#### Theory of Composite Shells Dr. Poonam Kumari Department of Mechanical Engineering Indian Institute of Technology, Guwahati

#### Lecture - 28 Free vibration of a composite cylindrical shell

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Welcome to the tutorial on the Free Vibration analysis of a Composite Cylindrical Shell. An all-round simply supported cylindrical shell which is made up of cross-ply laminate scheme (0/90/0) is considered.

It is a thick shell of 
$$S = \frac{R}{h} = 4$$
.

And is of axial length L, and circumferential span  $\alpha$ . The material properties of a lamina are that of an orthotropic material. Find the lowest natural frequency of the shell and visualize the mode shapes.

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The results are compared with those presented by Chen et al in this paper.

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	2440	W.Q. Chen e	et al.   International Jour	rnal of Solids and Struc	tures 41 (2004) 2429-2	446				
	Table 4									
	The lowest dim	ensionless frequency	ii for a three-ply ([90/0	(90°]) cylindrical panel	with weak interfaces (	$L/h = 5S, \alpha = \pi/3)^n$	_			
	( <i>m</i> , <i>n</i> )	S	R = 0.0	R = 0.3	R = 0.6	R = 0.9				
	(1,1)	4	11.66616	10.87918	10.31621	9.89192				
			(11.99395)	(10.46062)	(9.51144)	(8.90386)				
		10	12.86607	12.24169	11.71792	11.27108				
			(12.95592)	(11.66571)	(10.57431)	(9.67627)				
		20	11,20476	10,98330	10.77682	10.58373				
			(11.23782)	(10,76221)	(10.26312)	(9.76555)				
		50	8.19762	8,17022	8,14319	8.11654				
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	(2.1)	4	30.73004	29,10653	28.05967	27.32793				
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		10	39.32893	36,58271	34,54921	32,97619				
			(39.67459)	(34,31803)	(30,72844)	(28.27173)				
×		20	41,23324	39,18662	37.47011	36.00582				
14			(41.30724)	(37,13336)	(33.99432)	(30.67520)				
		50	32,68723	32 22254	31,77956	31.35668				
1. C		24	(32.70070)	(31.69756)	(30.59182)	(29.43239)				
·				20.22220	20 10201	22.4/220				Ċ,
	(2,2)	4	30.85077	29.43339	28.19291	21.463.39				

We can see the lowest dimensionless frequencies have been listed in this table.

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We model the shell, create a new model database and set the working directory. Create the new part which is named as shell vibration.

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And these are the construction lines for initializing the model as the circumferential span  $\alpha = \frac{\pi}{3}$ . The construction lines are at an angle of  $\frac{\pi}{3}$  and an arc is created at a distance of 3.5 unit which is corresponds to the inner surface of the shell. And the thickness is taken as 1 unit. Close the sketch for extrusion and it is extruded as 5S units i.e., 20 units.

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Then, the plies are created through an offset tool as previously explained.

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And a cylindrical coordinate system is also provided.

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Then, in the property module the material properties are assigned to the plies.

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The material properties are those shown in the problem statement earlier.

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The laminate scheme is taken to be 0/90/0.

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The outer two layers are at 0 degree.

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And the middle layer is at  $90^{\circ}$  orientation.

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Thereafter, we go for the assembly of the shell.

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And in the step module, this time we need to do the free vibration problem. We go further linear perturbation type and go for frequency.

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Using the solver of Lanczos the number of mode shapes that we want to calculate can be given in the values field.

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Then, we set the boundary conditions which is simply supported.

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There is no load as it is a free vibration analysis.

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Then the meshing is done after a convergence study.

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We take the 3D type element.

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Finally, the job is submitted for analysis.

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Once the analysis has been done, the data file for the analysis can be seen in the working directory as a DAT file.

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In the DAT file, we can find the calculated frequencies corresponding to the mode shapes.

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NIN	ORT ESTIMATE						
ESS FLOATING PT	MINIMIM MEMORY	MEMORY TO					
DER ITERATIO	REQUIRED (NEUTES)	(MEVIES)					

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He Edit F	omat Vew Help					
SUTEI						
(1)	SINCE ABAQUE DOS	ES NOT FRE-ALLOG	LATE MEMORY AND	OSLY ALLOCATES	MENORY AS SEED	ED DURING THE AMALYSI
	RNOWLEDGE AVAILS	BLE AT THE BEGI	INNING OF A STE	P BEFORE THE SOL	UTION PROCESS	BAS BEGUS.
(2)	THE ESTIMATE IS	HORMALLY OPDATE	ED AT THE SEGIN	MING OF EVERY 53	EP. IT 15 188	MAXIMUM VALUE OF THE
	ESTIMATE FROM IN	IE CURRENT STEP	TO THE LAST ST	EP OF THE AMALYS	US, WITH CHAYN	METRIC SOLUTION TARES
(2)	INTO ACCOUNT IF	APPLICABLE.				TERATION OF THE
1643	CURRENT STEP, IN	IE MENCRY ESTING	ATE HIGHT HE SI	GNIFICANTLY DIFF	TRENT TEAS ACT	TAL USAGE FOR
	EBORLENS WITH ST	IESTANTIAL CEAN	IES IN ACTIVE D	EGREES OF FREEDO	BETWEEN STEP	S (OR EVEN WITHIN
	THE SAME STEP).	EXAMPLES AND: 1	PROBLEMS WITH 5	IGNIFICANT CONTR	CT CRANDES, FR	COLENS WITH MODEL
	CEANSE, PROBLEM	TV SE ATTUATE	THE THE STELLY	LADI STATE DISON	TT PROLEDUSZS	KEEKE ACOUSTIC
(4)	FUR MULTI-PROCES	SS EXECUTION, TH	EZ ESTIMATED VA	LUE OF FLOATING	POINT OFERATIO	NS FOR EACS FROCESS
	IS BASED ON AN I	INITIAL SCREDULS	INS OF OPERATIO	NS AND MIGHT NOT	REFLECT THE A	CTUAL FLOATING
	POINT OPERATIONS	S COMPLETED ON B	CACH PROCESS. O	FERATIONS ARE DO	NUMICALLY BALA	NCED DURING EXECUTIO
	SO THE ACTUAL IS	ALASICE OF OPERAL	LICES BEINEES P	RDCESSES 15 EXTE	CIED TO BE BET	TER THAN THE ESTIMAT
(5)	THE UPPER LINIT	OF MENORY THAT	CAN BE ALLOCAT	ED BY ABAQUS WIT	L IN GENERAL D	EFEND ON THE VALUE OF
	THE "MEMORY" PAS	RAMETER AND THE	AMOUNT OF PHYS	ICAL MEMORY AVAI	LABLE ON THE M	ACHINE. FLEASE SEE
	THE "ABAQUS ASAD	LARIE DRES. 2 MAY	SUAL" FOR MORE	CETAILS. THE ACT	TURL USAGE OF M	ENORY AND OF DISE
	THAT TE THE NEW	IN DATA WILL DEN	TE CONTROL THE	YER LINIT AS HEL	A AS THE REMOK	I SEQUINED TO MISIMIC
	NENCRY DEAGE HIS	L BE CLOSE TO 1	THE ESTIMATED .	MENCRY IO MINIMI	IZE I/O" VALUE.	AND THE SCRATCH DISE.
	USAGE WILL BE CO	LOSE-TO-ZERO: 01	THERRISE, THE A	CTUAL MENORY USE	D WILL BE CLOS	E TO THE PREVIOUSLY
	MENTIONED MENCRI	E LIMIT, AND THE	E SCRATCH DISK	USAGE WILL BE RO	COMLY PROPERTS	OSAL TO THE DIFFERENC
	SETNEES THE ESTI	SCRATED "MENORY I	IN HISINIZE I/O	* AND THE HEHORY	UPPER LINIT.	SCHEVER ACCORATE
(6)	USING **RESTART,	WRITE" CAN SET	TERATE & LARGE	AMOUNT OF DATA &	BITTEN IN THE	HORE DIRECTORY.
NOTE NO	EIGENVALUE	153	EQUENCY	GENERALIZED NAS	IS COMPOSITE	HCCAL DAMFING
		(BAD/TIME)	(CTCLES/TINE)			
1	85124.	291.76	46.435	33614.	0.0000	
2	3.404992+05	\$83.52	92.971	33614.	0.0000	
3	5.86459E+05	763.81	121.85	22645.	0.0000	
	PARTICIP	ATION FF	CTOR5			
NODE NO	X-COMPONENT	Y-COMPONENT	2-COMPONENT	X-ROTATION	Y-ROTATION	I-ROTATION
1	1.3538	-3.41720E-12	-1.26639E-13	1.71438E-11	13,598	-5.7296
2	-6.12365E-11	S.46290E-12	-3.08805E-13	7.327878-11	6.7691	2.56794E-10
1	-2.39618E-10	1.0031	-0.106335-11	-16,031	3.149902-09	-1,UsessE-09
	LIT	COLLAR 2	5 A 3 3			
NODE NO	X-COMPONENT	Y-COMPONENT	2-COMPONENT	X-ROIATION	Y-ROTATION	Z-ROTATION
1.4	61.677	1 215167-10	8 10070F-11	0.070478-18	E 160718-06	1 101477-04
-	1.26295E-18	1.00514E-18	5.205408-21	1.80497E-18	1.540152+06	2.216418-15
3	2.014902-15	57682.	9.379305-17	5.76821E+06	2.226245-10	2.505072-16
£						

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We can see the eigenvalues listed here and on comparing the results after nondimensionalizing, it nearly matches with the results presented.

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We can also visualize the mode shapes.

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Model Results	Module Vousiantion • Model F/NPTELSHELL VBRATION/Vibration_Bmodes.cdb	Ш <b>З н 4 </b> > н
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