SSC Project Recommendation for FY 2016

Fatigue analysis of aluminum stiffened panels of marine structures using a FEA package and experimental investigations

Submitted by: Diego Sarzosa (dsarzosa@usp.br) - PNV (University of Sao Paulo, Brazil) &
José Marin (jrmarin@espol.edu.ec) - FIMCBOR (Escuela Superior Politécnica del Litoral, Ecuador)

1.0 OBJECTIVE.

1.1 To get a better understanding of fatigue problems of stiffened panels by carrying out experimentation with laboratory tests.

1.2 To evaluate the structural integrity of aluminum panels by using Finite Element Analysis with a commercial software.

1.3 To define a robust methodology for fatigue assessment of critical hot spot points in marine structures.

2.0 BACKGROUND.

2.1 Marine structures have experienced challenges through their different stages of evolution and development. Designed to withstand cyclic loads of the environment over their life cycle, structural analysis is compulsory required to understand the behavior of the ship under its operating conditions. Fatigue evaluation of structures has become more and more important over the years. In fact, during the last century, a substantial increase of references about it have been noticed compared to the previous one (Schijve, 2003), mainly due to failure cases occurred after load cycles. These failure cases are the result of the development of microcracks, which after a time increase, become so large that the fracture occurs. Although research about fatigue has increased, there are still several details not yet fully understood. This is because this structural phenomenon could be caused by many reasons as incorrect prediction of cyclic loads, improper design, or to bad workmanship (Hughes & Paik, 2010), which need to be tested in laboratory and compared with finite element analysis. (Li et al, 2014)

2.2 The interaction between the severe environment conditions and aluminum vessels is a complex problem that is not fully explained. Ships structures, comprised by stiffened panels, are usually subjected to a high-cycle fatigue occurring for a high number of cycles in the range of elastic deformations, (Hughes & Paik, 2010). Regarding the significant stress ranges under a ship operates, the presence of cracks in the ship's hull might be a threat to the structural integrity of the vessel. Due to the intricacy and involvement of several aspects to be considered into the analysis, it is necessary to carry out research to get a better understanding of the overall process of fatigue phenomenon of aluminum stiffened panels including the three stages of the process: crack initiation, crack propagation and final failure (Hughes & Paik, 2010). In order to do this, it is necessary to implement a project to deal with fatigue of marine structures, using marine aluminum with different material properties and stiffeners configurations, regarding common ships construction. To deal with this complexity, the project will be split in two different locations of two excellent Latin-American Universities such as USP, based in Sao Paulo, Brazil, and ESPOL, located in Guayaquil, Ecuador. The first university will be dealing with experimental investigation whilst the second one will be working on the development of numerical models of stiffened panels after an extensive consideration of references about this topic carried out by teams of both universities. Finally, a comparison of results will be carried out by the team of the project, comprised by at least these researchers:

- USP — Diego Sarzosa, PhD (dsarzosa@usp.br) ***Group Leader***
  Vitor Scarabeli, MSc. (vscarabeli@usp.br)
- ESPOL — Jose R. Marin, PhD (jrmarin@espol.edu.ec) ***Group Leader***
  Daniela Benites, MSc. (dbenites@espol.edu.ec)
  Guillermo Garcia, MSc.(gxgarcia@espol.edu.ec)

3.0 **<u>REQUIREMENTS</u>.**

3.1 Scope.

The scope of the project about "**Fatigue analysis comparison of aluminum stiffened panels of marine structures using a FEA package and experimental investigations**" will be:

3.1.1 The Contractor, comprised by USP and ESPOL, shall conduct a complete assessment and literature review about fatigue problems of stiffened panels of aluminum material. In order to do this, databases, articles and journals will be included as the main sources of the information to this first step. In addition, references about software packages will be collected regarding their capabilities on fatigue analysis and the possibility to include new theoretical formulations, in case this is needed. Special consideration will be made on how relevant is this software today, as a way to use the most updated tools available.

3.1.2 The Contractor, comprised by USP and ESPOL, shall built 15 stiffened panels (specimens) with different geometries to simulate several subcomponents of the vessel to be tested in the laboratory. These tests will be carried out using laboratory facilities available at the USP.

3.1.3 The Contractor, comprised by USP and ESPOL, along with each type of specimen (stiffened panel), will developed a numerical model to compare with the stiffened panel, including any defect obtained from the construction process. To do this, both teams of the contractor will be in constant communication, and from specific dates regarding the schedule, there will be a meeting to discuss any weaknesses or threats that might cause any delay in the execution of the project.

3.2 Tasks.

Regarding the scope of the project, these macro-tasks will be considered in order to successfully carry out the project:

3.2.1 The Contractor shall compile publications, journals, and articles referring to the topic of the fatigue phenomenon.

3.2.2 The Contractor shall define the characteristics of the stiffened panels to be tested. In case SSC has any special requirement to be tested, and regarding the capabilities of the laboratory, it will be included during the experimental investigations.

3.2.3 The Contractor shall acquire all the implements (marine aluminum plates, consumables, etc.,) in accordance with the previous step, and hire the adequate personnel or company to build 15 specimens.

3.2.4 The Contractor shall analyze the software market of FEA packages in order to buy that one with all the capabilities to carry out fatigue analysis.

3.2.5 The Contractor shall test 15 specimens built before in the laboratory facilities of the USP.

3.2.6 The Contractor shall develop numerical models to compare results with laboratory tests. Once these tasks are completed, there will be a meeting to present an analyze result with the leaders of both teams.

3.3 Project Timeline. See Enclosure (*x*).

4.0 GOVERNMENT FURNISHED INFORMATION.

4.1 The Contractor will follow the standards for the Preparation and Publication of SSC Technical Reports, regarding the instructions available at the SSC website.

5.0 DELIVERY REQUIREMENTS. (Identify the deliverables of the project).

5.1 The Contractor shall provide quarterly progress reports to the Project Technical Committee, the Ship Structure Committee Executive Director, and the Contract Specialist.

5.2 The Contractor shall two (2) reports regarding the deliverables of the project. The first report will be about the revision of the literature review accomplished during the first step of the project. The second report will be a complete description of the methodology, tests instructions and numerical model carried out during the execution of the project.

5.3 The Contractor shall provide a print ready master final report and an electronic copy, including the above deliverables, formatted as per the SSC Report Style Manual as posted on the website http://www.shipstructure.org.

6.0 PERIOD OF PERFORMANCE.

6.1 Project Initiation Date: June 2016.

6.2 Project Completion Date: December 2017 (18 months from the date of award)

7.0 GOVERNMENT ESTIMATE. These contractor direct costs are based on previous project participation expenses.

7.1 Project Duration: 16 months.

7.2 Total Estimate: $ 95.000,00 USD

7.3 The Independent Government Cost Estimate is attached as enclosure (*x*).

8.0 REFERENCES.

8.1 The references to prepare this proposal are listed below:

- A state-of-the-art review on fatigue life prediction methods for metal structures, Cui W., Marine Science and technology, 2002
- Fatigue of structures and materials in the 20th century and the state of art, Schijve J, International Journal of Fatigue, 2003
- Fatigue crack initiaciton life prediction for the aluminium alloy 7075 using crystal plasticity finite element simulations, Li Ling, Shen L., Proust G., Mechanics of material, 2014
- Ship Structural Analysis and Design, Hughes O. F., Paik J. K., Society of Naval Architects and Marine Engineers (SNAME), 2010