ADDITION OF THE AUTOSPC FEATURE TO NASTRAN

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SUMMARY

A new capability called the AUTOSPC feature has been incorporated in the April 1987 release of NASTRAN. It gives the user the option of automatically applying single-point constraints for the purpose of removing potential grid (and scalar) point singularities that have not been otherwise already constrained out. This paper gives details of the implementation of this feature and describes its usage, illustrating it with an example problem.

INTRODUCTION

In pre-April 1987 releases of NASTRAN, a table data block called GPST (Grid Point Singularity Table) was generated by the EMA (Element Matrix Assembler) module in all Rigid Formats. This table contains data on potential grid (and scalar) point singularities and was based on an examination of the stiffness matrix assembled by the EMA module. Based on the constraints specified by the user, as processed by the GP4 (Geometry Processor - Phase 4) module, this GPST table was subsequently examined by the GPSP (Grid Point Singularity Processor) module in order to identify those singularities that have been removed by the application of single-point or multipoint constraints. Any singularities not so removed were identified for the user's information because of potential problems that might be caused in the subsequent decomposition process.

In pre-April 1987 releases of NASTRAN, there was also a supplementary functional module called GPSPC (Constrain Stiffness Matrix Singularities). While not a part of any of the Rigid Formats, this module was designed to replace the GPSP module and to do not only what GPSP was doing, but, in addition, to automatically constrain singularities not otherwise constrained. However, this GPSPC module has had serious flaws both in design and implementation and has never worked properly as advertised in the NASTRAN User's Manual.

In order to resolve the above problem and have an effective means of automatically constraining singularities, the AUTOSPC feature has been introduced in the April 1987 release of NASTRAN. Details of its implementation and usage are given below, along with an illustrative example problem.

IMPLEMENTATION OF THE CAPABILITY

For the sake of efficiency and user convenience, the AUTOSPC feature was incorporated into NASTRAN by modifying and expanding the code in the existing GP4 module. This is the most logical and elegant way of doing this as this module processes all constraint data. There is no reason for a separate module to handle the new feature.

The following points summarize the important details of the implementation of the capability.

1. Deletion of old modules

   The GPSP and GPSPC modules existing heretofore in NASTRAN were deleted from the code.

2. Addition of a new module

   The GPST data block that has until now been generated by the EMA module has been based on the stiffness matrix assembled by the EMA module and has not included the contributions of general elements. This has now been corrected by postponing the computation of the GPST data block until after the contributions of the general elements have been added to the stiffness matrix assembled by the EMA module and by basing the computation of GPST on this total stiffness matrix. In order to perform this efficiently, a new module called GPSTGEN (GPST GENeration) was developed and incorporated into NASTRAN. This new module generates the GPST data block using the same method as was used earlier by the EMA module.

3. Changes to the EMA module

   As a result of the above, the EMA module was considerably simplified by the deletion of the code associated with the generation of the GPST data block. Also, as a result, the number of output data blocks generated by the EMA module was reduced from 2 to 1.

4. Changes to the GP4 module

   Significant changes were made to the GP4 module. These changes are described below.

   a. The GP4 module was modified to process the GPST data block generated by the new GPSTGEN module. A new subroutine called GP4SP was added to the GP4 module for this purpose. If the AUTOSPC feature is not turned on (the default), the GP4 module processes the GPST data block in the same way as was done earlier by the old GPSP module. However, if the user has turned on the AUTOSPC feature, then the GP4 module additionally applies single-point constraints to remove potential grid (and scalar) point singularities as per the scheme outlined later under the usage of the feature.

   b. As a result of the above change, the number of output data blocks for the GP4 module was increased from four to five. The fifth output data block is suitable for processing by the OFP

(Output File Processor) module and contains information about potential singularities that have not been removed.

c. In order to enhance user convenience, a new set, called the SAUTO-set, was added to the displacement sets already existing and recognized in NASTRAN. This new displacement set consists of those degrees of freedom that have been constrained by the GP4 module by the automatic application of single-point constraints when the AUTOSPC feature has been turned on. This new set is a subset of the s-set (single-point constraints). Until now, the s-set comprised two subsets, namely, the sg-set (permanent constraints) and the sb-set (boundary constraints). Under the new scheme, the s-set may also include the SAUTO-set. The printouts generated by DIAGs 21 and 22 in the GP4 module have been expanded to display the degrees of freedom belonging to this new SAUTO-set. (The SAUTO-set in DIAG 21 output is referred to as the AUTO SPC displacement set in DIAG 22 output.) These expanded printouts will be of great help to users.

d. In addition, when automatic single-point constraints are applied as above, SPC1 cards are generated and printed out (and, on option, also punched out), indicating the degrees of freedom that have been automatically constrained. This is explained further later under the usage of the feature.

e. Additional messages were introduced into the GP4 module to inform the user of the automatic application of single-point constraints when the AUTOSPC feature is turned on.

5. Resolution of a software problem

While the new capability was being developed, it was discovered that the GPST table was never generated in the HEAT approach, except in an extremely rare situation. This was traced to a software problem in the EMA module. This problem was resolved when the new GPSTGEN module was developed.

6. Changes to the Rigid Format Data Base

As a result of the work described above, all of the Rigid Formats in the Rigid Format Data Base were revamped as follows:

*   The new GPSTGEN module was incorporated.

*   The old GPSP module was deleted.

*   The EMA and GP4 module DMAP statements were modified as per the changes outlined above.

*   Other miscellaneous changes called for by the above modifications were made.

Also, all of the COSMIC-supplied DMAP ALTER packages were appropriately modified in line with the above changes.

USAGE OF THE AUTOSPC FEATURE

The AUTOSPC feature is exercised by the use of an integer DMAP parameter called AUTOSPC, normally specified via a PARAM bulk data card. It is available in all Rigid Formats. The default value of 0 for this parameter causes the new feature to be not used, thereby not changing the status quo. The new feature is exercised by specifying a non-zero value for this parameter. Acceptable values are 1, 2, -1 and -2. (Unacceptable values cause the singularity processing to be skipped.) The meanings of the various values for this parameter are described below.

AUTOSPC = 0

The AUTOSPC feature is not used.

AUTOSPC = 1

All singularities that are not already:

(a)   removed via single-point constraints, or
(b)   removed via multipoint constraints, or
(c)   specified on SUPORT cards,

are removed by the automatic application of single-point constraints.

A set of SPC1 cards is generated and printed out for the user's information and convenience, indicating the singularities that have been automatically removed as above. These SPC1 cards have the same SPC set ID as the current subcase (or a SPC set ID of 1 if the current subcase has no SPC set).

AUTOSPC = 2

There are two possible cases.

Case 1   There are no omitted degrees of freedom in the current subcase.

This case is handled in the same way as the AUTOSPC = 1 case.

SPC1 cards are generated and printed out as in the AUTOSPC = 1 case.

Case 2   There are omitted degrees of freedom in the current subcase.

This case is handled in the same way as the AUTOSPC = 1 case, but with one important difference as explained below.

All singularities that are not already:

(a)   removed via single-point constraints, or
(b)   removed via multipoint constraints, or
(c)   specified on SUPORT cards, or

4

are removed by the automatic application of single-point constraints, but only if the singularity is part of the o-set (omitted set).

SPC1 cards are generated and printed out as in the AUTOSPC = 1 case.

AUTOSPC = -1

This case is handled in the same way as the AUTOSPC = 1 case, except that the SPC1 cards generated are punched out as well as being printed out.

AUTOSPC = -2

This case is handled in the same way as the AUTOSPC = 2 case, except that the SPC1 cards generated are punched out as well as being printed out.

AUTOSPC < -2 or > 2

These illegal values cause singularity processing to be skipped in the GP4 module.

As can be seen from the above discussion, when there are no omitted degrees of freedom in a subcase, the use of AUTOSPC = '1' and AUTOSPC = '2' both work the same way, by removing all potential singularities that are not already part of the s-set (single-point constraints), m-set (multipoint constraints) or r-set (degrees of freedom specified on SUPORT cards). However, if there are omitted degrees of freedom in a subcase, then AUTOSPC = '2' will cause that singularity to be removed only if it is part of the o-set, while AUTOSPC = '1' will cause it to be removed even if it is not part of the o-set. This distinction is of relevance and interest in dynamic analyses, where the omit feature is frequently used to reduce the size of the analysis set. The user thus has a choice in the usage of the AUTOSPC feature in such situations.

COMMENTS ON THE USAGE OF THE AUTOSPC FEATURE

In pre-April 1987 releases of NASTRAN, the user has been required to explicitly remove singularities in many common situations. These include such cases as the constraining of grid point rotations in solid elements, the constraining of grid point rotations normal to the plate in plate elements and the constraining of specific grid point components in axisymmetric elements. A GRDSET card has been normally used to explicitly specify such constraints. The AUTOSPC feature now provides an alternative means of handling such situations in a convenient and elegant manner. This is illustrated in the example problem discussed below.

EXAMPLE PROBLEM

In order to demonstrate the usage of the AUTOSPC feature, NASTRAN Demonstration Problem No. D01-07-1A was selected. This problem performs static analysis of a spherical shell using toroidal ring elements (see the NASTRAN Demonstration Problem Manual for details). Among other data cards, this problem employs a GRDSET bulk data card to constrain grid point displacements tangential to the shell surface.

The standard demo was first run by commenting out the GRDSET card in the data deck, thereby introducing singularities into the problem. (In addition, in order to reduce the amount of output, the output request was limited to the displacement output.) The results of this run are shown in Appendix 1. As can be seen, the run terminated due to the singularities introduced into the problem.

The above data was then augmented by adding a PARAM bulk data card with AUTOSPC = 1 specified on it. The results of this run are shown in Appendix 2. As can be seen, this run ran successfully to completion, giving results that match those of the standard demo problem.

The above runs also illustrate some of the new user messages, as well as the expanded output resulting from the use of DIAGs 21 and 22. (Both of the runs were made on a post-April 1986 release of NASTRAN, containing the AUTOSPC feature discussed in this paper.)

CONCLUSIONS

A new capability called the AUTOSPC feature has been incorporated in the April 1987 release of NASTRAN. It gives the user the option of automatically applying single-point constraints for the purpose of removing potential grid (and scalar) point singularities that have not been otherwise already constrained out. This paper has presented the details of the implementation and usage of this new feature, illustrating it with an example problem.

APPENDIX 1

NASTRAN Demonstration Problem No. DO1-07-1A
Modified to Have Singularities

N A S T R A N   E X E C U T I V E   C O N T R O L   D E C K   E C H O

```
ID     DO1071A.NASTRAN
DIAG 21.22
APP    DISPLACEMENT
SOL    1.1
TIME   5
CEND
```

EXTERNAL PRESSURE LOADING

C A S E   C O N T R O L   D E C K   E C H O

```
CARD
COUNT
   1      TITLE = SPHERICAL SHELL WITH TOROIDAL RING ELEMENT
   2      SUBTITLE = NASTRAN DEMO DO1-O7-1A MODIFIED TO HAVE SINGULARITIES
   3      LABEL = EXTERNAL PRESSURE LOADING
   4      ECHO = BOTH
   5      SPC  = 1
   6      LOAD = 1
   7      OUTPUT
   8      DISP = ALL
   9      BEGIN BULK
```

EXTERNAL PRESSURE LOADING

I N P U T   B U L K   D A T A   D E C K   E C H O

1	2	3	4	5	6	7	8	9	10
CTORDRG 1	1	1	1	2	.0	2.0			
CTORDRG 2	1	2	2	3	2.0	4.0			
CTORDRG 3	1	3	3	4	4.0	6.0			
CTORDRG 4	1	4	4	5	6.0	8.0			
CTORDRG 5	1	5	5	6	8.0	10.0			
CTORDRG 6	1	6	6	7	10.0	15.0			
CTORDRG 7	1	7	7	8	15.0	20.0			
CTORDRG 8	1	8	8	9	20.0	25.0			
CTORDRG 9	1	9	9	10	25.0	27.0			
CTORDRG 10	1	10	10	11	27.0	29.0			
CTORDRG 11	1	11	11	12	29.0	31.0			
CTORDRG 12	1	12	12	13	31.0	33.0			
CTORDRG 13	1	13	13	14	33.0	35.0			
FORCE	1	1	0	1.0	.0		-8.85885		
FORCE	1	2	0	1.0	-2.16381		-61.9635		
FORCE	1	3	0	1.0	-8.64421		-123.618		
FORCE	1	4	0	1.0	-19.4063		-184.639		
FORCE	1	5	0	1.0	-34.4036		-244.795		
FORCE	1	6	0	1.0	-101.669		-576.596		
FORCE	1	7	0	1.0	-297.393		-1109.89		
FORCE	1	8	0	1.0	-519.309		-1426.79		
FORCE	1	9	0	1.0	-537.246		-1153.13		
FORCE	1	10	0	1.0	-366.120		-718.555		
FORCE	1	11	0	1.0	-417.584		-753.352		
FORCE	1	12	0	1.0	-471.266		-784.318		
FORCE	1	13	0	1.0	-526.891		-811.340		
							2		
$GRDSET									
GRID 1	1	0	.0	.0	90.00	.0			
GRID 2	2	0	3.141	.0	89.9451	.0			
GRID 3	3	0	6.2784	.0	89.7804	.0			
GRID 4	4	0	9.4077	.0	89.5068	.0			
GRID 5	5	0	12.5253	.0	89.1243	.0			
GRID 6	6	0	15.6285	.0	88.6329	.0			
GRID 7	7	0	23.2938	.0	86.9337	.0			
GRID 8	8	0	30.7818	.0	84.5721	.0			
GRID 9	9	0	38.0358	.0	81.5679	.0			
GRID 10	10	0	40.8591	.0	80.1909	.0			
GRID 11	11	0	43.6329	.0	78.7158	.0			
GRID 12	12	0	46.3536	.0	77.1453	.0			
GRID 13	13	0	49.0176	.0	75.4803	.0			
GRID 14	14	0	51.6222	.0	73.7235	.0			
MAT1	12	3.0E6		.1667		12.5 E-6	.0		CMAT11

EXTERNAL PRESSURE LOADING

I N P U T   B U L K   D A T A   D E C K   E C H O

	1	. .	2	. .	3	. .	4	. .	5	. .	6	. .	7	. .	8	. .	9	. .	10	.
	MOMENT	1	2	3	0	4		5	1.0	6	14.83917.0	7		8	-10.1998					
	MOMENT	1	3		0				1.0		14.79298.0				-20.3822					
	MOMENT	1	4		0				1.0		14.73849.0				-30.5275					
	MOMENT	1	5		0				1.0		14.73710.0				-40.6554					
	MOMENT	1	6		0				1.0		629.9624.0				-503.492					
	MOMENT	1	7		0				1.0		223.9160.0				-1180.98					
	MOMENT	1	8		0				1.0		217.7740.0				-1560.45					
	MOMENT	1	9		0				1.0		-1125.59.0				-950.370					
	MOMENT	1	10		0				1.0		13.35776.0				-132.642					
	MOMENT	1	11		0				1.0		13.01903.0				-141.715					
	MOMENT	1	12		0				1.0		12.64240.0				-150.533					
	MOMENT	1	13		0				1.0		12.29669.0				-159.092					
	PTORDRG	1	12		3.0		3.0		3.0											
	SPC	1	1		14				.0		14		134		.0					
	ENDDATA																			

TOTAL COUNT=   57

SPHERICAL SHELL WITH TOROIDAL RING ELEMENT
NASTRAN DEMO DO1-O7-1A MODIFIED TO HAVE SINGULARITIES

EXTERNAL PRESSURE LOADING

SORTED BULK DATA ECHO

CARD COUNT	1	2	3	4	5	6	7	8	9	10
1-	CTORDRG	1	1	1	2	.0	2.0			
2-	CTORDRG	2	1	2	3	2.0	4.0			
3-	CTORDRG	3	1	3	4	4.0	6.0			
4-	CTORDRG	4	1	4	5	6.0	8.0			
5-	CTORDRG	5	1	5	6	8.0	10.0			
6-	CTORDRG	6	1	6	7	10.0	15.0			
7-	CTORDRG	7	1	7	8	15.0	20.0			
8-	CTORDRG	8	1	8	9	20.0	25.0			
9-	CTORDRG	9	1	9	10	25.0	27.0			
10-	CTORDRG	10	1	10	11	27.0	29.0			
11-	CTORDRG	11	1	11	12	29.0	31.0			
12-	CTORDRG	12	1	12	13	31.0	33.0			
13-	CTORDRG	13	1	13	14	33.0	35.0			
14-	FORCE	1	1	0	1.0	.0		-8.85885		
15-	FORCE	1	2	0	1.0	-2.16381		-61.9635		
16-	FORCE	1	3	0	1.0	-8.64421		-123.618		
17-	FORCE	1	4	0	1.0	-19.4063		-184.639		
18-	FORCE	1	5	0	1.0	-34.4036		-244.795		
19-	FORCE	1	6	0	1.0	-101.669		-576.596		
20-	FORCE	1	7	0	1.0	-297.393		-1109.89		
21-	FORCE	1	8	0	1.0	-519.309		-1426.79		
22-	FORCE	1	9	0	1.0	-537.246		-1153.13		
23-	FORCE	1	10	0	1.0	-366.120		-718.555		
24-	FORCE	1	11	0	1.0	-417.584		-753.352		
25-	FORCE	1	12	0	1.0	-471.266		-784.318		
26-	FORCE	1	13	0	1.0	-526.891		-811.340		
27-	GRID	1	0	.0	.0	90.00				
28-	GRID	2	0	3.141	.0	89.9451				
29-	GRID	3	0	6.2784	.0	89.7804				
30-	GRID	4	0	9.4077	.0	89.5068				
31-	GRID	5	0	12.5253	.0	89.1243				
32-	GRID	6	0	15.6285	.0	88.6329				
33-	GRID	7	0	23.2938	.0	86.9337				
34-	GRID	8	0	30.7818	.0	84.5721				
35-	GRID	9	0	38.0358	.0	81.5679				
36-	GRID	10	0	40.8591	.0	80.1909				
37-	GRID	11	0	43.6329	.0	78.7158				
38-	GRID	12	0	46.3536	.0	77.1453				
39-	GRID	13	0	49.0176	.0	75.4803				
40-	GRID	14	0	51.6222	.0	73.7235				
41-	MAT1	12	3.0E6	0	.1667	1.0	12.5 E-6	.0		CMAT11
42-	MOMENT	1	2	0	1.0	14.8391	7.0	-10.1998		

EXTERNAL PRESSURE LOADING

SORTED BULK DATA ECHO

CARD COUNT	.	1	2	3	4	5	6	7	8	9	10
43-		MOMENT	1	3	.0	1.0	14.79298	.0	-20.3822		
44-		MOMENT	1	4	.0	1.0	14.73849	.0	-30.5275		
45-		MOMENT	1	5	.0	1.0	14.73710	.0	-40.6554		
46-		MOMENT	1	6	.0	1.0	629.9624	.0	-503.492		
47-		MOMENT	1	7	.0	1.0	223.9160	.0	-1180.98		
48-		MOMENT	1	8	.0	1.0	217.7740	.0	-1560.45		
49-		MOMENT	1	9	.0	1.0	-1125.59	.0	-950.370		
50-		MOMENT	1	10	.0	1.0	13.35776	.0	-132.642		
51-		MOMENT	1	11	.0	1.0	13.01903	.0	-141.715		
52-		MOMENT	1	12	.0	1.0	12.64240	.0	-150.533		
53-		MOMENT	1	13	.0	1.0	12.29669	.0	-159.092		
54-		PTORDRG	1	12	3.0	3.0					
55-		SPC	1	1	14	14	134	.0			
		ENDDATA									

*** USER INFORMATION MESSAGE - GRID-POINT RESEQUENCING PROCESSOR BANDIT IS NOT USED DUE TO
SMALL PROBLEM SIZE

NO ERRORS FOUND - EXECUTE NASTRAN PROGRAM

*** USER INFORMATION MESSAGE, TURN DIAG 38 ON FOR ADDITIONAL ELEMENT PROCESSING INFORMATION

13

SPHERICAL SHELL WITH TOROIDAL RING ELEMENT
NASTRAN DEMO DO1-O7-1A MODIFIED TO HAVE SINGULARITIES

EXTERNAL PRESSURE LOADING

*** USER INFORMATION MESSAGE 2118. SUBROUTINE GP4PRT - DIAG 21 SET-DOF VS. DISP SETS FOLLOWS.

INT DOF	EXT GP.-DOF	SAUTO	SB	SG	L	A	F	N	G	R	O	S	M
1	1-1		1					1	1			1	
2	1-2				1	1	1	2	2				
3	1-3				2	2	2	3	3				
4	1-4		2					4	4			2	
5	1-5				3	3	3	5	5				
6	1-6				4	4	4	6	6				
7	2-1				5	5	5	7	7				
8	2-2				6	6	6	8	8				
9	2-3				7	7	7	9	9				
10	2-4				8	8	8	10	10				
11	2-5				9	9	9	11	11				
12	2-6				10	10	10	12	12				
13	3-1				11	11	11	13	13				
14	3-2				12	12	12	14	14				
15	3-3				13	13	13	15	15				
16	3-4				14	14	14	16	16				
17	3-5				15	15	15	17	17				
18	3-6				16	16	16	18	18				
19	4-1				17	17	17	19	19				
20	4-2				18	18	18	20	20				
21	4-3				19	19	19	21	21				
22	4-4				20	20	20	22	22				
23	4-5				21	21	21	23	23				
24	4-6				22	22	22	24	24				
25	5-1				23	23	23	25	25				
26	5-2				24	24	24	26	26				
27	5-3				25	25	25	27	27				
28	5-4				26	26	26	28	28				
29	5-5				27	27	27	29	29				
30	5-6				28	28	28	30	30				
31	6-1				29	29	29	31	31				
32	6-2				30	30	30	32	32				
33	6-3				31	31	31	33	33				
34	6-4				32	32	32	34	34				
35	6-5				33	33	33	35	35				
36	6-6				34	34	34	36	36				
37	7-1				35	35	35	37	37				
38	7-2				36	36	36	38	38				
39	7-3				37	37	37	39	39				
40	7-4				38	38	38	40	40				
41	7-5				39	39	39	41	41				

SPHERICAL SHELL WITH TOROIDAL RING ELEMENT
NASTRAN DEMO DO1-07-1A MODIFIED TO HAVE SINGULARITIES

EXTERNAL PRESSURE LOADING

INT DOF	EXT GP. DOF	SAUTO	SB	SG	L	A	F	N	G	R	O	S	M
42	7 - 6				40	40	40	42	42				
43	8 - 1				41	41	41	43	43				
44	8 - 2				42	42	42	44	44				
45	8 - 3				43	43	43	45	45				
46	8 - 4				44	44	44	46	46				
47	8 - 5				45	45	45	47	47				
48	8 - 6				46	46	46	48	48				
49	9 - 1				47	47	47	49	49				
50	9 - 2				48	48	48	50	50				
51	9 - 3				49	49	49	51	51				
52	9 - 4				50	50	50	52	52				
53	9 - 5				51	51	51	53	53				
54	9 - 6				52	52	52	54	54				
55	10 - 1				53	53	53	55	55				
56	10 - 2				54	54	54	56	56				
57	10 - 3				55	55	55	57	57				
58	10 - 4				56	56	56	58	58				
59	10 - 5				57	57	57	59	59				
60	10 - 6				58	58	58	60	60				
61	11 - 1				59	59	59	61	61				
62	11 - 2				60	60	60	62	62				
63	11 - 3				61	61	61	63	63				
64	11 - 4				62	62	62	64	64				
65	11 - 5				63	63	63	65	65				
66	11 - 6				64	64	64	66	66				
67	12 - 1				65	65	65	67	67				
68	12 - 2				66	66	66	68	68				
69	12 - 3				67	67	67	69	69				
70	12 - 4				68	68	68	70	70				
71	12 - 5				69	69	69	71	71				
72	12 - 6				70	70	70	72	72				
73	13 - 1				71	71	71	73	73				
74	13 - 2				72	72	72	74	74				
75	13 - 3				73	73	73	75	75				
76	13 - 4				74	74	74	76	76				
77	13 - 5				75	75	75	77	77				
78	13 - 6				76	76	76	78	78				
79	14 - 1				77	77	77	79	79				
80	14 - 2		3					80	80			3	
81	14 - 3		4					81	81			4	
82	14 - 4		5					82	82			5	
83	14 - 5				78	78	78	83	83				
84	14 - 6				79	79	79	84	84				
--- COLUMN TOTALS ---		0	5	0	79	79	79	84	84	0	0	5	0

SPHERICAL SHELL WITH TOROIDAL RING ELEMENT
NASTRAN DEMO DO1-O7-1A MODIFIED TO HAVE SINGULARITIES

EXTERNAL PRESSURE LOADING

*** USER INFORMATION MESSAGE 2119, SUBROUTINE GP4PRT - DIAG 22 SET DISP SETS VS. DOF FOLLOWS.

SPC DISPLACEMENT SET

	-1-	-2-	-3-	-4-	-5-	-6-	-7-	-8-	-9-	-10-
1=	1-1	1-4	14-1	14-3	14-4					

SPHERICAL SHELL WITH TOROIDAL RING ELEMENT   FEBRUARY 6, 1987   RELEASE APR. 1986   PAGE   10
NASTRAN DEMO DO1-O7-1A MODIFIED TO HAVE SINGULARITIES

EXTERNAL PRESSURE LOADING

                                        ANALYSIS DISPLACEMENT SET

          -1-   -2-   -3-   -4-   -5-   -6-   -7-   -8-   -9-   -10-

  1 =   1-2   1-3   1-5   1-6   2-1   2-2   2-3   2-4   2-5   2-6
 11 =   3-1   3-2   3-3   3-4   3-5   3-6   4-1   4-2   4-3   4-4
 21 =   4-5   4-6   5-1   5-2   5-3   5-4   5-5   5-6   6-1   6-2
 31 =   6-3   6-4   6-5   6-6   7-1   7-2   7-3   7-4   7-5   7-6
 41 =   8-1   8-2   8-3   8-4   8-5   8-6   9-1   9-2   9-3   9-4
 51 =   9-5   9-6   10-1   10-2   10-3   10-4   10-5   10-6   11-1   11-2
 61 =   11-3   11-4   11-5   11-6   12-1   12-2   12-3   12-4   12-5   12-6
 71 =   13-1   13-2   13-3   13-4   13-5   13-6   14-2   14-5   14-6

SPHERICAL SHELL WITH TOROIDAL RING ELEMENT
NASTRAN DEMO DO1-O7-1A MODIFIED TO HAVE SINGULARITIES

FEBRUARY 6, 1987   RELEASE   APR. 1986   PAGE   11

EXTERNAL PRESSURE LOADING

BDRY SPC DISPLACEMENT SET

	-1-	-2-	-3-	-4-	-5-	-6-	-7-	-8-	-9-	-10-
1=	1-1	1-4	14-1	14-3	14-4					

*** USER WARNING MESSAGE 3017

ONE OR MORE POTENTIAL SINGULARITIES HAVE NOT BEEN REMOVED BY SINGLE OR MULTI-POINT CONSTRAINTS.

EXTERNAL PRESSURE LOADING

G R I D   P O I N T   S I N G U L A R I T Y   T A B L E   SPC   1   MPC   0

LIST OF COORDINATE COMBINATIONS THAT WILL REMOVE SINGULARITY

POINT ID.	TYPE	SINGULARITY ORDER	STRONGEST COMBINATION	WEAKER COMBINATION	WEAKEST COMBINATION
1	G	1	2		
2	G	1	2		
3	G	1	2		
4	G	1	2		
5	G	1	2		
6	G	1	2		
7	G	1	2		
8	G	1	2		
9	G	1	2		
10	G	1	2		
11	G	1	2		
12	G	1	2		
13	G	1	2		
14	G	1	2		

SPHERICAL SHELL WITH TOROIDAL RING ELEMENT
NASTRAN DEMO DO1-07-1A MODIFIED TO HAVE SINGULARITIES

EXTERNAL PRESSURE LOADING

*** USER FATAL MESSAGE 3097. SYMMETRIC DECOMPOSITION OF DATA BLOCK KLL ABORTED BECAUSE THE FOLLOWING COLUMNS ARE SINGULAR--
      1   6   12   18   24   30   36   42   48   54   60   66   72   77

*** USER FATAL   MESSAGE 3005

ATTEMPT TO OPERATE ON THE SINGULAR MATRIX KLL   IN SUBROUTINE FACTOR

FATAL ERROR

20

APPENDIX 2

Modified NASTRAN Demonstration Problem No. D01-07-1A
of Appendix 1 Run With AUTOSPC = 1

N A S T R A N   E X E C U T I V E   C O N T R O L   D E C K   E C H O

```
ID    DO1071A.NASTRAN
DIAG  21,22
APP       DISPLACEMENT
SOL       1,1
TIME      5
CEND
```

EXTERNAL PRESSURE LOADING

```
                      C A S E    C O N T R O L    D E C K    E C H O

     CARD
     COUNT
       1        TITLE = SPHERICAL SHELL WITH TOROIDAL RING ELEMENT
       2        SUBTITLE = MODIFIED NASTRAN DEMO DO1-O7-1A WITH AUTOSPC = 1
       3        LABEL = EXTERNAL PRESSURE LOADING
       4        ECHO = BOTH
       5        SPC = 1
       6        LOAD = 1
       7        OUTPUT
       8        DISP = ALL
       9        BEGIN BULK
```

SPHERICAL SHELL WITH TOROIDAL RING ELEMENT
MODIFIED NASTRAN DEMO DO1-O7-1A WITH AUTOSPC = 1

EXTERNAL PRESSURE LOADING

```
              I N P U T   B U L K   D A T A   D E C K   E C H O
        1 ..  2 ..  3 ..  4 ..  5 ..  6 ..  7 ..  8 ..  9 .. 10 .
CTORDRG  1          1     1     2          .0      2.0
CTORDRG  2          1     2     3          2.0     4.0
CTORDRG  3          1     3     4          4.0     6.0
CTORDRG  4          1     4     5          6.0     8.0
CTORDRG  5          1     5     6          8.0    10.0
CTORDRG  6          1     6     7         10.0    15.0
CTORDRG  7          1     7     8         15.0    20.0
CTORDRG  8          1     8     9         20.0    25.0
CTORDRG  9          1     9    10         25.0    27.0
CTORDRG 10          1    10    11         27.0    29.0
CTORDRG 11          1    11    12         29.0    31.0
CTORDRG 12          1    12    13         31.0    33.0
CTORDRG 13          1    13    14         33.0    35.0
FORCE    1          1     0    1.0        .0       0   -8.85885
FORCE    1          2     0    1.0   -2.16381      0   -61.9635
FORCE    1          3     0    1.0   -8.64421      0   -123.618
FORCE    1          4     0    1.0   -19.4063      0   -184.639
FORCE    1          5     0    1.0   -34.4036      0   -244.795
FORCE    1          6     0    1.0   -101.669      0   -576.596
FORCE    1          7     0    1.0   -297.393      0   -1109.89
FORCE    1          8     0    1.0   -519.309      0   -1426.79
FORCE    1          9     0    1.0   -537.246      0   -1153.13
FORCE    1         10     0    1.0   -366.120      0   -718.555
FORCE    1         11     0    1.0   -417.584      0   -753.352
FORCE    1         12     0    1.0   -471.266      0   -784.318
FORCE    1         13     0    1.0   -526.891      0   -811.340
                                                        2
$GRDSET
GRID     1          0     .0        .0     90.00       0
GRID     2          0     3.141     .0     89.9451     0
GRID     3          0     6.2784    .0     89.7804     0
GRID     4          0     9.4077    .0     89.5068     0
GRID     5          0    12.5253    .0     89.1243     0
GRID     6          0    15.6285    .0     88.6329     0
GRID     7          0    23.2938    .0     86.9337     0
GRID     8          0    30.7818    .0     84.5721     0
GRID     9          0    38.0358    .0     81.5679     0
GRID    10          0    40.8591    .0     80.1909     0
GRID    11          0    43.6329    .0     78.7158     0
GRID    12          0    46.3536    .0     77.1453     0
GRID    13          0    49.0176    .0     75.4803     0
GRID    14          0    51.6222    .0     73.7235     0
MAT1     1          3.0E6          .1667          12.5 E-6.0        CMAT11
```

EXTERNAL PRESSURE LOADING

INPUT BULK DATA DECK ECHO

1	2	3	4	5	6	7	8	9	10
MOMENT	1	2	0	1.0	14.83917.0		-10.1998		
MOMENT	1	3	0	1.0	14.79298.0		-20.3822		
MOMENT	1	4	0	1.0	14.73849.0		-30.5275		
MOMENT	1	5	0	1.0	14.73710.0		-40.6554		
MOMENT	1	6	0	1.0	629.9624.0		-503.492		
MOMENT	1	7	0	1.0	223.9160.0		-1180.98		
MOMENT	1	8	0	1.0	217.7740.0		-1560.45		
MOMENT	1	9	0	1.0	-1125.59.0		-950.370		
MOMENT	1	10	0	1.0	13.35776.0		-132.642		
MOMENT	1	11	0	1.0	13.01903.0		-141.715		
MOMENT	1	12	0	1.0	12.64240.0		-150.533		
MOMENT	1	13	0	1.0	12.29669.0		-159.092		
-FF-	PARAM,AUTOSPC,1								
PARAM	AUTOSPC	1							
PTORDRG	1	12	3.0	3.0					
SPC	1	14	14	.0	14	134	.0		
ENDDATA									

TOTAL COUNT= 58

SPHERICAL SHELL WITH TOROIDAL RING ELEMENT
MODIFIED NASTRAN DEMO DO1-07-1A WITH AUTOSPC = 1

EXTERNAL PRESSURE LOADING

S O R T E D   B U L K   D A T A   E C H O

CARD COUNT	1	2	3	4	5	6	7	8	9	10
1-	CTORDRG	1	1	1	2	.0	2.0			
2-	CTORDRG	2	1	2	3	2.0	4.0			
3-	CTORDRG	3	1	3	4	4.0	6.0			
4-	CTORDRG	4	1	4	5	6.0	8.0			
5-	CTORDRG	5	1	5	6	8.0	10.0			
6-	CTORDRG	6	1	6	7	10.0	15.0			
7-	CTORDRG	7	1	7	8	15.0	20.0			
8-	CTORDRG	8	1	8	9	20.0	25.0			
9-	CTORDRG	9	1	9	10	25.0	27.0			
10-	CTORDRG	10	1	10	11	27.0	29.0			
11-	CTORDRG	11	1	11	12	29.0	31.0			
12-	CTORDRG	12	1	12	13	31.0	33.0			
13-	CTORDRG	13	1	13	14	33.0	35.0			
14-	FORCE	1	0	0	1.0	.0	.0	-8.85885		
15-	FORCE	2	0	0	1.0	-2.16381	.0	-61.9635		
16-	FORCE	3	0	0	1.0	-8.64421	.0	-123.618		
17-	FORCE	4	0	0	1.0	-19.4063	.0	-184.639		
18-	FORCE	5	0	0	1.0	-34.4036	.0	-244.795		
19-	FORCE	6	0	0	1.0	-101.669	.0	-576.596		
20-	FORCE	7	0	0	1.0	-297.393	.0	-1109.89		
21-	FORCE	8	0	0	1.0	-519.309	.0	-1426.79		
22-	FORCE	9	0	0	1.0	-537.246	.0	-1153.13		
23-	FORCE	10	0	0	1.0	-366.120	.0	-718.555		
24-	FORCE	11	0	0	1.0	-417.584	.0	-753.352		
25-	FORCE	12	0	0	1.0	-471.266	.0	-784.318		
26-	FORCE	13	0	0	1.0	-526.891	.0	-811.340		
27-	GRID	1	0	.0	.0	90.00	.0			
28-	GRID	2	0	3.141	.0	89.9451	.0			
29-	GRID	3	0	6.2784	.0	89.7804	.0			
30-	GRID	4	0	9.4077	.0	89.5068	.0			
31-	GRID	5	0	12.5253	.0	89.1243	.0			
32-	GRID	6	0	15.6285	.0	88.6329	.0			
33-	GRID	7	0	23.2938	.0	86.9337	.0			
34-	GRID	8	0	30.7818	.0	84.5721	.0			
35-	GRID	9	0	38.0358	.0	81.5679	.0			
36-	GRID	10	0	40.8591	.0	80.1909	.0			
37-	GRID	11	0	43.6329	.0	78.7158	.0			
38-	GRID	12	0	46.3536	.0	77.1453	.0			
39-	GRID	13	0	49.0176	.0	75.4803	.0			
40-	GRID	14	0	51.6222	.0	73.7235	.0			
41-	MAT1	12	3.0E6		.1667	14.83917.0	12.5 E-6.0	-10.1998		CMAT11
42-	MOMENT	1	2	0	1.0	1.0				

EXTERNAL PRESSURE LOADING

S O R T E D   B U L K   D A T A   E C H O

CARD COUNT	1	2	3	4	5	6	7	8	9	10
43-	MOMENT	1	3	0	1.0	14.79298.0		-20.3822		
44-	MOMENT	1	4	0	1.0	14.73849.0		-30.5275		
45-	MOMENT	1	5	0	1.0	14.73710.0		-40.6554		
46-	MOMENT	1	6	0	1.0	629.9624.0		-503.492		
47-	MOMENT	1	7	0	1.0	223.9160.0		-1180.98		
48-	MOMENT	1	8	0	1.0	217.7740.0		-1560.45		
49-	MOMENT	1	9	0	1.0	-1125.59.0		-950.370		
50-	MOMENT	1	10	0	1.0	13.35776.0		-132.642		
51-	MOMENT	1	11	0	1.0	13.01903.0		-141.715		
52-	MOMENT	1	12	0	1.0	12.64240.0		-150.533		
53-	MOMENT	1	13	0	1.0	12.29669.0		-159.092		
54-	PARAM	AUTOSPC	1							
55-	PTORDRG	1	12	3.0	3.0					
56-	SPC	1	1	14	.0	134	.0			
	ENDDATA									

*** USER INFORMATION MESSAGE - GRID-POINT RESEQUENCING PROCESSOR BANDIT IS NOT USED DUE TO
SMALL PROBLEM SIZE

    NO ERRORS FOUND - EXECUTE NASTRAN PROGRAM

*** USER INFORMATION MESSAGE, TURN DIAG 38 ON FOR ADDITIONAL ELEMENT PROCESSING INFORMATION

*** USER INFORMATION MESSAGE 2435, AT USER'S REQUEST, ALL POTENTIAL SINGULARITIES HAVE BEEN REMOVED BY THE
APPLICATION OF SINGLE POINT CONSTRAINTS. REFER TO PRINTOUT OF AUTOMATICALLY GENERATED SPC1 CARDS FOR DETAILS.

SPHERICAL SHELL WITH TOROIDAL RING ELEMENT
MODIFIED NASTRAN DEMO DO1-O7-1A WITH AUTOSPC = 1

EXTERNAL PRESSURE LOADING

A U T O M A T I C A L L Y   G E N E R A T E D   S P C 1   C A R D S

CARD COUNT		1 ..	2 ..	3 ..	4 ..	5 ..	6 ..	7 ..	8 ..	9 ..	10 .
1-	SPC1	1	1	2	1	2	3	4	5	6	
2-	SPC1	1	1	2	7	8	9	10	11	12	
3-	SPC1	1	1	2	13	14					

SPHERICAL SHELL WITH TOROIDAL RING ELEMENT
MODIFIED NASTRAN DEMO DO1-07-1A WITH AUTOSPC = 1

EXTERNAL PRESSURE LOADING

*** USER INFORMATION MESSAGE 2118, SUBROUTINE GP4PRT - DIAG 21 SET-DOF VS. DISP SETS FOLLOWS.

INT DOF	EXT GP. DOF	SAUTO	SB	SG	L	A	F	N	G	R	O	S	M
1	1 - 1	1						1	1			1	
2	1 - 2				1	1	1	2	2				
3	1 - 3		1					3	3			2	
4	1 - 4				2	2	2	4	4				
5	1 - 5				3	3	3	5	5				
6	1 - 6				4	4	4	6	6				
7	2 - 1	2						7	7			3	
8	2 - 2				5	5	5	8	8				
9	2 - 3				6	6	6	9	9				
10	2 - 4				7	7	7	10	10				
11	2 - 5				8	8	8	11	11				
12	2 - 6				9	9	9	12	12				
13	3 - 1	3						13	13			4	
14	3 - 2				10	10	10	14	14				
15	3 - 3				11	11	11	15	15				
16	3 - 4				12	12	12	16	16				
17	3 - 5				13	13	13	17	17				
18	3 - 6				14	14	14	18	18				
19	4 - 1	4						19	19			5	
20	4 - 2				15	15	15	20	20				
21	4 - 3				16	16	16	21	21				
22	4 - 4				17	17	17	22	22				
23	4 - 5				18	18	18	23	23				
24	4 - 6				19	19	19	24	24				
25	5 - 1	5						25	25			6	
26	5 - 2				20	20	20	26	26				
27	5 - 3				21	21	21	27	27				
28	5 - 4				22	22	22	28	28				
29	5 - 5				23	23	23	29	29				
30	5 - 6				24	24	24	30	30				
31	6 - 1	6						31	31			7	
32	6 - 2				25	25	25	32	32				
33	6 - 3				26	26	26	33	33				
34	6 - 4				27	27	27	34	34				
35	6 - 5				28	28	28	35	35				
36	6 - 6				29	29	29	36	36				
37	7 - 1	7						37	37			8	
38	7 - 2				30	30	30	38	38				
39	7 - 3				31	31	31	39	39				
40	7 - 4				32	32	32	40	40				
41	7 - 5		2					41	41			9	

SPHERICAL SHELL WITH TOROIDAL RING ELEMENT
MODIFIED NASTRAN DEMO DO1-07-1A WITH AUTOSPC = 1

EXTERNAL PRESSURE LOADING

INT DOF	EXT GP. DOF	SAUTO	SB	SG	L	A	F	N	G	R	O	S	M
42	7 - 6				33	33	33	42	42				
43	8 - 1				34	34	34	43	43				
44	8 - 2	8						44	44			10	
45	8 - 3				35	35	35	45	45				
46	8 - 4				36	36	36	46	46				
47	8 - 5				37	37	37	47	47				
48	8 - 6				38	38	38	48	48				
49	9 - 1				39	39	39	49	49				
50	9 - 2	9						50	50			11	
51	9 - 3				40	40	40	51	51				
52	9 - 4				41	41	41	52	52				
53	9 - 5				42	42	42	53	53				
54	9 - 6				43	43	43	54	54				
55	10 - 1				44	44	44	55	55				
56	10 - 2	10						56	56			12	
57	10 - 3				45	45	45	57	57				
58	10 - 4				46	46	46	58	58				
59	10 - 5				47	47	47	59	59				
60	10 - 6				48	48	48	60	60				
61	11 - 1				49	49	49	61	61				
62	11 - 2	11						62	62			13	
63	11 - 3				50	50	50	63	63				
64	11 - 4				51	51	51	64	64				
65	11 - 5				52	52	52	65	65				
66	11 - 6				53	53	53	66	66				
67	12 - 1				54	54	54	67	67				
68	12 - 2	12						68	68			14	
69	12 - 3				55	55	55	69	69				
70	12 - 4				56	56	56	70	70				
71	12 - 5				57	57	57	71	71				
72	12 - 6				58	58	58	72	72				
73	13 - 1				59	59	59	73	73				
74	13 - 2	13						74	74			15	
75	13 - 3				60	60	60	75	75				
76	13 - 4				61	61	61	76	76				
77	13 - 5				62	62	62	77	77				
78	13 - 6				63	63	63	78	78				
79	14 - 1		3					79	79			16	
80	14 - 2	14						80	80			17	
81	14 - 3		4					81	81			18	
82	14 - 4		5					82	82			19	
83	14 - 5				64	64	64	83	83				
84	14 - 6				65	65	65	84	84				
--- C O L U M N T O T A L S ---		14	5	0	65	65	65	84	84	0	0	19	0

EXTERNAL PRESSURE LOADING

*** USER INFORMATION MESSAGE 2119, SUBROUTINE GP4PRT - DIAG 22 SET DISP SETS VS. DOF FOLLOWS.

SPC DISPLACEMENT SET

	-1-	-2-	-3-	-4-	-5-	-6-	-7-	-8-	-9-	-10-
1=	1-1	1-2	1-4	2-2	3-2	4-2	5-2	6-2	7-2	8-2
11=	9-2	10-2	11-2	12-2	13-2	14-1	14-2	14-3	14-4	

SPHERICAL SHELL WITH TOROIDAL RING ELEMENT
MODIFIED NASTRAN DEMO DO1-07-1A WITH AUTOSPC = 1

EXTERNAL PRESSURE LOADING

ANALYSIS DISPLACEMENT SET

	-1-	-2-	-3-	-4-	-5-	-6-	-7-	-8-	-9-	-10-
1=	1-3	1-5	1-6	2-1	2-3	2-4	2-5	2-6	3-1	3-3
11=	3-4	3-5	3-6	4-1	4-3	4-4	4-5	4-6	5-1	5-3
21=	5-4	5-5	5-6	6-1	6-3	6-4	6-5	6-6	7-1	7-3
31=	7-4	7-5	7-6	8-1	8-3	8-4	8-5	8-6	9-1	9-3
41=	9-4	9-5	9-6	10-1	10-3	10-4	10-5	10-6	11-1	11-3
51=	11-4	11-5	11-6	12-1	12-3	12-4	12-5	12-6	13-1	13-3
61=	13-4	13-5	13-6	14-5	14-6					

32

MODIFIED NASTRAN DEMO DO1-O7-1A WITH AUTOSPC = 1

EXTERNAL PRESSURE LOADING

BDRY SPC DISPLACEMENT SET

	-1-	-2-	-3-	-4-	-5-	-6-	-7-	-8-	-9-	-10-
1=	1-1	1-4	14-1	14-3	14-4					

MODIFIED NASTRAN DEMO DO1-O7-1A WITH AUTOSPC = 1

EXTERNAL PRESSURE LOADING

AUTO SPC DISPLACEMENT SET

	-1-	-2-	-3-	-4-	-5-	-6-	-7-	-8-	-9-	-10-
1 =	1-2	2-2	3-2	4-2	5-2	6-2	7-2	8-2	9-2	10-2
11 =	11-2	12-2	13-2	14-2						

***USER INFORMATION MESSAGE 3023--PARAMETERS FOR REAL   SYMMETRIC DECOMPOSITION OF DATA BLOCK KLL   (N =   65)
        TIME ESTIMATE=   1   C AVG =   7   PC AVG =   0   SPILL GROUPS =   0   S AVG =   1
        ADDITIONAL CORE=-242866   C MAX =   10   PCMAX =   0   PC GROUPS =   0   PREFACE LOOPS =   1

*** USER INFORMATION MESSAGE 3035

FOR SUBCASE NUMBER   1, EPSILON SUB E = 7.9516343E-14

SPHERICAL SHELL WITH TOROIDAL RING ELEMENT
MODIFIED NASTRAN DEMO D01-07-1A WITH AUTOSPC = 1

EXTERNAL PRESSURE LOADING

D I S P L A C E M E N T   V E C T O R

POINT ID.	TYPE	T1	T2	T3	R1	R2	R3
1	G	0.0	0.0	-5.466944E-04	0.0	1.683363E-06	2.264283E-07
2	G	-1.379353E-05	0.0	-5.465159E-04	9.711449E-09	1.683092E-06	-2.154376E-08
3	G	-2.758300E-05	0.0	-5.460528E-04	-4.874046E-08	1.682592E-06	4.688149E-08
4	G	-4.132202E-05	0.0	-5.448287E-04	-2.965820E-07	1.676809E-06	1.172040E-07
5	G	-5.488748E-05	0.0	-5.421350E-04	-8.169632E-07	1.656756E-06	2.187806E-07
6	G	-6.804022E-05	0.0	-5.369929E-04	-1.700009E-06	1.611340E-06	3.477465E-07
7	G	-9.602270E-05	0.0	-5.049501E-04	-5.982594E-06	1.304370E-06	7.566064E-07
8	G	-1.071690E-04	0.0	-4.272170E-04	-1.345247E-05	4.936754E-07	1.104621E-06
9	G	-8.639758E-05	0.0	-2.889577E-04	-2.183137E-05	-1.014970E-06	8.644736E-07
10	G	-6.754948E-05	0.0	-2.194551E-04	-2.388998E-05	-1.779485E-06	3.991782E-07
11	G	-4.435892E-05	0.0	-1.472862E-04	-2.399925E-05	-2.568128E-06	-3.909324E-07
12	G	-2.046372E-05	0.0	-7.944898E-05	-2.101134E-05	-3.285147E-06	-1.583341E-06
13	G	-2.309796E-06	0.0	-2.593311E-05	-1.352425E-05	-3.788745E-06	-3.284960E-06
14	G	0.0	0.0	0.0	0.0	-3.883259E-06	-5.282908E-06

35