FS2000

CMotion Vessel Transportation Loading

Advanced Structural Analysis
for Windows
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1.0 Introduction

Motion is a load pre-processor that interfaces with FS2000 for the generation of structural loads resulting from inertial forces developed due to motions of the type associated with sea going vessels. Forces due to heave, roll and pitch motions and plain accelerations are accounted for.

The user defines a base load case that is used to define the mass distribution within the structure. Defined forces in this load case are converted to masses using a global gravitational defined constant. This enables appropriate in-situ load cases to be also used for motion analysis.

The motion amplitudes and associated periods are used to define inertia forces. The locations of the centres of roll and pitch relative to the origin of the structure are independently defined to account for spatial effects i.e. the radius of rotations.

As output, the program generates the following eight load cases.

- Static
- Dynamic Heave (or Vertical g)
- Static Roll
- Dynamic Roll
- Heave/Static Roll
- Static Pitch
- Dynamic Pitch
- Heave/Static Pitch
- Surge g
- Sway g

Following analysis the results of the basic load cases may be combined in post-processing to give the structural loads appropriate to the design requirements and the configuration of the structure/vessel.

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2.0 Creating Definition Load Cases

The inertial masses within the structure are established from a definition load case created within the loads module of the post-processor of FS2000.The following describes how the loads from a definition load case are interpreted by Motion.

2.2 Structure Self Weight

Distributed masses due to element self-weight will be taken into account using the density of the element and the gravitational constants defined in the definition load case.

2.3 Nodal Forces and Masses

If nodal masses are defined at nodes these are simply taken to be concentrated masses at the respective node. Nodal forces in the **Y direction** will be converted to nodal masses by taking the absolute values of the force and dividing by a user defined gravitational constant in Motion. Forces defined in other directions will be ignored.

Do not apply both Y forces and masses unless for some reason these are required to be combined.

2.4 Element Distributed Loads

Element distributed loads in the **Y direction** will be converted to distributed masses. This done by taking the absolute values of the Y force and dividing by a user defined gravitational constant in CMotion. Forces defined in other directions will be ignored.

2.5 Element Mid Span Point Loads

Element mid span point loads in the **Y direction** will be converted to concentrated masses. This done by taking the absolute values of the Y force and dividing by a user defined gravitational constant in Motion. Forces defined in other directions will be ignored.

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3.0 Co-ordinate System and Transforms

To establish inertial forces it is essential to define the position of the structure (origin of the model) relative to the location of the centres of roll and pitch of the vessel. The reference co-ordinate system used by CMotion for this, is the co-ordinate system of the vessel.

The convention adopted for vessel co-ordinate system is shown in Appendix A. The Y-axis is vertical, the X axis is forward and the Z axis is starboard. Rotations follow the conventional right hand corkscrew rule.

Appendix A show the force directions corresponding to positive and negative pitch and roll for different structure locations. These figures may be useful in establishing suitable load case combinations.

In addition to defining the spatial position of the structure it is also possible to re-orientate the angular position of the structure by defining rotational transform angles relative to the vessel co-ordinate system (see Sect 4.4)

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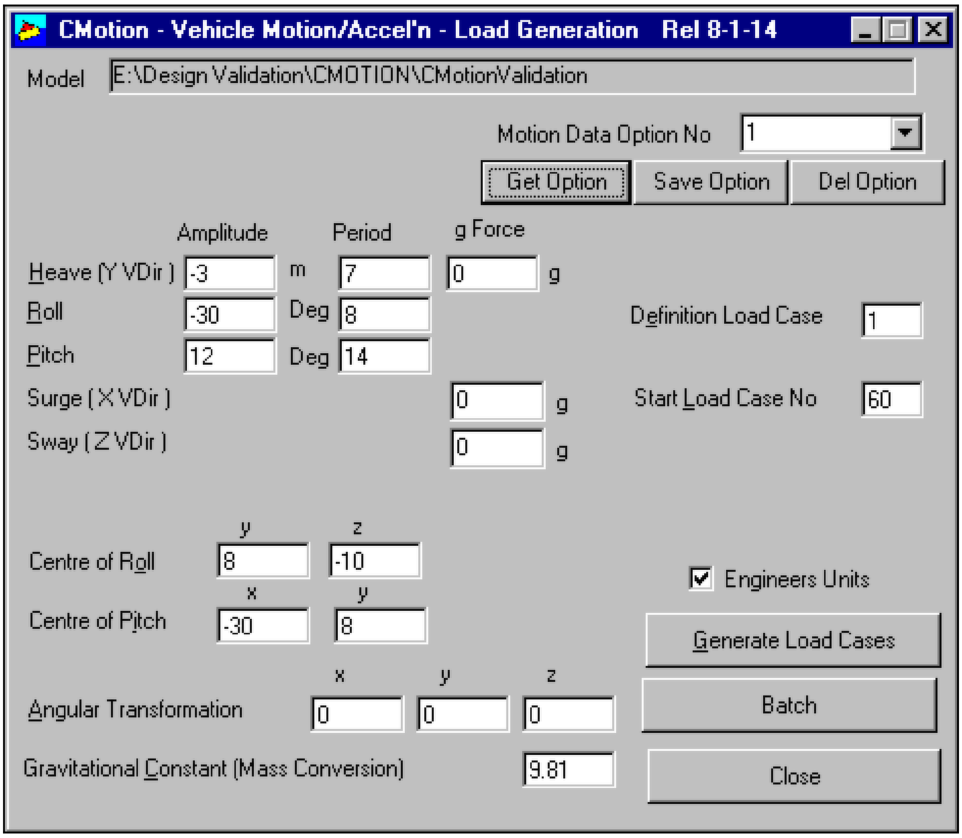
4.0 Operation of CMotion

CMotion can be run interactively or by batch operation. In either case a motion definition file is used to CMotion is started from the Task menu when the Loads Task is active. It can also be started from the CMotion icon in the FS2000 windows groups.

When the program has loaded the following input form will become visible.



Motion Data Option No - See 4.1.1

Motion Definition Boxes - See 4.2.2

Centers of Motion - See 4.1.3

Angular Transformation - See 4.1.4

Gravitatinal Constant - See 4.1.5

Definition Load Case - See Sect 2

Start Load Case - See Sect 4.1.7

Generate Load Case Button- See Sect 4.2

Batch Button - See Sect 4.3

4.1 Data Input

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4.1 Input Data

4.1.1 Motion File - Saving & Loading

User defined motion data can be saved or re-loaded using the Get Option and Save Option command buttons. Motion data is saved using the file extension '.UV"n"', where "n" is an ID number. Option Data will be archived with the model.

The **Save Option** button is used to save the current settings. The **Get Option** button is used to open a previously saved file. The drop down list shows existing option data.

When load cases are generated the current option data is re-saved.

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4.1.2 Motion Definition

The first three data boxes (Heave, Pitch and Roll) are used define the motion amplitudes (degrees and metres) and their corresponding period (seconds). The sign convention employed is important. Refer to Appendix A.

The defined amplitudes are single amplitudes.

A 'g' force as an alternative to amplitude and period may be used to define heave.

Forces due to surge (x-direction accel'n) and sway (z-direction accel'n) can be evaluated by defining a 'g' force in the appropriate direction.

When g forces are defined they are defined, as a fraction of the gravitational constant i.e. 0.5 would be an acceleration of 9.81 x 0.5 m/s2 in SI units.

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4.1.3 Centres of Motion

The centres of roll and pitch boxes are used to define the location of the origin of the model relative to the centres of motion of the vessel. The user is required to define the x, y and z offsets. These co-ordinates are in a vessel co-odinate system, the system employed is shown in Appendix A

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4.1.4 Rotational Origin

The angular transformation boxes are used to define model rotation relative to the vessel axis. With this capability it is not necessary to have the co-ordinate system of model and the co-ordinate system angularly aligned. If a model was created vertically to reflect the installed condition but is to be transported horizontally the same model orientation may be used for both analysis by using rotation transforms.

When using the orientation transform in CMOTION there is no graphical feedback that the transform is correct. If a user is unsure of the orientation sign convention then use the node transform facility in FS2000 to 'practice' the transform. This will show the model relative to the axis triad which will represents the vessel axis.

An alternative to using the above angular transforms is to copy and modify an additional model with the orientation corresponding to the vessel orientation. The disadvantages of this approach are that local member orientations may be incorrectly changed during transform. This may be eliminated by employing 3rd nodes definition for member orientation. In the case of tubular members where local orientation is unlikely to be critical the local orientation me be ignored.

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4.1.5 Gravitational Constant

The gravitational constant is used to convert the force definitions in the definition load case to masses and for the evaluation of inertia loading.

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4.1.6 Definition Load Case

This box is used to define the definition load case (see Sect 2.0).

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4.1.7 Start load Case

Depending upon the data entered, up to 10 successive load cases may be created. This entry defines the start number for these load cases.

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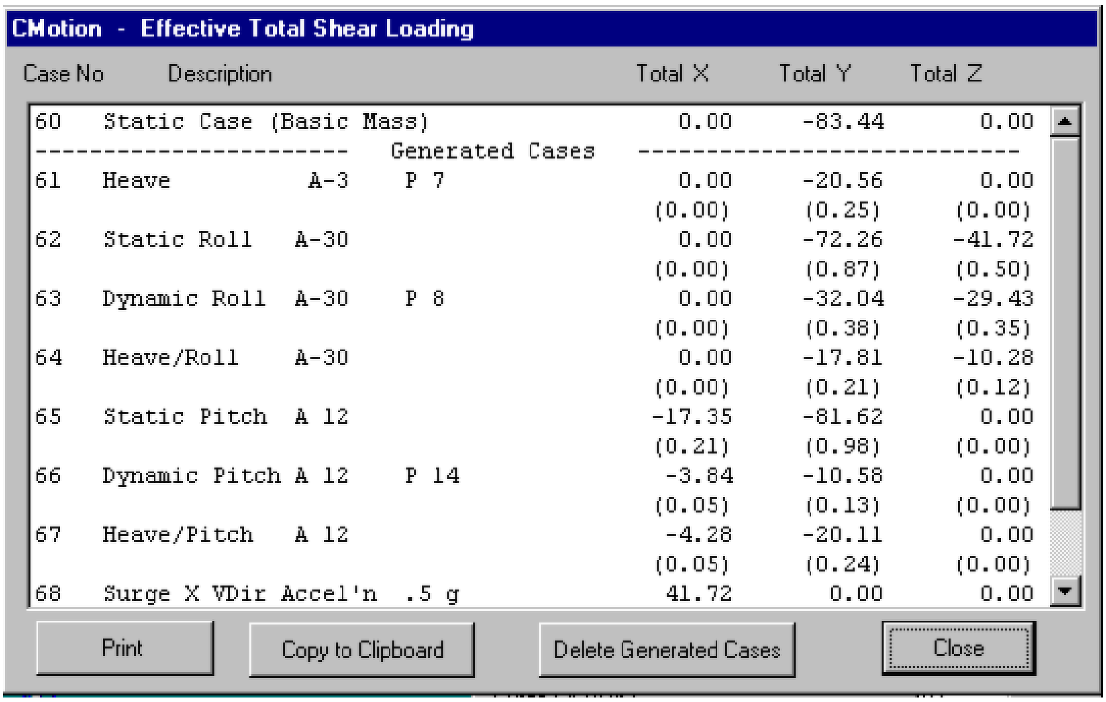
4.2 Generate Load Cases

When the **Generate Load Cases** command button is clicked the current option will be saved. Following the save process up to 10 load cases will be created in succession. If the start load case was defined as 60. The following load cases would be generated.

L60	Static
L61	Dynamic Heave
L62	Static Roll
L63	Dynamic Roll
L64	Heave/Static Roll
L65	Static Pitch
L66	Dynamic Pitch
L67	Heave/Static Pitch
L68	Surge (X Dir)
L69	Sway (Z Dir)

If amplitudes in any of the directions of motion are specified or g forced magnitudes specified as zero then load cases associated with that form of motion would not be created.

The applied loading to the model for each of the load cases will be shown in terms of the total loading applied to the model in the model co-ordinate system. It is very important that the directions of the component forces are appropriate. These are dependent upon the position of the structure in the vessel and the direction of motion specified.



CMotion creates secondary binary load files which contains the loads for each element and a text load case definition file (.L"m"). The .L"m" file only contains the total shear loads and identifies that the loading is from CMotion.

If a model is changed or saved in the Model Definition TASK then all generated load cases must be regenerated since all the secondary load files are purged (deleted).

If the Purge Results option is not active when the model is saved, the existing load cases do not require to be regenerated. This is not recommended practice.

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4.3 Batch (Command Line) Operation

Providing that an appropriate **'.UVn'** exists, the program may be operated from the Windows command line prompt.

CMOTION C1/C2/C2/

C1 Motion Data File ID

C2 Definition Load Case Number

C3 Start Load Case Number

The **Batch** button will append the current settings to the CMotion command line to the <ModelName>.BRM file.

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4.4 Files Created

The only files unique to CMOTION are the files, which contains the motion data. These files have the model filename with the extension **'.UVn'.**

Note that the load cases created are generated load cases with the load data defined in secondary definition files. They should be loaded into the loads module, re-saved or otherwise up-dated

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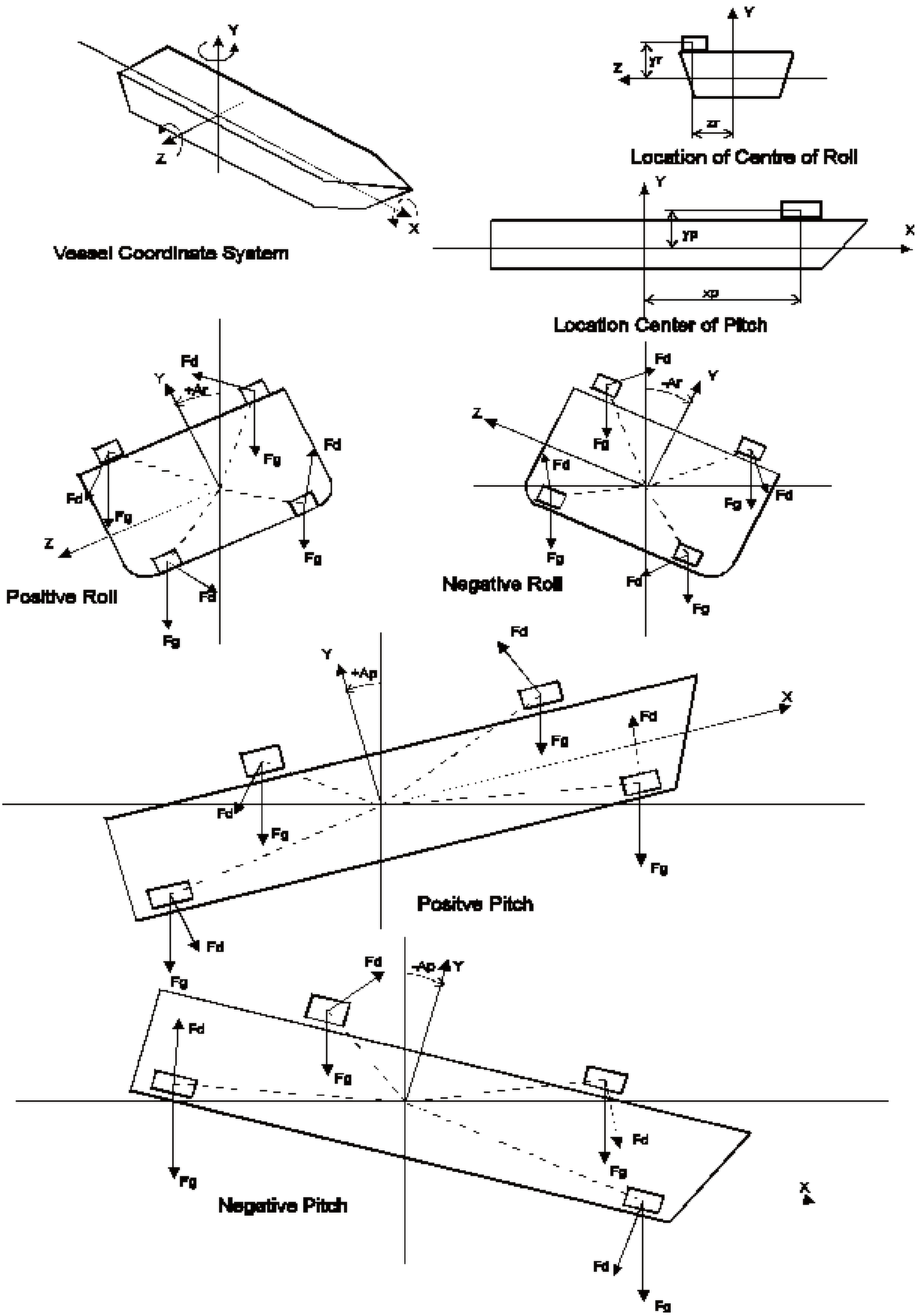
APPENDIX A Co-ordinate Systems



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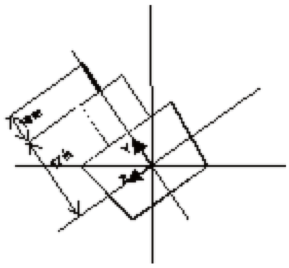
APPENDIX B - Validation/Demo Examples

Example 1 - MOTEXP1

A ship is rolling 35 deg in beam seas with a rolling period of 10 seconds. A solid mast 10 m long of 150 mm in diameter is attached to the deck at the midship section of the ship along its centreline. The density of the mast is 980 kg/m3 . The distance of the base of the mast from the axis of oscillation is 17 m.

Establish the moment and shear force at the base of the mast.



The model origin is 17 m above the centre of vessel roll.

*Mass of Mast 3.142 x 0.15**2 x 980 = 17.318 kg/m*

1) Static

Fy = 17.318 x 10 x 17.318 = 1.699 kN

2) Static Roll

Fy = 17.318 x 10 x 9.81 x cos35 = 1.392 kN

Fz = 17.318 x 10 x 9.81 x sin35 = 0.974 kN

*Mz = 17.318 x 10**2 / 2 x 9.81 x sin35 = 4.872 kNm*

3) Dynamic Roll

*FIZ at base of mast = 0.689 x M x Yr x Ar / Tr**2*

*FIZ = 0.689 x 17.318 x 17 x 35 / 10**2 = 70.99 N/m*

*FIZ at top of mast = 0.689 x M x Yr x Ar / Tr**2*

*FIZ = 0.689 x 17.318 x 27 x 35 / 10**2 = 112.76 N/m*

Total Shear at base of mast = (112.76 + 70.99) / 2 x 10 = 0.918 kN

Inertia Moment at base = 112.6 x 10**2 / 2 - (112.6 -70.99) / 6 x 10**2

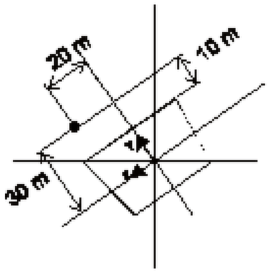
= 4.94 kNm

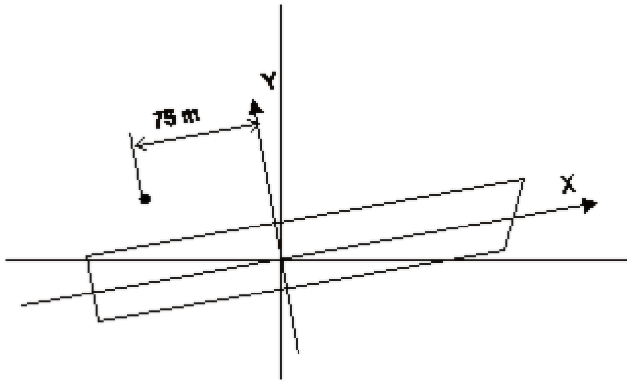
Total Moment at base of mast = 4.94 + 4.872 = 9.812 kNm

Total Shear at base of mast = 0.918 + 0.974 = 1.892 kN

Example 2 - MOTEXP2

A ship proceeding through a rough sea experiences a roll amplitude of 35 deg and a pitch amplitude of 10 deg., where the respective periods of roll and pitch are 8 secs and 5 secs. Determine the horizontal and vertical roll and pitch inertial forces for a mass of 1800 kg located 30 m above, 20 m athwartships (+z) and 75 m aft from centres of oscillation.





Model origin at X = -75 : Y = 20 : Z = 20 i.e. on deck of vessel

1) Static

$Fy = 1800 \times -9.81 = -17.66\ kN$

2) Static Roll

$Fy = 1800 \times -9.81 \times \cos35 = -14.46\ kN$

$Fz = 1800 \times 9.81 \times \sin35 = 10.128\ kN$

3) Dynamic Roll

$Fy = 0.689 \times M \times Zr \times Ar / Tr^{**}2$

$= 0.689 \times 1800 \times 20 \times 35 / 8^{**}2 = -13.564\ kN$

$Fz = 0.689 \times M \times Yr \times Ar / Tr^{**}2$

$= 0.689 \times 1800 \times 30 \times 35 / 8^{**}2 = 20.347\ kN$

4) Static Pitch

$Fx = 1800 \times -9.81 \times \sin10 = -3.066\ kN$

$Fy = 1800 \times 9.81 \times \cos10 = 17.39\ kN$

5) Dynamic Pitch

$Fx = 0.689 \times M \times Yp \times Ap / Tp^{**}2$

$= 0.689 \times 1800 \times 30 \times 10 / 5^{**}2 = -14.88\ kN$

$Fzy = 0.689 \times M \times Xp \times Ap / Tp^{**}2$

$= 0.689 \times 1800 \times 7.5 \times 10 / 5^{**}2 = -37.2\ kN$

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