Parallel computation for three-dimensional static/transient analysis based on FETI methods

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ABSTRACT

In the present paper, finite element tearing and interconnecting (FETI) methods are developed and utilized for large-sized computational problems. The proposed approaches divide the computational domain into non-overlapping sub-domains via Lagrange multipliers. Two types of Lagrange multipliers are imposed in order to enhance the continuity of the displacement at the interface across sub-domain boundaries. While a single set of the linear constraint is added to each corresponding node by using the global Lagrange multipliers, localized Lagrange multipliers are utilized to impose two kinematic constraints by supplying additional nodes. Within this aspect, the number of the degrees of freedom in localized Lagrange multipliers becomes twice larger than that by the global Lagrange multipliers. In addition, mixed Lagrange multipliers are used to take advantages of both Lagrange multipliers. Practical performance of the proposed methods is conducted by going through both static and time-transient analysis based on three-dimensional problems.

INTRODUCTION

One challenging problem in large-size computational analysis is related with its tremendous computing time and memory usage. The domain decomposition methods were developed to relieve such increased time and memory usage. One of such approaches is FETI method suggested by Farhat, et al[1] and further developed by Kwak, et al[2]. In addition, the three-dimensional computational problems are evaluated by the present authors[3]. In this paper, a three-dimensional shell element is used to analyze both static and time-transient problems.

NUMERICAL APPROACH

The total potential energy of the object is composed of the three components, as follows.

$$\Pi = \mathrm{A} + \Phi + \mathrm{V}_c \tag{1}$$

where A, Φ and V_c indicate respectively the total strain energy of the object, the total potential of the externally applied loads and the potential of the constraints. The penalty coefficients $(\bar{p}_g, \bar{p}_l)$ are added in order to manage the flexibility matrix of each subdomain corresponding to the global and local Lagrange multipliers. Finally, the principle of minimum total potential energy can be derived as follows.

$$\begin{bmatrix} K^* & -diag(P_{L_\alpha}) & R^T dia(P_{G_\alpha}) & diag(P_{L_\alpha} S_\alpha^T) \\ -C^T diag(P_{L_\alpha}) & C^T diag(P_{L_\alpha}) & 0 & -C^T diag(P_{L_\alpha}) \\ diag(P_{G_\alpha}) & 0 & 0 & 0 \\ diag(P_{L_\alpha} S_\alpha) & -diag(P_{L_\alpha})C & 0 & 0 \end{bmatrix} \begin{pmatrix} u \\ c \\ \lambda_G \\ \lambda_L \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \\ 0 \\ 0 \end{pmatrix} \quad (1)$$

Further details are included in Ref. [2].

NUMERICAL RESULTS

The present FETI approach is conducted for large-sized computational problems (585,600 DOF's) in parallel computing hardware. Figure 1 shows the three-dimensional configuration of objects and the decreasing trend of computational time with respect to the number of CPU's used.

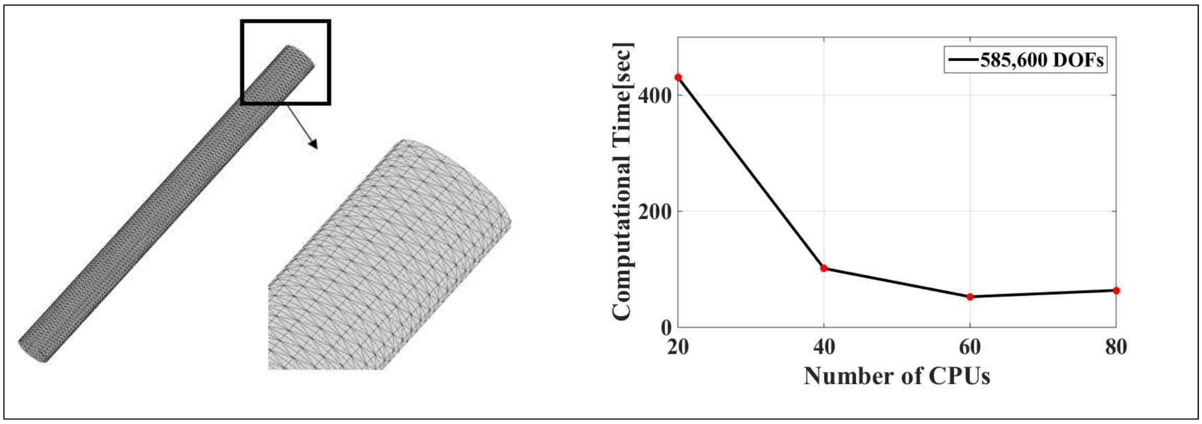

Figure 1. Three-dimensional configuration of structures and the decreasing trend of computational time

REFERENCES

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