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Input File for Modelling Floating Wind Turbine for Dynamic Structural Analysis

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Abstract

One of the complicated analyses problems in structural analysis is the floating wind converter, in this paper the preprocessor of LS-DYNA3D namely, FEMB28 is used in formulating the float geometry and preparing the input file ready to be exported the solver or processor for analysis. Keen methodology is followed in geometrical meshing, material, and contact boundary conditions, all precautions in model creation are detailed. The paper tend to investigate the power of the LSDYNA3D finite element code to model such complicated structure working in an extremely harsh environmental severe loading conditions, therefore the code robustness and capability to handle stress analysis for such dynamic structures.

Keywords: dynamic analysis of wind converter by LSDYNA3D; input file for floating structure**;** floating wind converter analysis; modelling wind converter for analysis**.**

1 Introduction

In this presentation, supplemented to good knowledge of both: floating wind energy converters and dynamic finite element analysis formulation, a pre-processor, FEMB-28 LSTC [1], the Keyword User's Manuals LSTC [2,3], the Theoretical Manual, Halliquist [4], Reid LSDYNA Examples Manual [5,6] are used and frequently consulted for preparing the input file for the LS-DYNA3D non-linear dynamic explicit code. In this paper, the use of this pre-processor is shown to produce the seventeen parts used in the developed detailed model presented in Figure (1). Before starting to digitize a model, a drawing has to be sketched, with dimensions intended to be used in the analysis, these drawings should represent different parts, and on the same global reference axis for the whole parts and does not need to be scaled. These parts will coincide or interact as one body once activated together and given the right materials, properties, contact and boundary conditions. The database file is opened in which a certain set of dimensions are readily picked and defined to be the default dimensions.

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These have to be strictly followed for a consistent set of units throughout the model till the stage of analysis. All parameters in this paper follow SI units as follows; mass (kg), length (m), stress (MPa), force (N), time (second), pressure (Pa), temperature (deg. C), modulus of elasticity (Pa) and mass (kg/m^3).

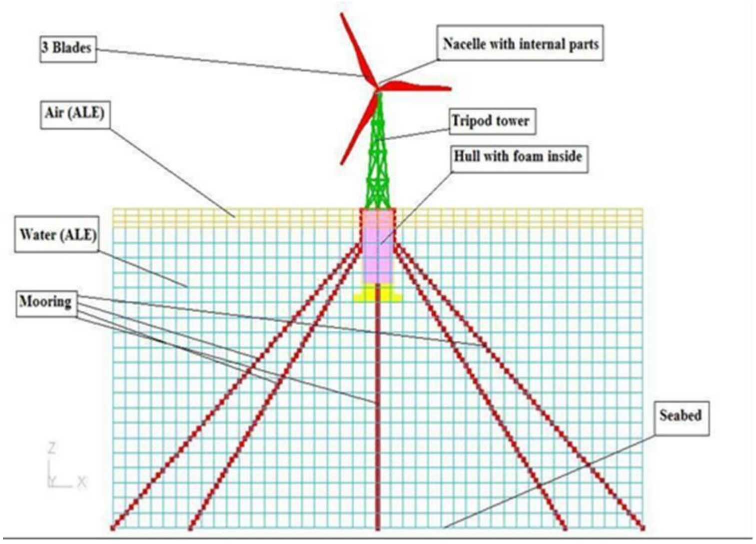

Figure 1: Floating wind energy turbine

2. Creating the Model

Most FEM models require certain steps procedure or pre-process, in order to create the keywords, input file which would be readily imported to the main solver for analysis. Obviously, the code must be capable of reading this file. In this work, the solver is LSDYNA3D code, version 970, of LSTC, and the pre-processor is FEMB-28, these mentioned steps are:

1. Modelling: or digitizing drawings to form nodes then elements, either directly through nodes or via creating lines or surfaces then elements.

In the modelling stage, the structure is merely translated to lines or surfaces, then finally to elements. Checked for model integrity and coincident nodes, the named functions of nodes, lines and surfaces could or must be deleted once they have served their purpose, and are no longer needed. However, if a geometrical change is required, this data is stored and could be recalled back. The aim of this stage is to interpret the structure into compatible elements and nodes.

2. Materials: have to be defined for each part(s) or elements.

This is the next stage, implemented through the material menu, and chosen from the ready material library (could also be user defined). Before material is created and assigned to a part, this part has to be current, parts are displayed in material color once they have been assigned a material, otherwise will be displayed in grey.

3. Property: has to be defined and assigned to appropriate parts to simulate the desired behavior or

boundary conditions. All model parts need to be turned on and displayed in either property color or in grey if property is not assigned. All elements should be assigned their intended geometrical properties.

4. Contact: this is for interaction of coupling surfaces in the model, specifically when modelling integral actions of parts.

5. Boundary conditions: this is the final formulation of the actual behavior of a part or material to simulate the intended action to be analyzed, most of the common boundary conditions are recognized by LS-DYNA3D and can be readily introduced. Mainly restraints of rotations translations and loads reflecting the intended action need be simulated.

The definition of a database is a precondition for creating parts; the code does not allow creation of parts in an empty database. Parts are created at the beginning and called when needed or created promptly when required once created they can be switched on and off for updating and modification, or to perform any operation that involve such parts. Materials and properties can either be defined upon creation of a part or assigned at a later stage.

As already stated, the model consists of seventeen parts; these will be mentioned in some detail in this paper with an emphasis on pre-processor use of preparing the input file. The basic emphasis here will be on the keyword cards related to materials, properties, boundary conditions, contact, constraints and load applications and will be discussed as follows:

2.1 Blades part

Turbine blades are made of shell elements, element formulation 16 is chosen to guard against hourglass modes material and property keyword cards are:

Modelled by shell elements, *SECTION_SHELL, two keyword cards required for defining property and material with the ID numbers appearing are arbitrary (but unique) and follows part successive order:

SEC ID	Section ID		15
ELFORM	Element Formulation		16
SHRF	Shear Factor		0.83333
NIP	Number of Integration Points		4
PROPT	Print out Option		3
QR/IRID	Quadrature Rule		0
ICOMP	Layered Composite Flag		0
SETYP	2D Solid Element Type		1
T1	Shell Thickness at Node1		0 .030
T2	Shell Thickness at Node2 T3 T3	Shell	0.030
Thickness at Node3			
			0.030

T3	Shell Thickness at Node4	0.030
NLOC	Location of Preference Surface	0
MAREA	Non-Structural Mass per	0

And material card is:

*MAT_PLASTIC_KINEMATIC

MID	Material ID	15
RO	Mass Density	976.3
E	Young's Modulus	$2.9x10^{11}$
PR	Poisson's Ratio	0.30
N	MADYMO3D Couple Flag	0
SIGY	Plastic Hardening modulus	0
BETA	Hardening parameter	0.1
SRC	Strain Rate Parameter	
SRP	Strain Rate Parameter	
FS	Failure Strain Eroding Elements	1.0
VP	Local Coordinate System or X-comp.	0

2.2 Hub part

Modelled by plate shells, *SECTION_SHELL, with property inputs:

SEC ID	Section ID	14
ELFORM	Element Formulation	16
SHRF	Shear Factor	0.83333
NIP	Number of Integration Points	4
PROPT	Print out Option	3
QR/IRID	Quadrature Rule	0
ICOMP	Layered Composite Flag	0
SETYP	2D Solid Element Type	1
T1	Shell Thickness at Node1	0.032
T2	Shell Thickness at Node2	0.032
T3	Shell Thickness at Node3	0.032
T3	Shell Thickness at Node4	0 .032
NLOC	Location of Preference Surface	0
MAREA	Non-structural Mass per	0

And material card is: *MAT-PLASTIC_KINEMATIC

MID	Material ID	14

RO	Mass Density	5148
E	Young's Modulus	$2.1x10^{11}$
PR	Poisson's Ratio	0.30
SIGY	Plastic Hardening modulus	$3.6x10^{6}$
BETA	Hardening parameter	0.4
SRC	Strain Rate Parameter	
SPR	Strain rate parameter	
FS	Failure Strain Eroding Elements	1.0
VP	Local Coordinate System or X-comp.	0

2.3 Transmission part

Section property is solid brick element or *SECTION_SOLID with parameters:

SEC ID	Section ID	13
ELFORM	Element Formulation	3
AET	Ambient Element Type	0

Modelled with material type 20 or *MAT_RIGID with factors:

MID	Material ID	3
RO	Mss Density	7850
E	Young's Modulus	$2.1x10^{11}$
PR	Poisson's Ratio	0.28
N	MADYMO3D Couple Flag	0.0
COUPLE	Coupling Option	0.0

M	MADYMO/CAL3D Couple	0.0
ALIAS	VDA Surface ALIAS	0.0
CMO	Centre of Mass Constraint	
CON1	Translation Constraint	
CON2	Rotational Constraint	
LCO OR A_1	Local Coordinate System or X-comp.	13
A_2	Y-comp. Vector 1	0
A_3	Z-comp. Vector 1	0
V_1	X-comp. Vector 2	0
V_2	Y-comp. Vector 2	0
V_3	Z-comp. Vector 2	0

2.4 Nacelle part

Modelled with shell elements or *SECTION_SHELL and parameters:

SEC ID	Section ID	8
ELFORM	Element Formulation	16
SHRF	Shear Factor	0.83333
NIP	Number of Integration Points	2
PROPT	Print out Option	3
QR/IRID	Quadrature Rule	0
ICOMP	Layered Composite Flag	0
SETYP	2D Solid Element Type	1
T1	Shell Thickness at Node1	0.02

T2	Shell Thickness at Node2	0.02
T3	Shell Thickness at Node3	0.02
T4	Shell Thickness at Node4	0.02
NLOC	Location of Reference Surface	0
MAREA	Non-structural mass per	0

And of material type 20 or *MAT_RIGID with parameters:

MID	Material ID	8
RO	Mss Density	7850
E	Young's Modulus	$2.1x10^{11}$
PR	Poisson's Ratio	0.28
N	MADYMO3D Couple Flag	0.0
COUPLE	Coupling Option	0.0
M	MADYMO/CAL3D Couple	0.0
ALIAS	VDA Surface ALIAS	0.0
CMO	Centre of Mass Constraint	
CON1	Translation Constraint	
CON2	Rotational Constraint	
LCO OR A_1	Local Coordinate System or X-comp.	8
A_2	Y-comp. Vector 1	0
A_3	Z-comp. Vector 1	0
V_1	X-comp. Vector 2	0
V_2	Y-comp. Vector 2	0

V_3	Z-comp. Vector 2	0

2.5 Gear part

Modelled with brick solid elements, *SECTION_SOLID with input values:

SEC ID	Section ID	9
ELFORM	Element Formulation	3
AET	Ambient Element Type	0

And material type 20 or *MAT_RIGID with input values:

MID	Material ID	9
RO	Mss Density	7850
E	Young's Modulus	$2.1x10^{11}$
PR	Poisson's Ratio	0.28
N	MADYMO3D Couple Flag	0.0
COUPLE	Coupling Option	0.0
M	MADYMO/CAL3D Couple	0.0
ALIAS	VDA Surface ALIAS	0.0
CMO	Centre of Mass Constraint	
CON1	Translation Constraint	
CON2	Rotational Constraint	
LCO OR A_1	Local Coordinate System or X-comp.	9
A_2	Y-comp. Vector 1	0
A_3	Z-comp. Vector 1	0

V_1	X-comp. Vector 2	0
V_2	Y-comp. Vector 2	0
V_3	Z-comp. Vector 2	0

2.6 Drive part

Modelled with solid brick elements, *SEC_SOLID with input values:

SEC ID	Section ID	10
ELFORM	Element Formulation	3
AET	Ambient Element Type	0

And material type 20, *MAT_RIGID with inputs:

MID	Material ID	10
RO	Mss Density	7850
E	Young's Modulus	$2.1x10^{11}$
PR	Poisson's Ratio	0.28
N	MADYMO3D Couple Flag	0.0
COUPLE	Coupling Option	0.0
M	MADYMO/CAL3D Couple	0.0
ALIAS	VDA Surface ALIAS	0.0
CMO	Centre of Mass Constraint	
CON1	Translation Constraint	
CON2	Rotational Constraint	
LCO OR A_1	Local Coordinate System or X-comp.	10
A_2	Y-comp. Vector 1	0
A_3	Z-comp. Vector 1	0

V_1	X-comp. Vector 2	0
V_2	Y-comp. Vector 2	0
V_3	Z-comp. Vector 2	0

2.7 Generator part

Also modelled with solid brick elements, *SEC_SOLID of parameters:

SEC ID	Section ID	11
ELFORM	Element Formulation	3
AET	Ambient Element Type	0

And material type 20, *MAT_RIGID with parameters:

MID	Material ID	11
RO	Mss Density	8900
E	Young’s Modulus	$1.25x10^{10}$
PR	Poisson’s Ratio	0.25
N	MADYMO3D Couple Flag	0.0
COUPLE	Coupling Option	0.0
M	MADYMO/CAL3D Couple	0.0
ALIAS	VDA Surface ALIAS	0.0
CMO	Centre of Mass Constraint	
CON1	Translation Constraint	
CON2	Rotational Constraint	
LCO OR A_1	Local Coordinate System or X-comp.	11
A_2	Y-comp. Vector 1	0
A_3	Z-comp. Vector 1	0

V_1	X-comp. Vector 2	0
V_2	Y-comp. Vector 2	0
V_3	Z-comp. Vector 2	0

2.8 Yaw ring part

Modelled with solid bricks, *SECTION_SOLID and parameters:

SEC ID	Section ID	7
ELFORM	Element Formulation	3
AET	Ambient Element Type	0

And material type 20, *MAT_RIGID, with input values:

MID	Material ID	7
RO	Mss Density	7850
E	Young’s Modulus	2.1×10^{11}
PR	Poisson’s Ratio	0.28
N	MADYMO3D Couple Flag	0.0
COUPLE	Coupling Option	0.0
M	MADYMO/CAL3D Couple	0.0
ALIAS	VDA Surface ALIAS	0.0
CMO	Centre of Mass Constraint	
CON1	Translation Constraint	
CON2	Rotational Constraint	
LCO OR A_1	Local Coordinate System or X-comp.	7
A_2	Y-comp. Vector 1	0

A_3	Z-comp. Vector 1	0
V_1	X-comp. Vector 2	0
V_2	Y-comp. Vector 2	0
V_3	Z-comp. Vector 2	0

2.9 Bearing part

Modelled with brick elements, *SECTION_SOLID of parameters:

SEC ID	Section ID	6
ELFORM	Element Formulation	3
AET	Ambient Element Type	0

And material rigid type 20, *MAT_RIGID of inputs:

MID	Material ID	6
RO	Mss Density	7850
E	Young's Modulus	$2.1x10^{11}$
PR	Poisson's Ratio	0.28
N	MADYMO3D Couple Flag	0.0
COUPLE	Coupling Option	0.0
M	MADYMO/CAL3D Couple	0.0
ALIAS	VDA Surface ALIAS	0.0
CMO	Centre of Mass Constraint	
CON1	Translation Constraint	
CON2	Rotational Constraint	
LCO OR A_1	Local Coordinate System or X-comp.	6

A_2	Y-comp. Vector 1	0
A_3	Z-comp. Vector 1	0
V_1	X-comp. Vector 2	0
V_2	Y-comp. Vector 2	0
V_3	Z-comp. Vector 2	0

2.10 Tower part

Modelled with beams, *SECTION_BEAM of inputs:

SEC ID	Section ID	5
ELFORM	Element Formulation	3
SHRF	Shear Factor	
QR/IR ID	Quadature Rule	2
CST	Cross Section Type	1
SCOOR	Location of TRIAD	2
A	Cross Sectional Area	$307x10^{-4}$
Iss	Inertia in S-dir	$9.14x10^{-4}$
Itt	Inertia in T-dir	$9.14x10^{-4}$
Irr	Inertia in R-dir	$18.3x10^{-4}$
SA	Shear Area	$307x10^{-4}$

And material type 98, *MAT_SIMPLIFIED_JOHNSON_COOK, with inputs:

MID	Material ID	11
RO	Mss Density	7850
E	Young's Modulus	$2.1x10^{11}$
PR	Poisson's Ratio	0.28
VP	Formulation Rate Effect	1.0
A	Parameter	$7.9200x10^{8}$
B	Parameter	$5.0951x10^{8}$
N	Parameter	0.26

C	Parameter	0.014
PSFAIL	Plastic Strain Failure	0.05
SIGMAX	Maximum Stress	$4.5x10^8$
SIGSAT	Saturation Stress	$4.5x10^8$
EPSO	Plastic Strain Rate	1.0

2.11 Hull part

Modelled with solid bricks, *SECTION_SOLID with inputs:

SEC ID	Section ID	3
ELFORM	Element Formulation	3
AET	Ambient Element Type	0

And material type 1, *MAT_ELASTIC with inputs:

MID	Material ID	3
RO	Mass Density	2213.4
E	Young's Modulus	$2.4x10^{10}$
PR	Poisson' ratio	0.25
DA	Axial Damping Factor	0
DB	Bending Damping Factor	0

The coupling card for hull fluid part set is as follows:

*CONSTRAINED_LAGRANGE_IN_SOLID

SlAVE	Slave part ID	3
MASTER	Master part ID	1
SSTYPE	Slave type	1
MSTYP	Master type	0
NQUAD	Quadrature rule for coupling	2

CTYPE	Coupling type	4
DIREC	Coupling direction	2
MCOUP	Multi-material option	-1
START	Start time for coupling	
END	End time for coupling	
PFAC	Penalty factor	0.01
FRIC	Coefficient of friction	
FRCMIN	Minimum volume fraction	
NORM	Normal orientation	0
NORMTYP	Penalty coupling spring direc…	0
DAMP	Damping factor	0.6
CQ	Heat transfer coefficient	
HMIN	Min air gap	
HMAX	Max air gap	
ILEAK	Leakage control	0
PLEAK	Leakage control penalty factor	0.01
LCIDPOR	Load curve for porous flow	

2.12 Foam part

Modelled with solid bricks, *SECTION_SOILD with parameters:

SEC ID	Section ID	4
ELFORM	Element Formulation	3
AET	Ambient Element Type	0

And material type 57, *MAT_LOW_DENSITY_FOAM with inputs:

MID	Material ID	4
RO	Mass density	44.14
E	Young's Modulus	$1.6x10^9$
LCID	Stress-strain LCID	5
TC	Tension cut-off stress	0
HU	Hysteretic unloading	1.0
BETA	Creep decay constant	
DAMP	Viscous coefficient	0.1
SHAPE	Shape factor	0.5
FAIL	Failure stress cut-off	0
BVFLAG	Bulk viscosity flag	1
ED	Young's relaxation	0
BETA1	Optional decay constant	0
KCON	Interface stiffness coefficient	200
REF	Reference geometry flag	1

2.13 Moorings part

The mooring cables consists of gripping corbels fixed at the hull deck outer circumference, 10m vertically below them are the shoe guides, firmly attached to hull outer surface, allowing cables to pass through. From there cables extend to mooring points at a piled seabed anchor, shared by more than one cable in the floating farm.

Section properties are defined by beams, *SECTION_BEAM with inputs:

SEC ID	Section ID	16
ELFORM	Element Formulation	6
SHRF	Shear Factor	

QR/IRID	Quadature Rule	2
CST	Cross Section Type	1
SCOOR	Location of TRIAD	3
NSM	Non structural mass per	8.7
VOL	Volume of Discrete Beam	1.716324×10^{-3}
INER	Inertia of Discrete Beam	1.4221×10^{-4}
CID	Coordinate System ID optional)	0
CA	Cable Area	4.2274×10^{-2}
Offset	Cable Offset	
RCON	R-rotational Constraint	0.0
SRCON	S-rotational Constraint	0
TRCON	T-rotational Constraint	0

And modelled with material type 71, *MAT_CABLE_DISCETE_BEAM with inputs:

MID	Material ID	16
RO	Mass Density	1
E	Young's Modulus	9×10^{9}
LCID	Load Curve ID (stress-strain) optional	3
FO	Inertial Tensile Force	0

The coupling card for cables and water is:

*CONSTRAINED_LAGRANGE_IN_SOLID

SlAVE	Slave part ID	17
MASTER	Master part ID	1
SSTYPE	Slave type	1
MSTYP	Master type	1
NQUAD	Quadrature rule for coupling	0
CTYPE	Coupling type	2
DIREC	Coupling direction	1
MCOUP	Multi-material option	
START	Start time for coupling	
END	End time for coupling	
PFAC	Penalty factor	
FRIC	Coefficient of friction	0.01
FRCMIN	Minimum volume fraction	
NORM	Normal orientation	0
NORMTYP	Penalty coupling spring direc…	0

DAMP	Damping factor	0.05
CQ	Heat transfer coefficient	
HMIN	Min air gap	
HMAX	Max air gap	
ILEAK	Leakage control	0
PLEAK	Leakage control penalty factor	0.01
LCIDPOR	Load curve for porous flow	

And the coupling card for cable and air is:

*CONSTRAINED_LAGRANGE_IN_SOLID

SlAVE	Slave part ID	17
MASTER	Master part ID	2
SSTYPE	Slave type	1
MSTYP	Master type	1
NQUAD	Quadrature rule for coupling	0
CTYPE	Coupling type	4
DIREC	Coupling direction	2
MCOUP	Multi-material option	
START	Start time for coupling	
END	End time for coupling	
PFAC	Penalty factor	
FRIC	Coefficient of friction	0.001
FRCMIN	Minimum volume fraction	
NORM	Normal orientation	0
NORMTYP	Penalty coupling spring direc…	0
DAMP	Damping factor	
CQ	Heat transfer coefficient	
HMIN	Min air gap	
HMAX	Max air gap	
ILEAK	Leakage control	0
PLEAK	Leakage control penalty factor	0.01
LCIDPOR	Load curve for porous flow	

2.14 Water part

Modelled with solid ALE element, *SECTION_SOLID_ALE

SEC ID	Section ID	1
ELFORM	Element Formulation	11

AET	Ambient Element Type	0
AFAC	Smoothing W.F. –simple ave.	0
BFAC	Smoothing W.F. –volume w..	0
CFAC	Smoothing W.F. –Isoparam.	0
DFAC	Smoothing W.F. –Equipoten.	0
STAR	Start time for smoothing	0
END	End time for smoothing	0
AAFAC	ALE Advection factor	0

While material for water part is modelled using material type 9, *MAT_NULL with parameters and equation of state as:

MID	Material ID	15
RO	Mass density	1025
PC	Pressure cut-off	$-1.0132x10^{3}$
MU	Viscosity coefficient	$8.684x10^{-4}$
TEROD	Relative volume in tension	0
CEROD	Relative volume in compression	0
YM	Young's modulus	0
PR	Poisson's ratio	0

This requires the definition of equation of state,*EOS_GRUNEISEN as:

EQSID	Equation of state ID	1
C	Equation constant	$1.647x10^{3}$
S_1	Equation constant	1.921
S_2	Equation constant	$-9.6x10^{-2}$
S_3	Equation constant	0
GAMA0	Equation constant	0.35
A	Equation constant	
EO	Initial internal energy	
V0	Initial relative volume	1.0

2.15 Air part

Also modelled with solid ALE elements, *SECTION_SOLID_ALE with input values:

SEC ID	Section ID	2
ELFORM	Element Formulation	11
AET	Ambient Element Type	4
AFAC	Smoothing W.F. –simple ave.	0
BFAC	Smoothing W.F. –volume w..	0
CFAC	Smoothing W.F. –Isoparam.	0
DFAC	Smoothing W.F. –Equipoten.	0
STAR	Start time for smoothing	0
END	End time for smoothing	0
AAFAC	ALE Advection factor	0

And material type 9, *MAT_NULL with inputs:

MID	Material ID	2
RO	Mass density	1.1845
PC	Pressure cut-off	-1.0132×10^{2}
MU	Viscosity coefficient	1.8444×10^{-5}
TEROD	Relative volume in tension	0
CEROD	Relative volume in compression	0
YM	Young's modulus	0
PR	Poisson's ratio	0

This material requires an equation of state as, *LINEAR_POLYNOMIAL as:

EQSID	Equation of state ID	2

C0	Equation constant Equation constant	0
C_1		0
C_2	Equation constant	0
C_3	Equation constant	0
C_4	Equation constant	0.4
C_5	Equation constant	0.4
EO	Initial internal energy	253307.82
V0	Initial relative volume	1

2.16 Seabed part

Modelled with shell element, *SECTION_SHELL with input values:

SEC ID	Section ID	17
ELFORM	Element Formulation	16
SHRF	Shear Factor	0.83333
NIP	Number of Integration Points	4
PROPT	Print out Option	3
QR/IRID	Quadrature Rule	0
ICOMP	Layered Composite Flag	0
SETYP	2D Solid Element Type	1
T1	Shell Thickness at Node1	0 .050
T2	Shell Thickness at Node2 Shell Thickness at	0.050
	Node3	0.050
T3		
T3	Shell Thickness at Node4	0.050
NLOC	Location of Preference Surface	0
MAREA	Non-Structural Mass per	0

And material type 20, *MAT_RIGID defined by parameters:

MID	Material ID	17
RO	Mss Density	1800
E	Young’s Modulus	$9x10^9$
PR	Poisson’s Ratio	0.25
N	MADYMO3D Couple Flag	0.0
COUPLE	Coupling Option	0.0
M	MADYMO/CAL3D Couple	0.0
ALIAS	VDA Surface ALIAS	0.0

CMO	Centre of Mass Constraint	-1
CON1	Translation Constraint	2
CON2	Rotational Constraint	111111
LCO OR A_1	Local Coordinate System or X-comp.	17
A_2	Y-comp. Vector 1	0
A_3	Z-comp. Vector 1	0
V_1	X-comp. Vector 2	0
V_2	Y-comp. Vector 2	0
V_3	Z-comp. Vector 2	0

*INITIAL_VOLUME_FRACTION_GEOMETRY

Defining the concrete cylinder disk geometry in water as:

Variable	Description	Value(s)
SID_ALE	Part or part set ID	1
ST_ALE	Set type	1
GROUP	Group ID	1
GEOTPE	Geometry type	4
IN_OPT	Set type	0
GR_FILL	Group ID	2
X0	x-coordinate of special point	0
Y0	y-coordinate of special point	0
Z0	z-coordinate of special point	0
X1	x-coordinate of normal vector	0
Y1	y-coordinate of normal vector	0
Z1	z-coordinate of normal vector	2.5
R1	Radius of lower base of cone	9.5
R2	Radius of upper base of cone	9.5

*INITIAL_VOLUME_FRACTION_GEOMETRY

Defining the concrete cylinder part geometry in water:

Variable	Description	Value(s)
SID_ALE	Part or part set ID	1
ST_ALE	Set type	1
GROUP	Group ID	1
GEOTPE	Geometry type	4
IN_OPT	Set type	0
GR_FILL	Group ID	2
X0	x-coordinate of special point	0
Y0	y-coordinate of special point	0

Z0	z-coordinate of special point	2.5
X1	x-coordinate of normal vector	0
Y1	y-coordinate of normal vector	0
Z1	z-coordinate of normal vector	2.5
R1	Radius of lower base of cone	6.25
R2	Radius of upper base of cone	6.25

*INITIAL_VOLUME_FRACTION_GEOMETRY

Defining the concrete cylinder geometry part in air:

Variable	Description	Value(s)
SID_ALE	Part or part set ID	2
ST_ALE	Set type	1
GROUP	Group ID	2
GEOTPE	Geometry type	4
IN_OPT	Set type	0
GR_FILL	Group ID	2
X0	x-coordinate of special point	0
Y0	y-coordinate of special point	0
Z0	z-coordinate of special point	25
X1	x-coordinate of normal vector	0
Y1	y-coordinate of normal vector	0
Z1	z-coordinate of normal vector	31
R1	Radius of lower base of cone	6.25
R2	Radius of upper base of cone	6.25

3. Control Cards

These are for instructing the code for certain tasks to modify the default values concerning dynamic relaxation time, starting, ending, cpu time, termination time, ………etc. These tasks are readily defined by the code, some of them are compulsory, while others are optional. Due to the importance of defining these cards, compulsory cards and some optional cards used are detailed:

*CONTROL_ACCURACY

OSU	Objectives Stress Update	1
INN	Invariant Node Numbering	2

*CONTROL_CPU

CPUTIM	Seconds of CPU Time	00

*CONTROL_ENERGY

HGEN	Hourglass Energy Calcu	1
RWEN	Stone Wall Energy Dissipat	2
SLNTEN	Sliding Interface Energy Dis	1
RYLEN	Damping Energy Dissipation	2

*CONTROL_HOURGLASS

IHQ	Hourglass Viscosity Type	4
HQ	Hourglass Coefficient	0.0001

*CONTROL_OUTPUT

NPOPT	Input Phase Print Suppressi	0
NEECHO	Input phase Echo Suppressi	0
NREFUP	Beam Reference Node Update	0
IACCOP	Averaged Accelerations	1
OPIFS	Interface Output Inter	0
IPNINT	Initial Time Step Print Option	0
IKEDIT	Problem Status Output Option	0
IFLUSH	Number of Time Steps Interval	0
IPRIF	Default Print Flag for Rbdo	0

*CONTROL_SHELL

WRPANG	Shell Warpage Angle [degrees]	020
IRIST	Triangular Shell Sorting	1
IRNXX	HUGES_LIU Shell Normal up	-1
ISTUPD	Shell Thickness Change Option	1
THEORY	Shell Theory	2
BWC	Warping Stiffness Belytsch	2
MITER	Plane Stress Plasticity Option	1
PROJ	Projection Method	1

*CONTROL_SOLUTION

SOLN	Analysis Solution Procedure	0

*CONTROL_TERMINATION

ENDTIM	Termination Time	5
ENDCYCL	Termination Cycle	
DTMIN	Initial Time Step S.F	
ENDENG	Percent Energy Change	

ENDMAS	Percent Mass Change	

*CONTROL_TIMESTEP

DTINIT	Initial Time Step Size	
TSSFAC	Computed Time Step	0.9
ISDO	Time Step Formula	0
ISLMIT	Shell Element Minimum Time Step	0
DT2MS	Mass Scaling	0
LCTM	Time Step Load Curve	0
ERODE	Errosion Flag	0
MSIST	Mass Scaling Limit	0

DATABASE Cards:

*DATABASE_GLSTAT

DT	Time Interval Output	1

*DATABASE_MATSUM

DT	1

*DATABASE_BINARY_D3PLOT

DT/CYCL	Time Interval of Output	1
LCDT	Time Interval Load Curve	0
BEAM	Convergence Flag	0
NOLTC	Overrides on “DT” field	0

*DATABASE_BINARY_D3THDT

DT/CYCL	Time Interval of Output	1
LCDT	Time Interval Load Curve	0

4. Analysis Phase

The procedure started with a drawing using known dimensions, nodes, lines or surface, then elements. From there, materials, properties, boundary conditions, constraints, loads, contact, control cards, title, load curves, coordinate system….-. With all these are now defined, the next step is the analysis. First: the input file is exported by FEMB 28 (written in Notepad format) then edited for checking the format or inserting required data that are not supported by the pre-processor. The input file is either given a user defined name or saved as a default (file.dyn) to be recalled for running with LS-DYNA3D solver. Second: the LS-DYNA3D is activated (via solver function) the programme is run and database files defined will be automatically created, to be read by the attached post-processors, LSTC [7].

5. Conclusion

Using the powerful preprocessor FEMB 28. the geometry, material, properties, load curves, contacts, time control, and hourglass guard fitted in the code, an input file capable of representing different aspects of the complicated structure at harsh load condition and special contact conditions to model complex behavior close enough to the actual situation for the actual structure; to insure the solving capacity of the code without risking too much time and memory needed for running the full scale model, a typical tow-dimensional and 3-dimentional small models of the structure were created and run satisfactorily, [8] and [9]. hence created input file assumed satisfactory.

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