N74-14613

THE APPLICATION OF NASTRAN AT SPERRY UNIVAC HOLLAND

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SUMMARY

Very divergent problems arising with different calculations indicate that NASTRAN is not always accessible for common use. Problems with engineering, modelling, and use of the program system are analysed and a way of solution is outlined. Related to this, some supplementary modifications are made at Sperry UNIVAC Holland to facilitate the program for the less skilled user. The implementation of a new element also gives an insight into the use of NASTRAN at Sperry UNIVAC Holland.

INTRODUCTION

As the users of UNIVAC computers are from very different kinds of industries like shipbuilders, petrochemical industries, and building industries, the variety of problems coming from these users is very large. This variety results in experience not with one special kind of calculation nor one special kind of construction, but with a wide area of problems arising in the use of NASTRAN. These problems can roughly be divided into three different groups:

(1) Recognition of what is to be calculated and how

(2) Construction of a model

(3) Handling the NASTRAN program

These are the basic problems for every less skilled user of NASTRAN and the Application/Research Department of Sperry UNIVAC has to give reasonable answers to these questions. The correctness and accuracy of NASTRAN is hardly a question. Except for very complicated structures and calculations, the prospective user accepts NASTRAN as the best available tool, in spite of the monopoly of ASKA at the Dutch universities and the almost historical preference for ICES. The description of the following calculations illustrates the procedure of tackling different types of problems. As the details and numerical results of the calculations give no essential information, they are not shown.

RECOGNITION OF WHAT IS TO BE CALCULATED AND HOW

One of our customers had problems with a propulsion system for ships. A simplified schematic diagram is shown in figure 1. There was serious damage on the roller

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bearings of the hollow shaft for reasons other than torsional frequencies. Obviously, something was wrong with the design of the system. Together with the customer a summary was made of all possible sources of damage. After that, a selection from among parts of the system was made to determine the loading conditions that had to be calculated. The conclusion was to make a static analysis to determine whether the connection between the hollow shaft and the gear wheel was strong enough and also to make an analysis of the natural frequencies of the shaft and gear wheel with NASTRAN. A model was made from triangular and quadrilateral ring elements and rigid formats 1 and 12 were used.

The result of these analyses was that the connection seemed barely strong enough and that the gear frequency was almost the same as the natural frequency of the shaft and wheel with four other natural frequencies in the same region. Combined, these could be the source of damage. Obviously, modelling and calculating with NASTRAN was no problem. The only way to solve the problem was to make an extensive overview of possible sources. If that were available, the rest would be no problem because almost everything could be calculated with a program like NASTRAN. So this is essentially a problem that only can be solved with engineering practice. Only a methodical approach to a problem like this can give a satisfactory result, and simple rules cannot be given for solving these problems.

CONSTRUCTION OF A MODEL

Two entirely different examples will show problems arising with modelling. For building blocks of flats, one of our customers, a building contractor, wants to know the loads on the piles, the stresses in the structure, and the possible overload the structure may absorb for a certain wall thickness. When the problem is stated this way, it seems to be a stability problem, hardly solvable because of the properties of the material, reinforced concrete. Nevertheless, the biggest problem for the building contractor is how to make a model because he has no idea about the effect of the element and element size on his results. As all his problems are topologically almost the same – only walls and floors – like figure 2, the best thing to do is to make a preprocessor for NASTRAN with a simple mesh generator resulting in a model like figure 3. This procedure was entirely sufficient for this model.

A totally different modelling problem was the stress calculation of a reactor containment vessel of a nuclear power plant. This is a kind of pressure vessel with a radius of about 90 feet and about 140 feet high (see fig. 4). One of the greatest problems was a crane girder at the top of the vessel. Because of the rotational symmetry of the vessel, the conical shell element could be used, but the bulkheads of the girder disturbed the symmetry and prevented the use of this model. Modelling with plate elements would increase computer time enormously. The solution was the use of multipoint constraints. With several hundred multipoint constraints, the bulkheads had a zero inplane stiffness. This condition gave the model a reasonable stiffness. Of course, this is not a completely new way of using these multipoint constraints, but it shows again that intelligent modelling can give accurate results, shorter computing times, and simpler models.

So if modelling is a serious problem, either a skilled user of the finite-element method, or, for simple models, some piece of software must make the model. The fact that a simple model description is important pleads for a general mesh generator, so that only a description of the contours and the element kind will produce an optimal mesh.

HANDLING THE NASTRAN PROGRAM

An underestimation of this problem is dangerous because a program will be used if it is easy to use. For a common user, a large program like NASTRAN is never easy to use. Therefore, it must be made as easy as possible; that is: little input, only a few control cards, surveyable output, and so on. This statement results in some remarkable conclusions. The way of substructuring in NASTRAN seems to be too complicated for a common user. Usually, he wants to use more core for calculating the whole model at once if possible, instead of calculating substructures and saving computer time. For this reason, enlarging the available core is desirable. This enlargement could be done by some alterations in the subroutine MAPFNS.

With the updating program (see fig. 5) the available core on the UNIVAC 1108 is increased to 117K words. Another way to make NASTRAN as easy to handle as possible is to reduce the number of control cards. This can be done by a subroutine called LINKO. (See fig. 6.) This FORTRAN program tests the run condition word and after that starts the sequence of link steps. For this purpose file 12 is available if no BCD plot file is used. The executive control language of all link steps is written on this file 12 and LINKO takes the control. Already with these few alterations NASTRAN seems to be more accessible.

If there is a problem in handling the NASTRAN system, often it can be solved by making simplifications in different fields. Of course, the simplification is only valid for relatively simple calculations using only rigid formats without DMAP sequence alterations. But most of the calculations are as simple as that.

NEW ELEMENT

The data processing division of Rijkswaterstaat, Ministry of Transport Water Control and Public Works, an engineering firm of Netherlands government, has developed three plate elements – a triangular, a rectangular, and a quadrilateral element. They have implemented them in ICES. UNIVAC has obtained these elements for implementing in NASTRAN. The stiffness matrix of these elements is derived by the method of assumed stress distribution as outlined by Pian (ref. 1). In this method the expression for the strain energy in the element requires both displacement compatibility and stress equilibrium conditions. These elements have now been tested. The results will be available for all interested people as soon as all advantages and disadvantages of these elements are known.

CONCLUDING REMARKS

Although the emphasis in using NASTRAN is mostly for complicated constructions and calculations, most of the computing time used by NASTRAN is for relatively simple problems. To simplify the use of NASTRAN, many alterations can be introduced, mainly in the field of reducing input data. Related to that, a more automatic input generation should be desirable.

REFERENCE

1. Pian, T. H. H.: Derivation of Element Stiffness Matrixes by Assumed Stress Distributions. AIAA J., vol. 2, no. 7, July 1964, pp. 1333-1336.

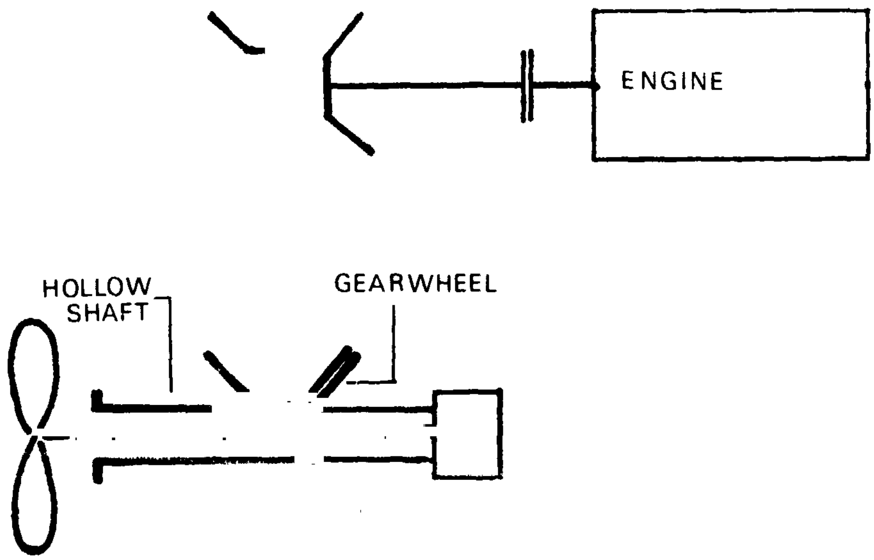

Figure 1.- Propulsion system.

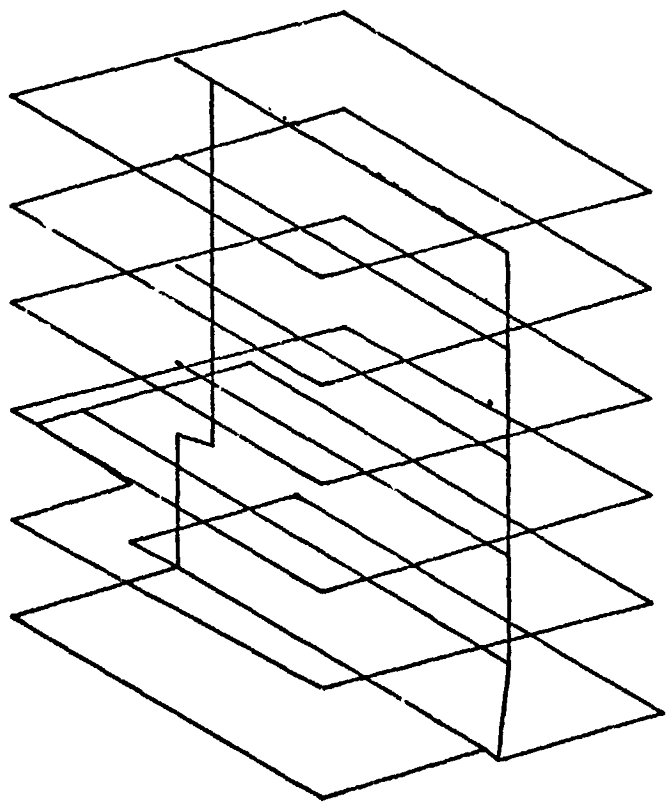

Figure 2.- Contour plot of a block of flats.

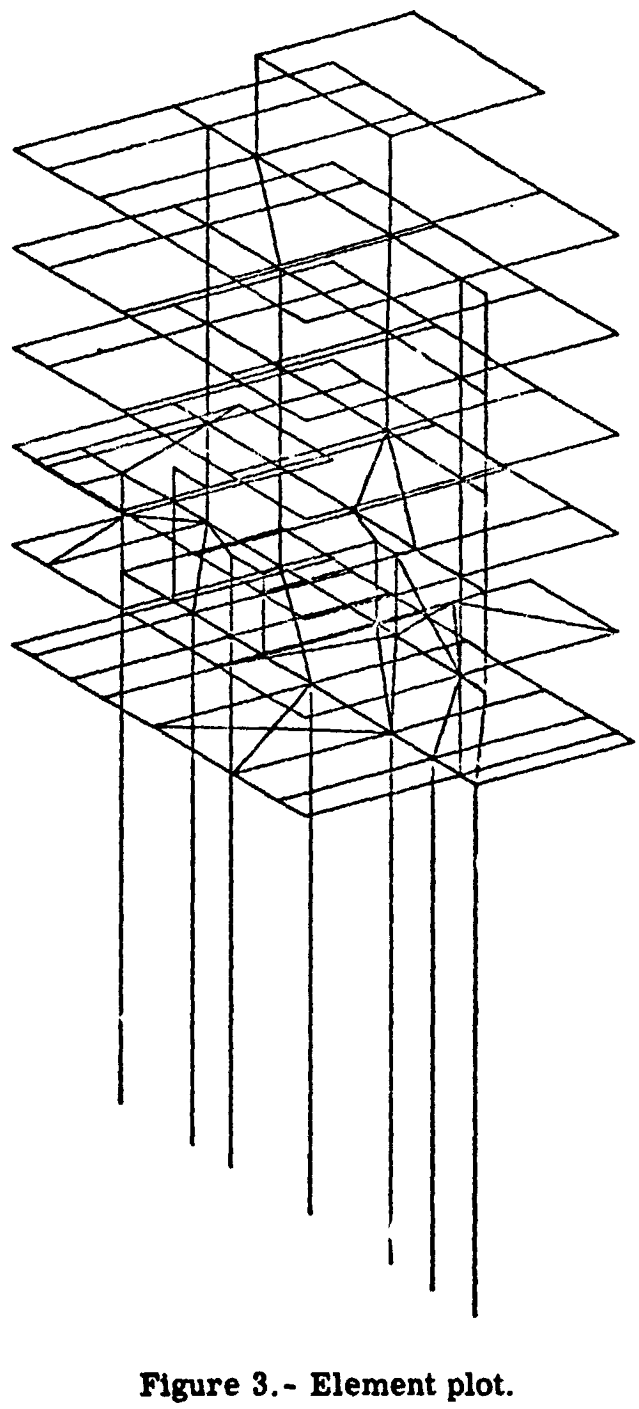

Figure 3.- Element plot.

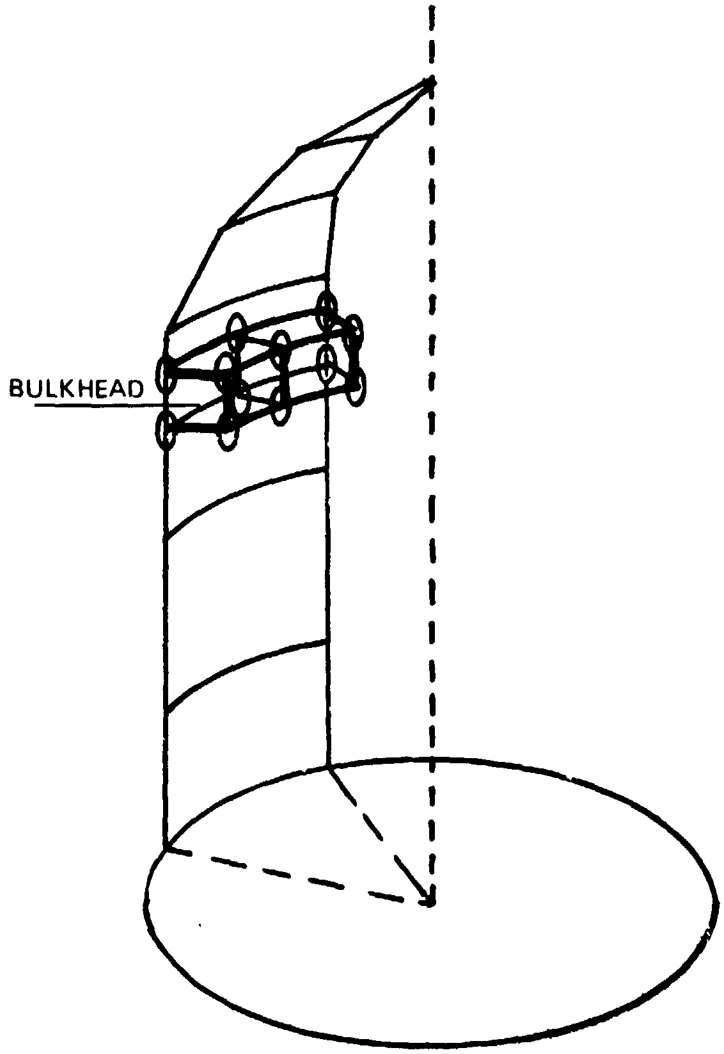

Figure 4.- Reactor containment.

```
@RUN,/TP NASTRA,UNASTRAN01,UNIVAC,3,600
@ASG,T SYM.,F2/1000//2000
@ASG,T OBJ.,F2/500//1000
@ASG,A NASTRAN15-S.
@ASG,A NAS15-S.
@COPIN NAS15-S.,SYM.
@COPIN,S NAS15-S.,SYM.
@COPY,G NASTRAN15-S.,OBJ.
@FREE NASTRAN15-S.
@COPY,S OBJ.,SYM.
@FREE NAS15-S.
@ASG,A NAS15-RC.
@MSG NAS15-RC MET RING
@FOR,SU SYM.WPLT10,OBJ.WPLT10
-46,46
      N= IABS(N-M*TEN(I))
@ASM,SU SYM.MAPFNS,OBJ.MAPFNS
-16,17
AND*    L       A0,0,X11
        L       A0,0,A0
        L       A1,1,X11
        L       A1,0,A1
        AND     A0,A1
-23,24
ORF*    L       A0,0,X11
        L       A0,0,A0
        L       A1,1,X11
        L       A1,0,A1
        OR      A0,A1
-30,32
XOR*    L       A0,0,X11
        L       A0,0,A0
        L       A1,1,X11
        L       A1,0,A1
        XOR        A0,A1
        S       A1,A0
-37,37
COMPL*  L       A0,0,X11
        LN      A0,0,A0
-41,44
LSHIFT* L       A0,1,X11
         L      A1,0,A0
        S,J1    A1,$+4
        L       A0,0,X11
```

Figure 5.- Updating program.

```
         L         A0,0,A0
         JZ        A1,3,X11
-49,52
RSHIFT*  L         A0,1,X11
         L         A1,0,A0
         S,J1      A1,$+4
         L         A0,0,X11
         L         A0,0,A0
         JZ        A1,3,X11
-99,99
         L,016     A1,0337770
-105,105
         L         A2,1,X11
         SN        A1,0,A2
-110,110
SETC*    L         A0,0,X11
         L         A0,0,A0
-125,125
         L         A1,0,X11
         S         A0,0,A1
-134,134
         L         A0,0,X11
         S         A1,0,A0
-138,138
FACIL*   L         A1,0,X11
         L         A1,0,A1
-148,148
OUT      L         A0,1,X11      . STORE FLAG IN IO
         S         A1,0,A0
-155,155
TSWAP*   L         A1,0,X11
         L         A1,0,A1
-164,164
         L         A1,1,X11
         L         A1,0,A1
-176,176
         L         A2,1,X11
         L         A2,0,A2
@COPOUT  SYM.,NAS15-RC.
@COPOUT  OBJ.,NAS15-RC.
```

Figure 5.- Concluded.

```
"FOR,SI   LINKO,LINKO
      DIMENSION   B(3)
      DIMENSION   C(14,4)
      DATA  (( C(I,J),I=1,14),J=1,4)
     1 42HK        LMNO    LMNP    KOO     LMNOP  KP      KPQ      ,
     2 42HKOP      KOP     KO      LMN     MOP    LMN     KOP      ,
     3 42HKLMN     KLMN    KLMN    KLMN    KLMN   KLMN    KLMN     ,
     4 42HKLMN     KLMN    KLMN    KLMN    KLMN   KLMN    KLMN     ,
     5 42HJN       JN      JN      JN      JN     JN      JN       ,
     6 42HJN       JN      JN      JN      JN     JN      JN       ,
     7 42HJMN      JMN     JMN     JMN     JMN    JMN     JMN      ,
     8 42HJMN      JMN     JMN     JMN     JMN    JMN     JMN      ,
      REWIND 12
      B(1)=6H"ADD,E
      B(2)=6H  12.
      B(3)=6H   .
      CALL EROPT(I)
      J=4
      IF(I.EQ.6HM      ) J=3
      IF(I.EQ.6HL      ) J=2
      IF(I.EQ.6HU      ) J=1
      IF(J.EQ.4) I=6HM
      CALL ERTRAN(8,M)
      M=FLD(30,6,M)
      READ(5,30,END=100,ERR=100) A
   30 FORMAT(F8.0)
  100 CONTINUE
      IF(M.LT.10) WRITE(12,10)C(M,J),M,I
      IF(M.GT.9.AND.M.LT.15) WRITE(12,20) C(M,J),M,I
      IF(M.EQ.15) STOP
      CALL ERTRAN(6,B)
      STOP
   10 FORMAT(
     2  5H"XQT,,A6,13H NASTRAN.LINK,I1,4H .   ,/,
     3  5H"XQT,,A6,25H NASCON.LINKO/NASTRAN .   )
   20 FORMAT(
     2  5H"XQT,,A6,13H NASTRAN.LINK,I2,4H .   ,/,
     3  5H"XQT,,A6,25H NASCON.LINKO/NASTRAN .   )
      END
"ASM,SI    EROPT,EROPT
           AXR$.
$(1).
EROPT*.
           SX        X11,('REOX11')
```

Figure 6.- LINKO subroutine.

```
         SA        A0,('REDA0  ')
         SA        A1,('REDA1  ')
         SA        A2,('REDA2  ')
         SR        R1,('REDR1  ')
         ER        OPT$
         SA        A0,('OPTIES')
         LX        X11,0,X11
         LXI,U     X11,1
         L,U       A2,037
         SZ        ('LETTER')
LUS.
         L         A1,('      ')
         L,U       R1,5
LUS1.
         AN,U      A2,1
         S,S1      A2,('LETTER')
         TNE,U     A2,4
         J         EINDLUS
NEXT.
         JNB       A0,EINDLUS1
         DSL       A0,1
         SSL       A1,5
         A         A1,('LETTER')
         JGD       R1,LUS1
         J         EINDLUS
EINDLUS1.
         SSL       A0,1
         J         LUS1
EINDLUS.
         S         A1,0,*X11
         TZ        A0
         J         LUS
         LA        A0,('REDA0  ')
         LA        A1,('REDA1  ')
         LA        A2,('REDA2  ')
         LR        R1,('REDR1  ')
         LX        X11,('REDX11')
```

Figure 6.- Concluded.