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VOLUME 3

DISCUSSION ON THE REPORT OF

TECHNICAL COMMITTEE II.1

QUASI-STATIC RESPONSE

MANDATE

Concern for the quasi-static response of ship and offshore structures, as required for safety and serviceability assessments. Attention shall be given to uncertainty of calculation models for use in reliability methods, and to consider both exact and approximate methods for the determination of stresses appropriate for different acceptance criteria.

CONTRIBUTORS

Dr. S. Valsgård, Official Discusser

Prof. W. Fricke
Prof. K. Suzuki
Dr. Ph. Rigo
Mr. D. Catley
Dr. T.P.J. Mikkola
Prof. C. Guedes Soares

Reply by:

Dr. R. Porcari

Session Chair:

Prof. J.W. Lee

CONTENTS

Niemi, E. (Ed.) (1995). *Stress Determination for Fatigue Analysis of Welded Components*. Abington Publishing, Cambridge (UK).
Poutiainen, I. and Niemi, E. (2000). The determination of hot spot stress in gusset structures using a coarse element mesh. IIW-Doc. XIII-1820-2000, International Institute of Welding.

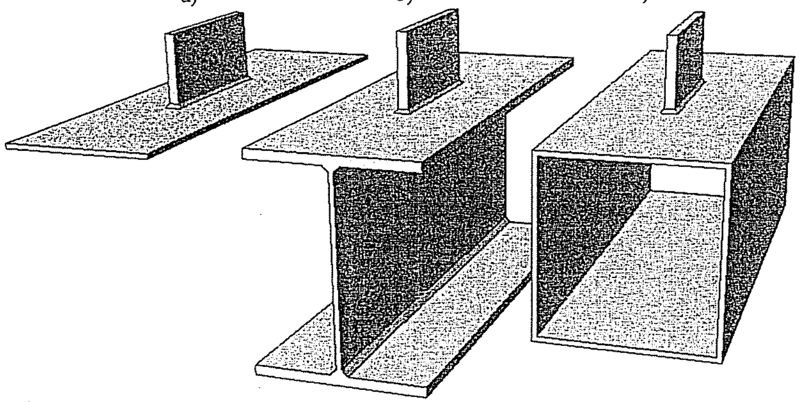

Fig. 1: Longitudinal Gussets investigated by Poutiainen and Niemi (2000)

1.2.2 Prof. K. Suzuki (Japan)

I would like to congratulate on the wonderful work on the committee. The committee report not only review the recent works, but also gives many suggestion and stress on the importance of finite element modelling. As all of us knows, the accuracy of the analysis greatly depends on the model, not only in the sense of discretization, but also in the sense of idealisation, which committee report deals with intensively.

If I may allowed, I would like to advice to add some more recent work on the field of computational mechanics.

Committee report handles guidelines of how finite element mesh should be generated, and gives examples. However, these kind of results greatly depends on the element type, not only 4 node or 8 node etc. but definition of the shape function. For example, element with assumed strain or assumed stress method is said to give better results than just simple assumed displacement element, and MSC/NASTRAN and other commercial code does use these element implicitly.

Also mesh free analysis has been developing recently quite rapidly. Some quotation is shown in the section of adaptive method, but more detailed review is advised.

1.2.3 Dr. Ph. Rigo (Belgium)

I congratulate the II.1 committee members for their excellent and valuable report. Being involved in the development of optimization tools I would like to raise the committee attention on a specific point that has not been mentioned in the II.1 report (neither in IV.1 and IV.2 report). It concerns the importance of the rational design formulations (also called first principle approaches) for ship optimization at the preliminary design stage.

The preliminary design stage is the best time and least cost-sensitive period to perform global ship structural optimization. It is the relevant time to change the scantling to reach a specific goal, for instance, the minimum construction cost or the minimum weight. After the preliminary design, impact of design changes on the schedule and on the cost becomes larger and larger. Thus, it is too late to optimize the structure.

It is important to mention the development of new optimization software's dedicated to preliminary ship design. For instance, we could mention the LBR-5 software developed at the University of Liege, Belgium (Rigo 1998, 99 and 2000) in collaboration with IRCN (French Research Institute in Naval Architecture). This program is based on a coherent group of 3 modules including:

- A set of rational structural constraint (direct analysis procedure) to define the constraints (yielding, buckling, ultimate strength, deflection…),
- A least construction cost defined as being the objective function and including production parameters
- A mathematical optimizer based on a convex linearization combined with a dual approach.

In conclusion, we believe that the next Committee II.1 (in agreement with Committee IV.2) should in the future have a greater attention on the optimization-oriented methods. Such methods are specific to design stage and optimization techniques. They have to form a coherent set that cover all the failure modes or limit states. They concern modeling technique, quasi-static analysis, buckling, ultimate strength, etc. One of the future ISSC'2003 committees should report their advances and specificities.

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Rigo, Ph. (1998). An integrated optimisation model for hydraulic and naval structures (Développement d'un modèle intégré d'optimisation des structures navales et hydrauliques), Thesis: Agrégation de l'Enseignement Supérieur, *University of Liege*, Belgium, 378.
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Rigo, Ph., Toderan, A. (2000). Least cost and scantling optimization at the initial design stage of ships, *ICETECH 2000 Conference*, St. Peterburg, Russia.
Rigo, Ph., Hage, A. (2000). LBR-5, A ship hull optimization tool, *SIMOUEST'2000, European Conference*, Marine Technology, Nantes, France.

1.2.4 Mr. D. Catley (UK)

I have been involved with ISSC for seven congresses and have not previously observed such a strong overlap between this committee report and the Design Methods committee report. A lack of collaboration between these committees is suggested by the reference in section 3.1.2 (Direct Calculations) to an individual paper rather than the exposition of the evolving classification society systems, which is given in the Appendix to IV.2 report where it surely belongs. The exposition, albeit with a different emphasis, is then also given in section 4 of the current report! I would like echo a comment of the Official Discusser and to see improved integration of the ISSC reports prior to their publication.

A second point is that in section 3.3.1 the KCS TRIBON system was restructured over a year ago with the withdrawal of the Initial Structural Design System, the functionality of which has been included in a Basic Design module. In this approach, symbolic representation is used for modelling the structure prior to its explicit definition for production purposes in the TRIBON Hull module. This distinction is not brought out in the report.

strength assessment process, relevant activities and progress should be mainly carried out and monitored in co-operation with future Committees I.2, VI.2 and III.1.

2.2 *Reply to Floor and Written Discussers*

2.2.1 *Reply to Prof. W. Fricke*

The Committee thanks Prof. Fricke for his comments and additional contributions to the report. He mentions his paper presenting a new beam element able to improve displacement and stress prediction. It was referred in section 3.3.2 on F.E. modelling techniques on page 155 but unfortunately it was omitted in the list of references. The Committee apologizes for that.

Prof. Fricke concentrates his questions and comments to the results of the comparative study, and in particular to the underestimation of the hot spot stress by shell elements at bracket toe in position 1. This underestimation is confirmed by other studies, including the report of the previous Committee. This behaviour is essentially due to the poor capabilities to model local geometry by shell elements, especially when the bracket is positioned at an underneath web. In fact in this case bracket elements are directly connected to the web elements without considering the flange thickness effect.

Shell elements are simple elements suitable for modelling three-dimensional thin walled structures and show all their limitations when thickness effects cannot be neglected neither in terms of geometry nor in terms of strain components as in this case.

Some approaches have been investigated in order to enrich the modelling capabilities of shell elements by means of artifices such as the introduction of constraint equations or internal links, the use of extra thickness and the modelling of fillet weld by inclined shell elements (Tveiten *et al.*, 2000).

Results can be quite good, however, their quality seems to be highly dependent on the analyst's skill and experience, making these procedures probably not so suitable for adoption in usual structural design offices at shipyards.

In this scenario, an alternative way, as already mentioned by the official discusser, could be to consider less sophisticated approaches for the analysis and to adopt different extrapolation schemes (e.g. quadratic), this should allow to achieve in an easier way the same quality of results.

REFERENCE

Tveiten, B.W., Moan, T. (2000). Determination of structural stress for fatigue assessment of welded aluminium ship details. *Marine Structures*,13:3, 189-212.

2.2.2 *Reply to Prof. K. Suzuki*

The Committee thanks Prof. Suzuki for his contribution to the discussion of the report including some practical indications about types of finite element to be adopted. As far as adaptive techniques are concerned, the Committee recommends them and finite element convergence studies among topics to be included in the future Committee work.

2.2.3 *Reply to Dr. Ph. Rigo*

The Committee thanks Prof. Rigo for his additional contribution on optimisation techniques to be used in the preliminary design stage. The report does not include a specific section about optimisation but only few studies about weight and cost optimisation are referred in sections concerning reliability analysis, double hulls ships and containers ships.

A possible cooperation with Committee IV.2 is definitely a good suggestion for future work of the Committee.

2.2.4 *Reply to Mr. D. Catley*

A better collaboration among committees surely would allow an improved integration and complementariness of committees' reports. This intention is always at the basis of the work planning of each committee at the beginning of its three years mandate, but in practice it is very difficult to obtain final reports duly checked, integrated and without overlaps. Generally speaking, it is probably better having some overlap than some lack of information about some topic.

As far as the KCS TRIBON system is concerned, unfortunately we had available reference not so updated to report recent TRIBON restructuring.

2.2.5 *Reply to Dr. T.P.J. Mikkola*

Dr. Mikkola suggests an explanation for the underestimation of hot spot stresses by shell elements consisting in the modelling of connection of the bracket to the flange. As mentioned in the reply to Prof. Fricke, surely the two dimensional modelling capabilities of shell elements seems not adequate to represent the real three dimensional geometry of the welded joint and relevant effects on stress-strain field. He also says he got quite significant improvements introducing some geometry corrections and some artificial stiffness. These techniques could be quite good and effective ways to improve stress prediction. However, as previously mentioned, these techniques should be managed by structural designers with sufficient skill and experience.

As far as existing studies about measurements accuracy are concerned, generally, published material seems to be quite limited. In our case the results came from two locations with four measurements at each location. The scatter band was so small to be negligible if compared to the calculated results. The problem of measurement accuracy is more a matter of geometrical changes in the fabrication process. Here, there is also a discrepancy between the geometrical data according to the drawing and the actual data after the fabrication process. More or less a problem that cannot be solved for welded structures.

2.2.6 *Reply to Prof. C. Guedes Soares*

The Committee thanks Prof. Soares for comments and additional contribution to the report. Concepts on reliability analysis and design have been included in the report in order to evidence all research activities in this field, and also because this approach is becoming more and more an important part in establishing new design and verification criteria for ship structures. Work carried out in this direction by the European Classification Societies is surely worth noting.

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