Extreme waves

There can be few people in the world that have as much knowledge about extreme waves as Sverre Haver, StatoilHydro Senior Specialist, Structural Safety. His name has become synonymous with the now infamous New Year Wave" at the Draupner platform. In a rare interview, Mr Haver discusses his fascination with extreme waves and he reveals his thoughts about whether an offshore platform can ever be deemed truly safe.

Mr Haver admits to having a fascination with extreme waves. He speculates that perhaps this originates from his childhood where he grew up on the coast of southern Norway. Winter storms and hearing waves crashing over the cliffs were impressive, he comments but at that time, he naturally, had no idea that most of his career would be involved in the extreme wave phenomena.

Eureka moment A Eureka moment came at university where he studied naval architecture. "I found the study somewhat boring until the third year when I followed a course 'Stochastic modelling of ocean waves'. That was a turning point. Since that course I have never regretted my choice of study."

In addition to being fun, prediction of the most severe wave events corresponding to a target annual exceedance probability, is also very important, he stresses. There are considerable, good quality observations about waves but the amount of observa-

exposed

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tions corresponding to annual exceedance probabilities of say $2*10^{-2}$ or lower, (i.e. a return period of 50 years or larger), is rather limited, Mr Haver adds.

This means that empirical knowledge is limited to occurrence rates much more frequent than those that could pose a threat to a properly designed structure. According to some design codes an offshore structure is expected to withstand the 10^{-4} – annual probability wave event – with at most, some minor local damage. This means that a considerable extrapolation from this empirical experience has to be done in order to predict wave events corresponding to occurring frequencies in the order of 10^{-4} per annum.

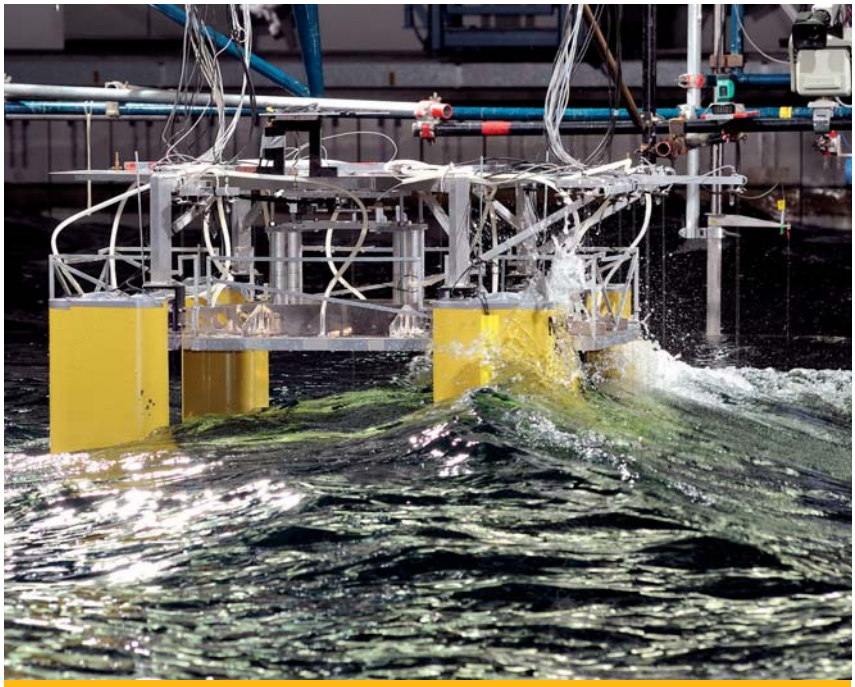
The 10,000-year wave Mr Haver stresses that he prefers to refer to extreme waves and responses by their annual occurrence probability rather than the return period. His experience is that most people are more concerned when the wave is defined as occurring during next year with probability 10^{-4} , rather than the 10,000-year wave – although – of course, it is the same wave.

The extrapolation referred to above, needs support from the underlying physics. "However, the belief regarding governing physics can only be consistently verified from available measurements and yet, we do not have any measurements from the most extreme sea states!", he points out. "Can we be sure that governing physical mechanisms are the same for the 10^{-4} – annual probability weather event as for the 10^{-1} – 10^{-2} weather events?," he asks.

Many readers will associate Mr Haver with the New Year Wave of January 1, 1995, which was measured at a Statoil platform.

Mr Haver took on the role of "presenting this strange beast of a wave" at conferences. Initially, he did a presentation at a wave conference in Banff. But at this time he did not say anything about how unlikely it was. A few years later he presented more details about the wave in Melbourne in Florida. Here, Mr Haver comments he gave his opinion, based on gut feeling, on how the sea surface could have been one or two minutes immediately prior to the wave, during the wave and a few minutes after the wave. Mr Haver was then asked by Professor Al Osborne for the measured time series including the Draupner Wave because he wanted to see if a mathematical model could explain that sort of behaviour. The rest as they say is history. Since then, the Draupner platform wave has been analysed many times by people all over the world.

Do freak waves exist? Mr Haver also has personal experience of this type of wave event. Prior to that winter some work was done from a temporary working platform underneath the cellar deck. The work was not completed before the winter so Mr Haver had to consider whether a temporary deck could be left there over the winter.



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CresT JIP: Towards an understanding of extreme waves and their impact on offshore structures

Wearing his other hat, Sverre Haver is also Chairman of the CresT JIP, initiated by MARIN. This JIP involves nearly 30 wave and offshore experts from industry and academia and aims to improve our understanding of the impact of large wave crests on offshore structures. Since its start in October 2007, numerous field measurements of severe hurricane and major storm environments - including steep wave events - have been analysed by Shell. Hindcast analyses of some of these environments were provided by Oceanweather. A selection of the most extreme environments was calibrated and measured in MARIN's Offshore Basin by a large spatial wave probe arrangement. Forristall Ocean Engineering then analysed these measurements, examining abnormal waves, wave crest and height distribution. Hydrodynamic responses, loads and their impact on a TLP during these extreme sea states were determined by model tests. Designed by Aker Solutions, the TLP was of moderate size and based on those operating in the Gulf of Mexico. The model was built by MARIN and tested in the Offshore Basin. Impressive wave-structure interactions related to wave run-up and high deck loads, due to airgap exceedance, were observed. MARIN is now analysing this data to provide Imperial College and Ocean Wave Engineering with input for the development and use of non-linear numerical models for the prediction of non-linear wave phenomena. Based on the findings so far, DNV will develop enhanced rules and regulations which quantify the risk due to extreme wave crests.

Following the company's standard approach for predicting the crest height level, (resulting effect of tide, storm surge and waves), corresponding to an annual exceedance of 10^{-4} per year, Mr Haver concluded that the deck could be left there. But just after New Year 1995, several messages reached him from the operational unit of the platform. One message was an old friend from university, exclaiming, "You were wrong!". It turned out the platform had experienced a 10,000-year wave!

Fortunately, there was no damage to the platform. But after that event Statoil reviewed its procedure for extreme crest height predictions for the North Sea. In view of the updated crest heights, the annual exceedance probability of the crest height (18.5 m) of the New Year Wave was in the order of 10^{-3}.

Many questions still fascinate Mr Haver. "Do 'real freak' waves really exist?," for instance. Mr Haver admits that at present it is hard to answer this question with reasonable confidence. "Although I think that so-called real freak waves do exist, I will not be deeply concerned provided the observed occurrence rate of 'freak waves' is the true frequency, (i.e. it will be valid also if we experience sea states well beyond those we have frequently experienced). If that is the case they will be too rare to affect the design of offshore structures."

Can offshore platforms be truly safe? Another question always on the industry's mind is if there is any such thing as a safe offshore platform that cannot fail. "Within the framework of acceptable costs, I don't think one can design a structure that cannot fail," he says. The challenge for those involved in the design process is to fulfil all of the rule requirements in a robust way but at a competitive cost," stresses Mr Haver.

A number of challenges still need to be addressed, he comments. One concerns the life extension of existing structures approaching their design life. Another more fundamental challenge, he says, is still the reliable prediction of the frequency of occurrence of the most extreme weather events.

"Since I realised my erroneous faith in numerical methods in the early nineties, I have been involved in a number of model tests."

Are research institutes set to play a role? So what role does Mr Haver see for research institutes in this field of extreme waves and platform response? Funnily enough, he admits, he used to be quite sceptical.

After finishing a PhD in 1980, he started working at the Norwegian Hydrodynamic Laboratories (now Marintek). "At that time I believed that model testing was a dying sort of activity and I did not like the idea of doing model tests." He even pointed out in his interview that he would prefer not to be involved in model testing, although he was applying for a job at a ship model basin! Despite this, he got the job and worked there for three years (but without doing any model testing).

"Nearly 30 years later I see how wrong I was. Since I realised my erroneous faith in numerical methods in the early nineties, I have been involved in a number of model tests."

Mr Haver comments: "My contribution in that respect, I think, is to advocate the importance of doing many repetitions with different random seeds of each sea state, in order to capture inherent randomness properly." This is particularly important when dealing with strongly non-linear response problems – in particular if an on-off mechanism is involved, he adds.

Model testing is more important than ever, stresses Mr Haver. "As we are doing designs for more and more complex structures and also aim for accurate predictions of extremes using sophisticated computer programs, we can not trust our predictions before the tool is validated by model testing.

"Some structural problems are – and I guess will be for a foreseeable future – too complicated for numerical methods. In such cases we need to be able to obtain loads/responses to be used for design directly from model testing."

In the future, Mr Haver believes that research institutions will be given more and more assignments that require both model testing and the use of computer tools in order to deliver what the customer requires.