TU Delft

Offshore & Dredging Engineering

Technische Universiteit Delft

Dynamic analysis of the Ampelmann GXL gangway

The Ampelmann system is an active motion compensation system that can compensate the vessel motions in six degrees of freedom. The Ampelmann, together with the attached gangway, makes it possible for people to transfer between a vessel and offshore structures safely.
The Ampelmann system has been designed in the early stages based on a set of static load cases. For design and analysis related to fatigue life estimation, system operability and control improvements, it is necessary to obtain more insights in the structural dynamics of the system. With the earliest system approaching a lifetime of 10 years, fatigue lifetime is of high importance and forms the main goal of this study

The main function of the Ampelmann gangway is to serve as a bridge for people transfer between the ship, where the Ampelmann system is placed on board, and the offshore structure. Ampelann utilize various types of gangway in the market. This will be focus primarily on the most widely used gangway (G25), which consist of a Main Boom and a telescoping T-boom. The transfer deck in which gangway is attached to is assumed to be rigid.
To asses G25 for fatigue, first dynamic behavior under certain loading must be determined. In general the gangway in operation experiences various load conditions, which have to be taken into account. However, in this only the load condition under steady wind velocity, base excitation and rotation of the gangway under applied torque is considered.
The T-boom cross section, dimension as well as weight are different to the main boom. The gangway as a whole consist of three parts: the main boom, overlapping T-boom in the main boom and the T-boom. The gangway is modeled as a step or segmented Euler-Bernoulli beam to describe the dynamic characteristic. The dynamic characteristics are the mode shape and natural frequency in its vibrating plane. Since the gangway is a 'U shape' like beam, the offset of the shear center will cause coupled effect between bending and torsion in its relevant vibrating plane. A one dimensional Finite Element Beam model is implemented to determine the structural vibration characteristic and the dynamic behavior under external loading.

From experimental data the damping ratio was determined and the free vibration decay between the one dimensional model and experiment was compared. It was found that the period of vibration and the static deflection of the model is slightly higher than experimental data. The dynamic behavior of the gangway under constant wind velocity was investigated. The results show that for high wind velocity the gangway is highly damped due to the aerodynamic damping in the model and also appears that bending displacement damped out faster than the torsional displacement.

Two models were used to describe the dynamics of the gangway under base excitation, the first one being a sinusoidal model and the second model being a pulse excitation. The sinusoidal model is used to describe when the Ampelmann system is in non-compensation mode where the base dynamics are dominated by wave-induced vessel motions, while pulse excitation describes the system in compensation mode where the dynamics are dominated by the hexapod reaching its workspace limits. No coupled motion is expected in this case since the shear center lies on the vibrating axis. The results in sinusoidal model shows that the steady state is rapidly reached and less abrupt oscillation is observed when compare to the pulse excitation model.

Vibration of the gangway during operational cycle (Luffing, Slewing and Telescoping) were also investigated without the wind loads and base excitation and later used to determine the fatigue life of the Ampelmann system. During telescoping motion of the gangway is was observed that the period of vibration decreases and increases when the T-boom is retracting and extending respectively.
The fatigue life time analysis was done according to the stress life approach and rainflow cycle counting was used to obtain the number of stress cycles. The results show that the Ampelmann gangway can withstand up to 10^6 operational cycles. However, it should be emphasize that during operation external loadings is always present. Thus, the fatigue life time of the gangway will be lower than the expected number of operational cycles.

Student	Sponsor	Thesis committee
Yiu Cho Chung	Ampelmann Operations B.V.	Prof.dr. A. Metrikine
July 6th, 2016		Ir. T. Lu
		Dr.ir. K.N. van Dalen
		Ir. M. Gutierrez
		Ir. A. Ronse