion rate and then you have some significant statistical scatter around this corrosion rate. The mean value is the best estimate and the scatter gives you the degree of uncertainty around the mean value. From that you can create a probabilistic model.'

StatoilHydro, says Delane, combines the prediction model with inspection regimes. 'We have our general programme for the next five years and during that period of time there will be the annual visual inspection. There will also be some more detailed non-destructive examination and more detailed local visual inspection. The programme, the amount of inspection and



the focus on the different items, all depend on the criticality of the different structure elements. It also depends on the probability of failure of the different elements and among other things, their fatigue life and also the inspection history. Based on this information, we define an annual inspection programme.'

According to Delane, there are few design challenges for existing types of offshore structures and merely a steady flow on improvements. The load models do however sometimes miss the unexpected. The early encounter off West Coast Africa with vortex induced vibration from strong currents meant designers had to come up with fairings and strakes to change the flow pattern and avoid the oscillation.

However designing for ultra deep water and the Arctic, is a different matter says Delane. The strength and flexibility of the risers and moorings are the challenge when designing down to around 3,000m, while 'In temperatures of -40C, there are challenges related to the icing, to different types of ice loading, ice ridges, icebergs and so forth'. He adds, 'It really is difficult to calculate the load on fixed and floating structures from ice, and we are short of good data. There is a lack of load models for some types of ice loading, and only a few standards. But with the challenge of fields like Shtockman is substantial and much technical and design work is going on.'

"It really is difficult to calculate the load on fixed and floating structures from ice, and we are short of good data."

Using semi-submersibles in the Arctic adds Leira poses significant design challenges. Risers will need to be stronger and more flexible. The properties not just of metals but thermo-plastics will need careful analysis and using the current limited data on ice loads, the industry he says "is going to have to think very carefully about the design rules".

Extending structure life

One of the main challenges Delane sees in the next few years is the work currently under way on extending the life of offshore vessels and, in some cases, their capacity – with attendant tensions between surveyors and operators,

'At the moment, there is a lot of work going on to establish and develop standards for life time extension,' he says, 'because we need such standards and also tools to document extended life of the structure. If we have a structure where we have significant fatigue problems, we will come to a situation where we will ask if this is a safe structure. We need good inspection tools. We also need tools for estimating the remaining reliability.'

This is a very important issue because probabilistic fatigue and risk-based inspection is a useful tool when it comes to estimating the remaining life of the structure. But, in order to ensure that we have the right answer, we need very good information and data. We need materials data, environmental information, and information about the quality of inspections, for example.

'It is one thing we need to focus on and develop further. It is important the industry standardises the data and information it already has and comes to a consensus on what data we should be using in different cases. I think, for example, two different companies may use quite different data and come up with quite different results. Therefore, it is important to standardise and reach an agreement about what is the best available data for the different types of inspection and different types of fatigue problem.' ●

[Profesor Bernt Leira][Jan Inge Delane]

Profesor Bernt Leira
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Jan Inge Delane
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