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ENHANCEMENTS TO **COUPLE**

by
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CONTRACTOR REPORT

Prepared for

Defence Research Establisnment Atlantic

Centre de Recherches pour la Défense Atlantique

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ABSTRACT

The development and incorporation of the latest enhancements to the COUPLE code are described. The purpose of this work was to ensure that the code runs as efficiently as possible. To this end, several new features and upgrades have been added. These include the implementation of bandwidth optimization routines, updating the code so that it is compatible with version 6.1 of the VAST finite element program, and the incorporation of a number of new subroutines so that matrix calculations for very large models may be performed out-of-core.

RÉSUMÉ

Description du développement et de l'intégration des derniers perfectionnements apportés au code COUPLE. Cette étude avait pour but d'assurèr des passages du code aussi efficaces que possible. Plusieurs caractéristiques nouvelles et améliorations ont été apportées à cette fin, dont la mise en oeuvre de sous-programmes d'optimisation des largeurs de bande, la mise à jour du code pour le rendre compatible avec la version 6.1 du programme à éléments finis VAST, et l'incorporation d'un certain nombre de nouveaux sous-programmes pour permettre d'effectuer les calculs de matrices hors mémoire pour les très grands modèles.

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1. INTRODUCTION

The finite element-based computer program COUPLE [1] has been developed at DREA to work in conjunction with the finite element program VAST [2] to predict the resonant frequencies of submerged or fluid-filled structures. The program, which uses modified versions of several of the VAST routines, is currently compatible with version 5.0 of VAST and some of the sections of COUPLE have not had their functionality maintained as the program has been modified over the last several years. The allowable size of the fluid and structural finite element models are limited to 3000 nodes and 1000 nodes, respectively, in COUPLE as all calculations are performed in-core. These sizes of model are not sufficient for the larger ship structure models which are to be analyzed in the future. The present contract addresses the need to upgrade COUPLE to compatibility with version 6.1 of VAST and to increase the problem size capability of COUPLE by incorporating the currently non-functioning bandwidth reduction routine into COUPLE and by allowing COUPLE to perform the matrix computations out-of-core. In the report which follows, details concerning the development and incorporation of these latest upgrades to the COUPLE code will be presented.

2. COMPATIBILITY WITH VERSION 6.1 OF VAST

Upgrading COUPLE to be compatible with Version 6.1 of VAST was a relatively straightforward task, which for the most part, involved modifying the READ and WRITE statements to reflect the "I5" nodal format used by Version 6.1 of VAST. As a result, modifications to the code were restricted to the main program module "couple.f".

3. BANDWIDTH REDUCTION

3.1 Introduction

In previous versions of the COUPLE program, the sections of the code responsible for bandwidth reduction had been de-activated, resulting in substantially higher solution times than would be the case if bandwidth optimization was available. This deficiency in COUPLE has now been addressed in these latest enhancements to the code. COUPLE has now been linked with the VAST 6.1 bandwidth reduction module BANRD, which provides bandwidth based on a hybrid combination of the Gibbs-Poole-Stockmeyer (GPS) and node shuffling algorithms (NS) [2]. Fortunately, the framework required to handle the bandwidth optimization of the fluid matrices generated by COUPLE was already in place. As a result, most of the work required to implement this option dealt with re-activating and checking older code which already existed. The remaining time spent on this item focused on ensuring compatibility between the COUPLE code and the BANRD subroutines.

3.2 Impact of Bandwidth Reduction on the Performance of COUPLE

Perhaps the most significant effect of incorporating bandwidth reduction into the routines responsible for operating on the fluid matrices generated by COUPLE is the potential reduction in cpu times required to generate the matrix products $[H]^{-1}[Q]$ and $[H]^{-1}[L]$. This is due to the fact that the cpu time required for matrix decomposition is directly related to the matrix semi-bandwidth.

4. COUPLE Out-of-Core Operation

4.1 Matrix Decomposition

In order to perform the the decomposition of the [H] fluid matrix out-of-core, a modified version of the decomposition routines found in the VAST suite were incorporated into an updated version of the COUPLE code.

4.2 Matrix Multiplication

The multiplication of large matrices (too large to reside solely in memory) is now possible in COUPLE. This has been made possible by partitioning the matrices into "blocks", the size of which is limited by the available computer memory. Temporary scratch files are used to store the results generated by performing multiplication on these matrix blocks. Once all blocks have been processed, the intermediate results are then assembled to form the global matrix product.

REFERENCES

1. L.E. GILROY and S. TANG, "An Improved Finite Element Based Method for Coupled Fluid/Structure Eigenvalue Analysis," DREA Technical Memorandum 91/209, 1991.

2. "Vibration and Strength Analysis Program (VAST): User's Manual, 6.1," Martec Limited, Halifax, N.S., December 1993.

3. L.E. GILROY, Private Communication.

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