M 7/4*

ZUR SYSTEMATIK NUMERISCHER NÄHERUNGSVERFAHREN IN DER STATIK UND DYNAMIK DER KONSTRUKTIONEN

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The availability of efficient computers has shifted considerable emphasis on the utilization of discontinuous methods in engineering. On the other hand, the availability of these facilities has also enlarged the applicability of analytical solutions of mechanical problems, especially the coupling of analytical and numerical methods.

There are several reasons for not applying in every case only the prominent finite difference or finite element methods. In many cases other methods lead to solutions of sufficient accuracy under relatively small requirements for the size of computers and computer-time.

It is worthwhile to classify the manifold methods and techniques to realize the common roots and to show, how it is possible to develop further methods.

The starting points of a classification are the different ways to describe mathematically a physical situation:

differential equations (integro-differential equations) and variational principles.

On the basis of these two different formulations it is possible to develop various methods to solve special, but also more general, problemsin Structural Mechanics. The variational problem is the basis of the methods associated with the names of Ritz, Trefftz and Kantorowich, but also the most frequently used numerical method, the finite element method, is based thereupon. The differential equations are the starting point of various methods as finite differences, dynamic relaxation, and collocation (point matching), least squares and discrete least squares, applied to boundaries and domains. A special case is the application of linear programming to boundary value problems.

In cases where there are restrictions in the values of displacements or forces some difficulties arise, and it is intelligent to apply a simplex-algorithm.

A general method to establish finite differences formulation to a whole range of differential equations is based on collocation. Some other methods (transfer matrices, Fourier-transforms) can be included in the systematics.

Some special methods for solving linear equations are applicable directly to the mechanical models (dynamic relaxation, Monte-Carlo-method). Such way of application is very interesting and avoids the necessity to establish and to handle large systems of linear equations in the computer.

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DISCUSSION

Q V. HOPPE, Denmark

My first question is related to comment no. 3 which states that the Galerkin and the Ritz methods are equivalent under certain conditions. Actually the Galerkin method is a little more general in that it may handle problems that are not self adjoint.
It was mentioned earlier at this conference that it was desirable if the boundary point least square method and the finite element method were brought closer together.
According to my opinion it should be possible to solve differential equations to which complete sets of solutions are available as for instance the potential equation by cutting up the total domain which may be complicated connected into simpler domains in which an exact solution can be composed of a simple set of solutions without any singularities. Then the complete solution can be found by a boundary point least square method on the external boundary as well as on the boundary between the different subdomains. Are you aware of any such solution being used ?

A K. BRANDES, Germany

To your first question: I agree with you that the comment no. 3 to table 1 is not exactly correct in this short form. But the conditions are well-known under which the methods of Ritz and Galerkin are equivalent.
To your second remark: I think that it would be possible to use the finite element method in a more general sense. There are several papers concerned with this problem (s. (2.13), (14.7)). But I did not see up to now papers, which used a method like these you prescribed.

Q H. H. ERBE, Germany

1. Bei der linearen Programmierung und der Kollokationsmethode erreichten Sie einmal sehr schlechte und einmal sehr gute Ergebnisse. Woran prüften Sie die Ergebnisse ? Kann man Aussagen über di e Konvergenz machen ?
2. Bei zeitabhängigen Problemen erhalten Sie nach Ihren Verfahren Systeme von gewöhnlichen DGL's. Können Sie Aussagen machen über Approximationen im Zeitbereich (Raum-Zeit-Elemente) ?

A K. BRANDES, Germany

1. Die Ergebnisse wurden im allgemeinen dadurch überprüft, dass verschiedene Ansätze benutzt wurden. Wenn jeweils etwa gleiche Ergebnisse entstanden, wurde angenommen, dass dies die richtigen seien. Bei der linearen Programmierung veränderten sich die Ergebnisse mit den verschiedenen Ansätzen besonders stark. In einigen wenigen Fällen waren allerdings auch exakte Lösungen bekannt, so dass ein Vergleich numerischer Ergebnisse möglich war.
2. Bisher habe ich noch keine Ergebnisse zu konkreten Aufgabenstellungen. Daher sind mir Aussagen dazu nicht möglich.

Q

U. SCHOMBURG, Germany

Sehen Sie eine Möglichkeit, mit der diskreten Fehlerquadratmethode auch für zweidimensionale Bereiche beliebig vorgegebene Randbedingungen exakt zu erfüllen ?

A

K. BRANDES, Germany

Nein, leider nicht. Ich sehe auch keinen Weg, hier weiter zu kommen, denn eine Gewichtung der verschiedenen Gleichungsarten führt nicht zu einem wirklich brauchbaren Verfahren.