Helicopter Theory

----------Blade Flap Response For the Helicopter Rotor----------

Q1.

For calculation of this question following control inputs are considered:

$\mu = 0.2857,\ \theta_o = 8.2^o,\ \theta 1c = 3.3^o,\ \theta 1s = -11.2^o.$

Figure 1:
Plotting the Root blades hub shear forces in the rotating frame of reference as a function of azimuth ψ

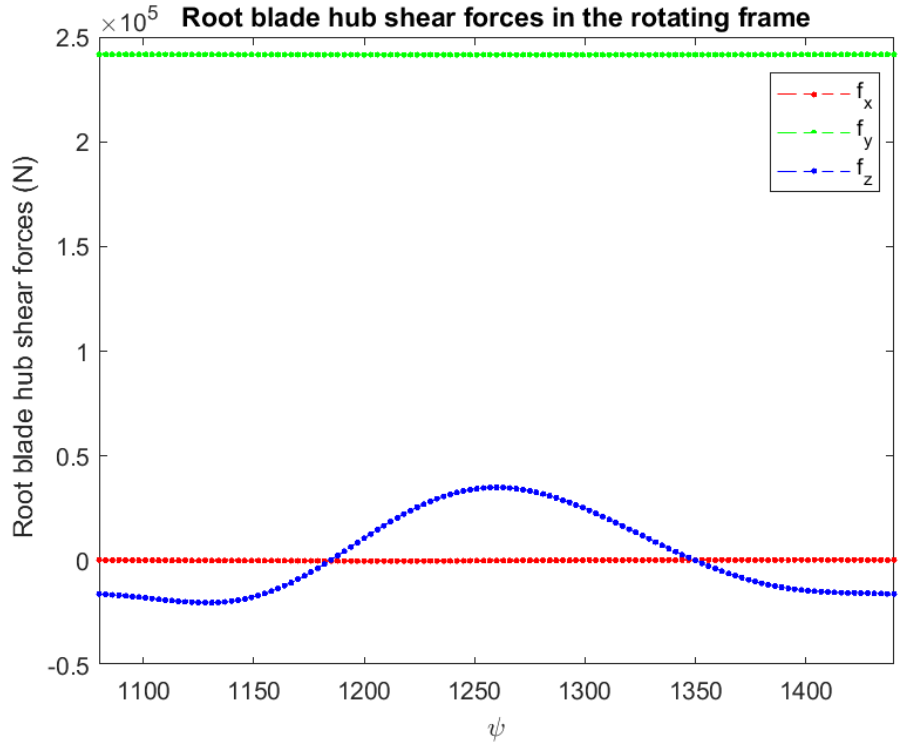


Figure 2:
Plotting the Root blades hub moments in the rotating frame of reference as a function of azimuth ψ

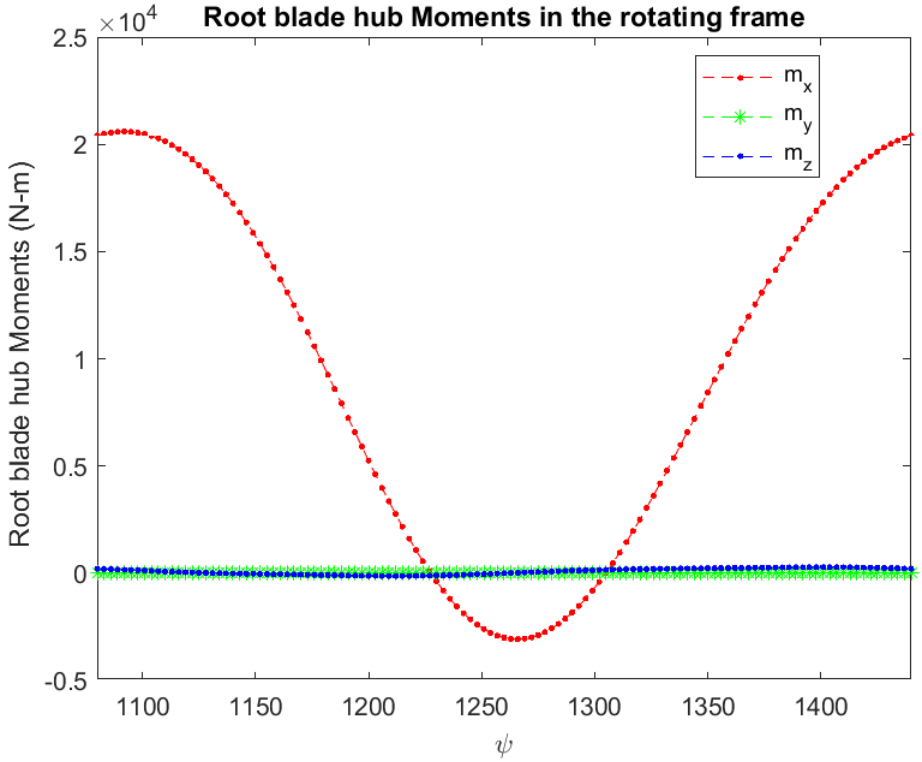


Figure 3:
Plotting the variation of non-dimensional rotating frame vertical shear force as a function of ψ for all 4 blades.

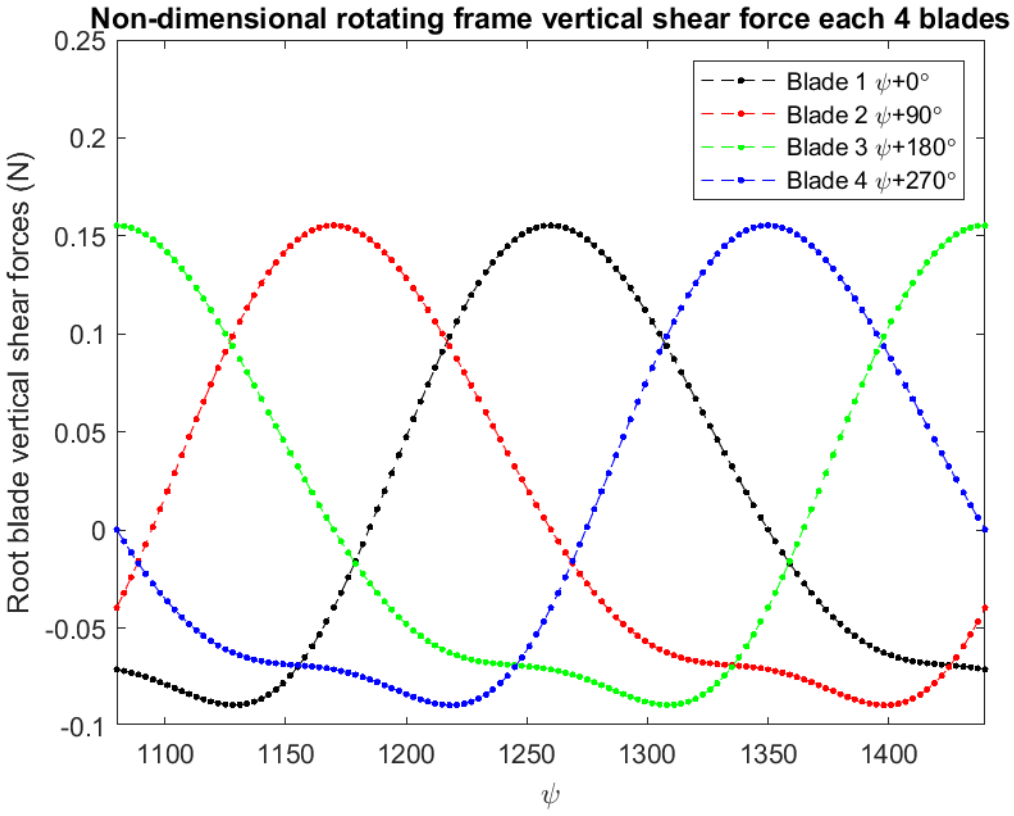


Figure 4:
Plotting the variation of forces and moments in fixed frame of reference as a function of ψ

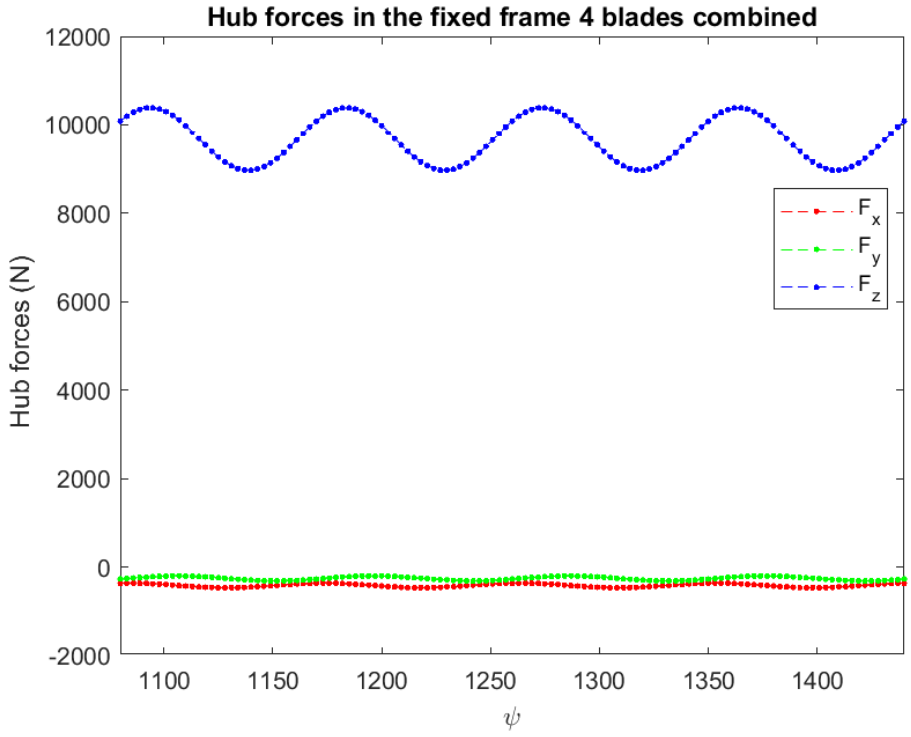
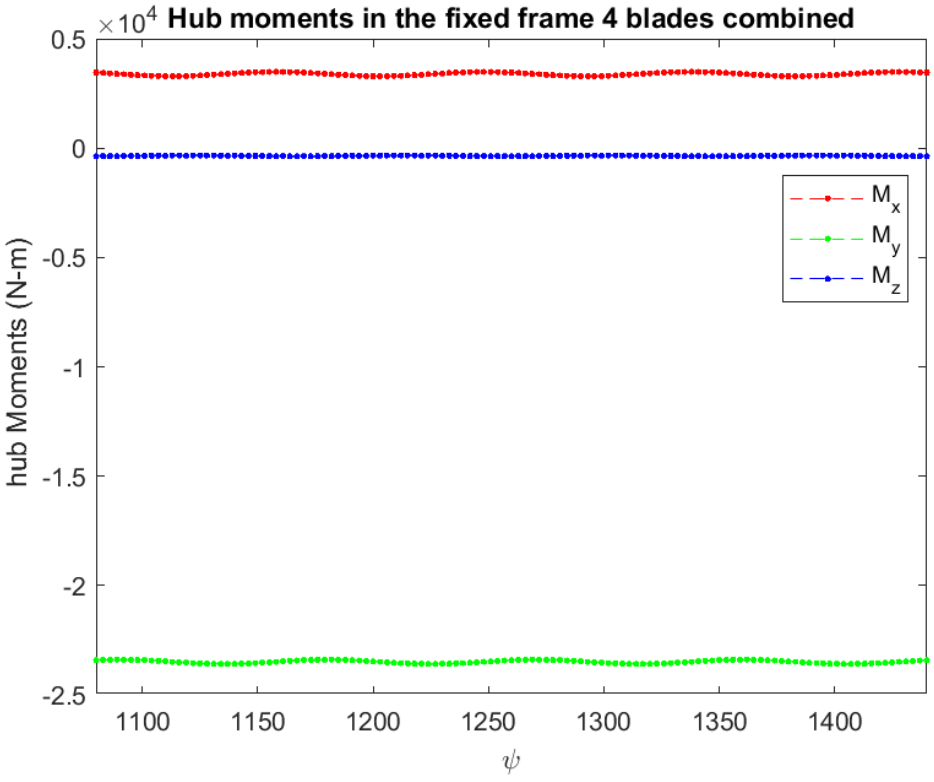


Figure 5:
Plotting the variation of moments in fixed frame of reference as a function of ψ



Comment:

- As we can see in Figure 1, for one revolution we can see force in z-direction has one oscillatory response. Because it has a combined effect of force in vertical direction and also harmonic component due to Beta_2star (this harmonic component has a very high effect on value of force in z-direction).
- In Figure 1 for force in y-direction is significantly large due to the centrifugal force component. For force in x-direction is low comparatively which is mostly due to the drag force on blades.
- As we can see in Figure 2, for the root blades hub moments shows the similar oscillatory variation as forces, in this plot moment in x-direction is comparatively more oscillatory because it is outcome of blade flapping moment.
- In Figure 2, we also see the variation of moments in z direction is due to lag moment which in turn is due to force in x-direction which is less significant. Moment in y-direction is close to zero because, moment about the elastic axis, which is generally close to quarter-chord.
- In Figure 1&2 the rotating frame where the Y component forces are maximum the moments in Y component are minimum as seen per revolution. This is because in the rotating frame Y direction is where the tangential component of tip speed is directing but moment in that direction means the torsion which is negligible due to no pitching moment.
- As we can see in Figure 3,variation of non-dimensional rotating frame vertical shear forces at 90 degree shifted phase for 4 blades of rotor shows similar variation for all 4 blades.
- As we can see in Figure 4, the forces in fixed frame for all 4 blades combined at particular ψ location are plotted, it can be seen from the graph that it has oscillatory response of 4 per rev due to fact that our hub act as a filter and only allow the passage of frequency' s steady component and which are multiple of number of blades.
- In Figure 4, we can observe that force is y-direction has reduced significantly as compared to the rotating frame root hub force in y-direction, due to fact that Centrifugal force component integrate to zero when transformed to fixed frame.
- As we can see in Figure 5,component of Moment in y-direction is significantly high as compared to x & z direction due to moment required for the forward tilt of tip-path-plane as a result forward motion of helicopter.