

Direct Calculation Approach and Design Criteria for Wave Slamming of an FPSO Bow

Ge Wang, Shaojie Tang and Yung Shin
American Bureau of Shipping, Houston, Texas, USA

ABSTRACT

Wave slamming is a recognized hazard for an FPSO. Severe slamming may cause damage to structures and possible flooding of compartments. The consequences of wave slamming can be mitigated through a combination of enhancing structural design and implementing preventative operation procedures. The design of an FPSO is dependent on the installation site. This requires direct calculation tools, but a complete analysis system does not seem to be available. This paper presents a direct calculation approach, which may be used for designing shell scantlings of an FPSO bow against wave-impact loads. This approach includes determining ship motions relative to waves, calculating wave-slamming pressure, analyzing structural responses, and judging the acceptance of a design. Because this approach is based on some engineering programs and analytical formulae, it is also a practical engineering analysis methodology. Its practicability is demonstrated by applying it to the design of an FPSO bow for 3 different installation sites. The approach is applicable to both new constructions and conversions, and it can be used for investigating damages due to wave slamming.

INTRODUCTION

Hydrodynamic impact loading accounts for more than 10% of structural damages for conventional vessels. It has been a design consideration to prevent such damages and/or minimize the consequences. Major classification societies have established rules to address slamming for commercial ships; these rules are based on experiences and many investigations using first principal technology.

More and more ship-shaped FPSO are seen in offshore oil exploration; they are similar in many ways to oil tankers. Wave slamming may also cause damage to hull structures. Damages have been reported in FPSO bow structures that are believed due to the severe slamming load (MacGregor et al., 1999). Relevant design standards generally rely on long-term experiences gained from commercial ships (e.g., ABS 2000).

An FPSO is intended to serve a specific field for a specific time span, a different situation from commercial ships, which are generally designed for unlimited services of approximately 20 years. Because of this mission and site dependency, it is not fully justified to directly apply the experiences of oil-tanker designs to FPSO. Direct calculation approaches provide more detailed information with respect to specified service life and installation sites, and are thus more suitable for use as design tools for FPSO.

A direct calculation approach to help design for slamming does not seem to be available in a complete form. The purpose of the present study is to present a direct calculation approach that may be used in the design stage. The engineering methodology uses a series of practical engineering tools to calculate both loads and structural responses, based on which structural scantlings may be determined.

RISKS

Wave slamming is a recognized hazard for an FPSO. Severe wave slamming may cause indentation or rupture of shell plating, buckling or detaching of supporting members, significant deformation of main supporting members, collapse of bow structures (forecastle, members supporting mooring systems) or collapse of hull girder. These structural damages may result in flooding of some compartments, damages to topside equipment, deck houses or such mounted on/near the bow, damages to mooring systems, or loss of the entire vessel.

Fig. 1 shows a profile of an FPSO bow and a portion of its No. 1 tank. The shadowed area is where hull structures are probably susceptible to wave-slamming damage.

Indentation and rupture of shell plating and severe local deformation of supporting members are very likely. Indentation of shell plating is the most frequently reported damage. Design for

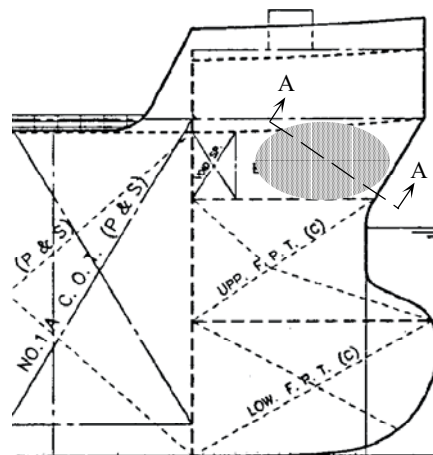


Fig. 1 Bow and No. 1 tanks typical of an FPSO. Shadowed area susceptible to wave-slamming damage. See Fig. 3 for reference to AA section in case study.

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