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APPLICATION OF NASTRAN IN NONLINEAR ANALYSIS OF A CARTRIDGE CASE NECK SEPARATION MALFUNCTION

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SUMMARY

The problem of case neck separation malfunction in the field of ammunition structural analysis is investigated. The axi-symmetric solid of revolution RING element was utilized in the manual piece-wise linear analysis to obtain the expansion of the wall of the cartridge case and barrel chamber by the pressure of propellant gases and the stresses in the structure. The analysis included the varying material properties along the wall of the case and the chamber. Additional instructions were provided to change the element material ID's without recomputing the entire stiffness matrix.

INTRODUCTION

A characteristic problem in the field of ammunition structural analysis is the interaction between the cartridge case and gun barrel chamber. Specifically of interest is a case neck separation (CNS) malfunction where rupture occurs at the neck-shoulder section, see Figure 1. CNS presents serious problems in double ended linkless feed systems, i.e., system in which the fired cases and released rounds are returned to the storage drum. Round control of cases with partially or completely separated necks is lost by the hand-off sprockets, resulting in a system jam. In systems where the fired cases are dumped overboard, CNS presents no problems unless the separated case neck remains in the gun barrel chamber, which can result in a jam when a subsequent round is fed into the same barrel.

When a round is fired, the powder pressure builds up and the sidewall expands elastically to its yield point and then completes its expansion plastically. Although the sidewall may or may not enter the plastic range before taking up the initial clearance between the case and the chamber, it will be completely plastic when the pressure reaches its maximum value. At this instant of maximum pressure, both the case outside diameter and chamber inside diameter will have expanded together to a common maximum value. Here the cartridge case sidewall will be acted upon on the inside by the internal pressure and on the outside by the chamber-cartridge case interface friction and pressure. The chamber wall will be acted upon by equal and opposite friction and pressure. Knowing the radial loads on the cartridge case at this instant of maximum pressure, the associated state of stress in the sidewall can be determined for various assumed values of axial (longitudinal) stress in the sidewall. This is done by applying the Von Mises or the Tresca law of yielding together with its associated flow rule.

In the problem of expansion of the wall of cartridge case and barrel chamber by the pressure of propellant gases and the stress analysis of the structure, it is desired that the axi-symmetric solid of revolution RING element be utilized. This element offers both simplicity and accuracy over other elements. Since the piece-wise linear analysis option of NASTRAN has not been developed for this element, a program was initiated to perform the piece-wise linear analysis manually (see Reference 1). A summary flow diagram is given in Figure 2.

INTERNALLY PRESSURIZED CARTRIDGE CASE

We now proceed to investigate the design of the cartridge case neck and barrel chamber interface section of a high pressure ballistic system. Figure 3 depicts the finite elements used in synthesizing the NASTRAN model of part of the cartridge case, barrel chamber and projectile. The case and chamber are assumed to be free at one end and clamped at the other end while the projectile was assumed to be free at both ends. Rigid Format 1 and trapezoidal RING elements were used. The overall model had 254 elements, yielding a total of 654 degrees of freedom. Bi-linear stress-strain curves are selected for the elastic-plastic materials which varied along the cartridge case. MPC was used at the interfaces of the chamber-case and case-projectile. Displacement and force conditions for skewed boundary are imposed on some part of the structure whose boundary surface is not oriented with respect to the global axis system. Internal pressure is applied in increments. The incremental displacements and stresses were cataloged and filed after each run. These were then added to the previous results to obtain the total displacements and stresses. After each run the stresses were tested with the Von Mises Condition. The elastic material properties of those elements that satisfied the yield criterion are changed into plastic material properties.

In order to form a manual piece-wise linear analysis and to change the element material ID's without recomputing the entire stiffness matrix, the following changes are needed in the NASTRAN DMAP instructions.

To use files rather than tapes for data storage, the following card must be inserted before the Executive Control Deck, see Reference 2.

```
NASTRAN SYSTEM_(45) _ = _ 1920, _ CONFIG = 6$
```

For Run 1 the following cards are inserted in the Executive Control Deck in order to change the rigid format.

```
ALTER 32
OUTPUT1   ,,,,//C,N,-1/C,N,2    $
OUTPUT1   KGGX,,,,//C,N,0/C,N,2   $
ALTER - 110
OUTPUT 1, __,,,,//C,N,-1/C,N,0/C,N,USERPLA  _$
OUTPUT 1 _ _ _UGVV,,,,//C,N,0/C,N,0/C,N,USERPLA _ _$
END ALTER
```

For Run 2

```
ALTER 31
PARAM    //C,N,NOP/V,N,IM1=-1 $
INPUTT1    /,,,,/C,N,-1/C,N,3 $
INPUTT1    /KGGXX,,,,/C,N,0/C,N,3 $
CHKPNT  KGGXX $
ELCHANG   MPT,ECPT/ECPT1,ECPT2/V,N,NOCHAN  $
SAVE  NOCHAN $
EQUIV   KGGXX,KGGX/NOCHAN  $
COND  YANG1,NOCHAN  $
SMA1 CSTM,MPT,ECPT1,GPCT,DIT/KGGX1,,GPST1/V,N,NOGENL/V,N,NOK4GG/V,
Y,OPTION  $
SMA1 CSTM,MPT,ECPT2,GPCT,DIT/KGGX2,,GPST2/V,N,NOGENL/V,N,NOK4GG/V,
Y,OPTION  $
ADD5   KGGX1,KGGX2,KGGXX,,/KGGXXX/C,Y,ALPHA=(1.,0.)/C,
Y,BETA=(-1.,0.)/C,Y,GAMMA=(1.,0.)  $
CHKPNT  KGGXXX  $
EQUIV   KGGXXX,KGGX/IM1  $
JUMP YANG1  $
MATPRN  KGGXXX,,,,// $
ALTER 32
LABEL   YANG1  $
OUTPUT1   ,,,,//C,N,-1/C,N,2  $
OUTPUT1   KGGX,,,,//C,N,0/C,N,2  $
ALTER _110
INPUTT1  /UGPREV,,,,/C,N,-1/C,N,1/C,N,USERPLA _$
ADD _ _ UGPREV, UGV/UGVV _ _$
OUTPUT 1, _ _,,,,//C,N,-1/C,N,0/C,N,USERPLB _ _$
OUTPUT 1 _ _ _ UGVV,,,,//C,N,0/C,N,0/C,N,USERPLB _ _$
ALTER _ 121
SDR2 _ CASE CC, SDTM, MPT, DIT, EOEXIN, SIL, GPTT, EDT, BGPDT, PGG, OB, UGVV,
EST,/
_ OPG2, OOG2, OUGV2, OES2, OEF2,/C,N,STATICS _$
OFP _ OUGV2, OPG2, OOG2, DEF2, OES2,//V,N,CARDNO/V,Y,OPTION _$
END ALTER
```

For Run 3, USERPLA is changed to USERPLB and USERPLB is changed to USERPLC.

Alters 31 and 32 are used in conjunction with CHANGEL cards for changing element material ID's without recomputing the entire stiffness matrix, along with output tape INP2 and input tape INP3.

Alters 110 are used to perform a manual piece-wise linear analysis, along with output tape INPT and input tape INP1. Alters 121 allow the incremental stresses, forces, and displacements to be printed out.

The following control cards are needed:

Run 1

```
Request, INPT, *PF.
Request, INP2, *PF.
Request, IDLF, *PF.
Rewind, INPT, INP2, IDLF.
NASTRAN(,,IDLF)ATTACH.
Catalog, INPT, INPT, ID=FREDERICK.
Catalog, IDLF, IDLF, ID=FREDERICK.
Catalog, INP2, INP2, ID=FREDERICK.
```

Run 2

```
Request, INPT, *PF.
Request, INP2 *PF.
Request, IDLF, *PF.
Rewind, INPT, INP2, IDLF
Attach, INP3, INP2, ID=FREDERICK.
Attach, INP1, INPT, ID=FREDERICK.
Rewind, INP3, INP1.
NASTRAN(,,IDLF)ATTACH.
```

Output data is saved on the IDLF file which is the punch file by using the options available in the Case Control Deck, see Reference 1.

```
Example: DISP(PRINT,PUNCH) = ALL
         STRESS(PRINT,PUNCH) = ALL
```

In order to have a realistic model after each run the elements actually change position according to their displacement. Some Fortran routines were developed to incorporate these changes in the model.

Program WIDEF initially converts GRID data to 16 column fields in order to allow the displacement values to be utilized regardless of how small the numeric value is. (Run once.)

Program GEOMX takes the displacement values from the IDLF file and adds them to the GRID values from the file created by WIDEF. The new data input file is the new NASTRAN run. GEOMX allows the user to change the LOAD card, the material properties by the use of CHANGEL card (explained below) and insert any other new data cards to the NASTRAN deck.

CHANGEL Cards

```
CHANGEL ELID OMID ELID OMID ELID OMID ELID OMID +A
+A      ELID OMID ....... ENDT
```

ELID is an element ID number.

OMID is the old material ID for that element. The new material ID must be placed on the element connection card.

ENDT is required.

If no CHANGEL cards exist, the previously computed stiffness matrix (from INP3) will be used. All material cards referenced on property cards, connection cards, and CHANGEL cards must be included. If restarting after DMAP number 33, do not include any alters, INP2 or INP3 tapes. These changes work for all elements with material. ID's for elements with more than one material ID, just the first one indicated on the property card can be changed with this method.

In addition, two other Fortran programs take the output from IDLF. The first program sums up the individual normal stresses (R,θ,Z) and shear stresses (ZX) and applies the Von Mises Law of Yielding together with its associ flow rule. The second Fortran routine sums up the displacements (R,Z). Thu each step while performing a piece-wise linear analysis the data is organized results are easily studied.

ACKNOWLEDGEMENT

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REFERENCES

1. "Application of Nonlinear Analysis to NASTRAN Using Ring Elements Including Aspect Ratio Effect," J.C.S. Yang and D. Frederick, Frankford Arsenal Technical Note TN-1178, August 1973.

2. The NASTRAN User's Manual, NASA SP-222, September 1970, Section 3.

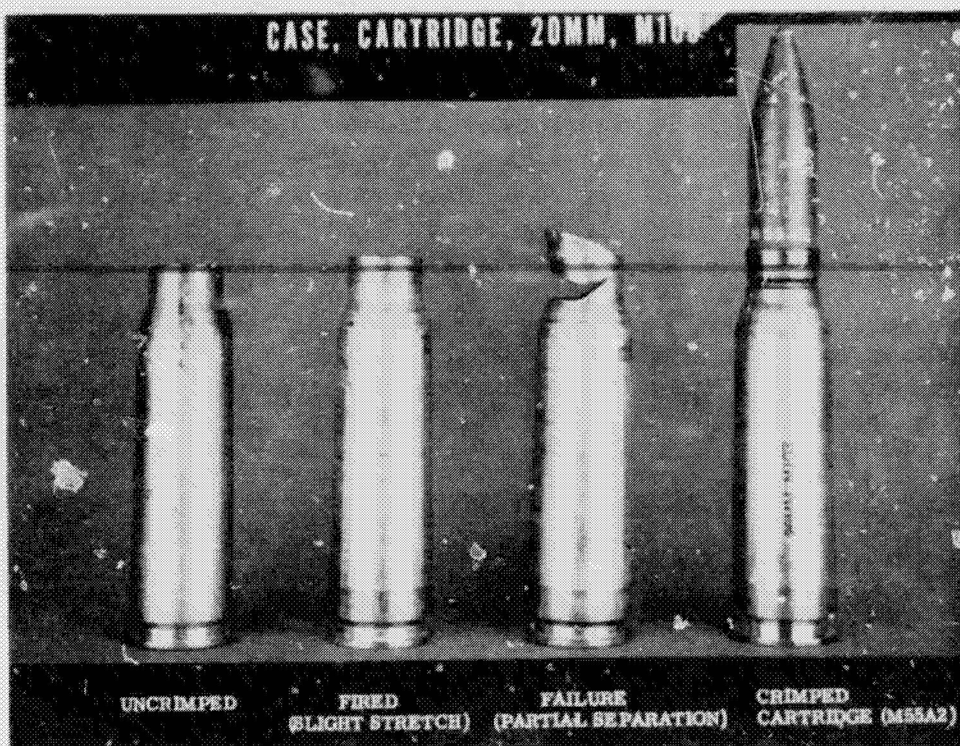

Figure 1.- Case neck separation.

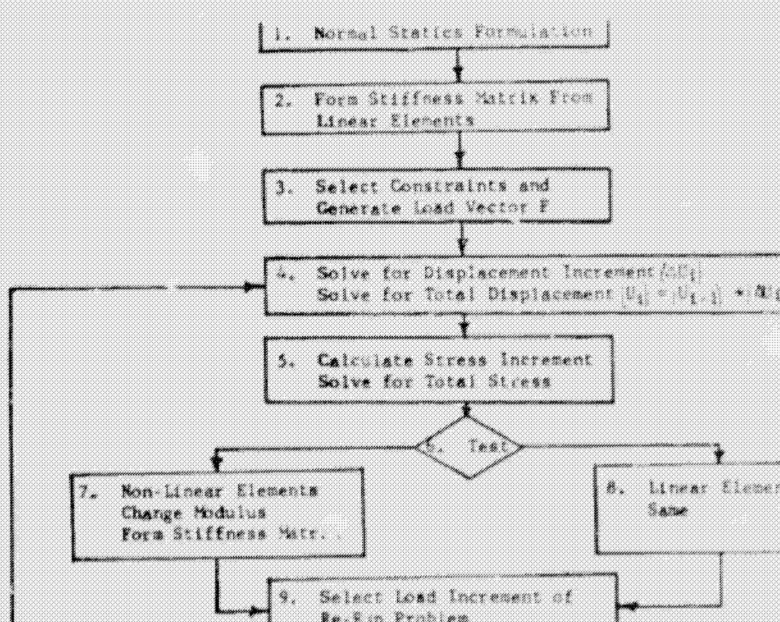

Figure 2.- Manual piece-wise linear flow diagram.

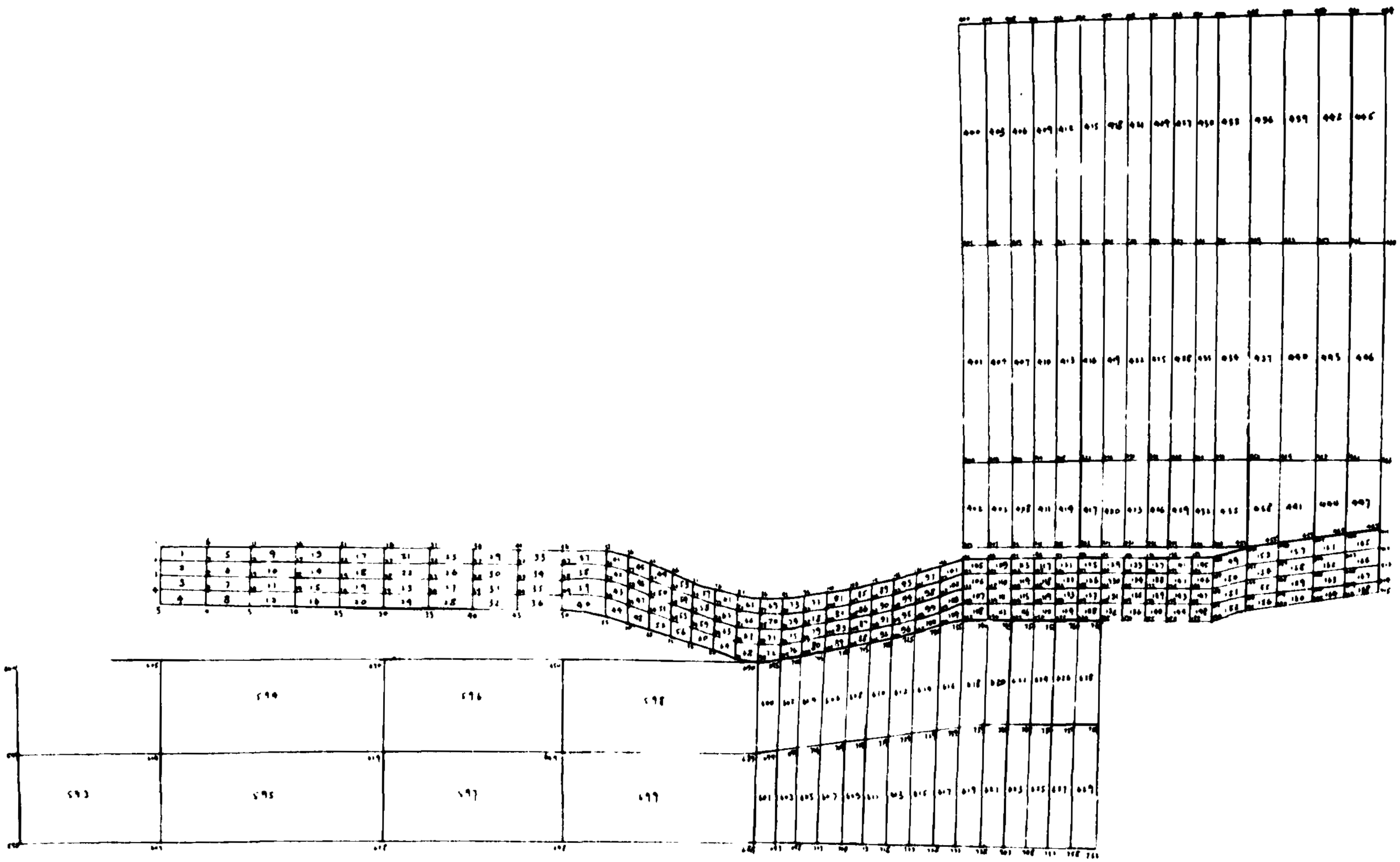

Figure 3.- NASTRAN mcdel of internally pressurized case, chamber and projectile.