ABSTRACT

The oil companies nowadays are turning their attention towards the oil and gas deposits lying deep in the oceans and to trap them out from the oceans, it is important to think beyond the fixed platform technologies. It is a well known fact that for shallow water, fixed platform can be used, but for deep water this would results in impractical dimensions and excessive material use, which adversely influence the cost, both for fabrication as well as for the installation. Therefore, the concept of special deep water towers called compliant offshore structures comes into consideration because of their lessened structural weight. Three types of such structures, widely employed are: *Guyed Towers*, *Tension Leg Platforms* (TLP) and *Articulated Tower Platform*s (ATP). The Articulated tower is a compliant structure which is economically attractive especially as loading and mooring terminal to deep waters. It is a linear structure, flexibly connected to the sea bed through a universal joint and held vertically by the buoyant force acting on it. The tower does not resist forces due to wind, waves and currents rather these forces are countered by a large buoyancy force. By providing one or more intermediate hinges in the tower, it will become more economical for deeper waters and will be called as multi hinged Articulated tower. Since the Articulated tower is a compliant structure and is free to oscillate along with the waves, the wave force on the structure is much less than that of a fixed structure. The dynamic amplification factor is low compared to the other fixed structures, since its natural frequency is much less than the frequency of wave. For storage and loading of oil into the moored tankers, these towers are used as a portable offshore system. This arrangement is economical and suitable for areas where production of oil is limited thus, saving the expenses on lying of pipe line. Articulated towers can be transferred and installed at other place with minimum cost, when it is found that oil is getting depleted at working site.

In the past, significant research work has been done in the field of Articulated towers but the computation of wave forces has been done with the application of Airy's linear wave theory. Though Airy's theory is very useful but the theory is a simple theory of wave motion with the assumption of sinusoidal wave form whose height is small in comparison to wave length and water depth. In real environment this condition does not exists and researchers applied this theory for their convinience. When waves become large or travel toward shore into shallow water, higher order

wave theories are required to describe the wave phenomena. These theories represent nonlinear waves. As sea is in itself of very complex nature, there exist many nonlinearities, so the behaviour of sea can never be ascertained by linear wave theory and therefore, the study of nonlinear wave theory is imperative. The present study deals with the investigation of the dynamic response of a double hinged Articulated tower platform under the action of wind, wave and current. The wave forces has been computed with the application of Stokes' fifth order wave theory. The Houbolt method has been used for the solution of nonlinear equations. A computer programme has been developed for the dynamic analysis of double hinged Articulated tower. Two Articulated tower models has been selected for the comparative response under the application of Airy's linear wave theory and Stokes' nonlinear wave theory. The Articulated tower comparative response has been meticulously studied under two sea state with or without current and establishes the worth of Stokes' fifth order wave theory.

Once it has been established that Stokes' theory is giving more accurate results in comparison to linear wave theory, the study has been extended to random waves and varying current velocity. Five sea states has been considered to ascertain the dynamic behaviour of Articulated tower. Responses are obtained in the time domain with the consideration of various nonlinearities such as large displacement, variable submergence and variable added mass. The hydrodynamic loads has been computed with the use of Morison's equation, and Monte Carlo simulation is adopted to assess the random sea environment. Time traces and PSDs of the responses under the five sea states show the wave and low frequency responses.

The study further extended to the dynamic analysis of Articulated tower under the action of wind, waves and currents to approach very near to the realistic environment. Three sea states has been considered and standard wind velocity spectrums, viz; Ahsan Kareem and Ochi and Shin are used to model random wind loads. The Pierson Moskowitz sea surface elevation spectrum has been used to model the random wave loads. The responses has been obtained under single point and multi point wind field for both the wind spectrum. The study highlights lot of imporatnt results which may be beneficial to the design of offshore Articulated tower structure.

The critical reliability or safety assessment of Articulated Tower's joint (bottom and intermediate) is all the more important as its failure may lead to the failure of the entire structure causing a great loss of money, life and the energy resources. In order

to avoid the risk of a catastrophic failure, and dangers involved, their reliability assessment is very essential. The study has been extended to the reliability assessment of base and intermediate articulation joint under the action of wind, wave and currents. The reliability assessment against cumulative fatigue damage caused by wind and wave fluctuations with the effect of current has been carried out for two tower models. The S-N curve approach and Fracture Mechanics approach has been used to calculate the cumulative fatigue damage of articulation joint. The Advance FORM and Monte Carlo simulation method has been used for the assessment of reliability. It has been found that results given by S-N curve approach gave conservative estimate of probability of failure as compared to Fracture Mechanics approach.

The study provides a lot of important results which will be helpful in the field of offshore structures particularly Articulated tower platforms. The Stokes' fifth order non linear wave theory assessed the wave forces more accurately in comparison to Airy's linear wave theory. The dynamic analysis of Articulated tower is greatly influenced with the use of Stokes' fifth order non linear wave theory. Further, the investigations shows that the dynamic and reliability analysis of double hinged Articulated tower under wind, wave and currents would be an important consideration in the design of towers. It is understood that the design of offshore tower should be to the norms of serviceability and safety of the structure. The fatigue damage of articulation joint is an important concept and the serviceability and survivability of the Articulated tower platform depends mainly on the life of articulation joints. The study would prove to be all time beneficial in the design of Articulated tower platforms.