A APPENDIX

A.1 Elements of the type II Seesaw mass matrix (case B) and type I Seesaw mass matrix (Case C):

$$S_{11} = \left(c_{12}^2 c_{13}^2 - X c_{12}^{2\ \mu\tau}\right) m_1 + e^{2i(\beta-\delta)} s_{13}^2 m_3 + \left(c_{13}^2 s_{12}^2 - X s_{12}^{2\ \mu\tau}\right) e^{2i\alpha} m_2 \tag{A.1}$$

$$\begin{aligned} S_{12} = &\left(-c_{12}c_{13}c_{23}s_{12} - c_{12}^2 c_{13}s_{13}s_{23}e^{i\delta} + X c_{12}^{\mu\tau} c_{23}^{\mu\tau} s_{12}^{\mu\tau}\right) m_1 + \\ &\left(-c_{13}s_{12}c_{12}c_{23}e^{2i\alpha} - c_{13}s_{12}^2 s_{13}s_{23}e^{i(2\alpha+\delta)} + X c_{12}^{\mu\tau} c_{23}^{\mu\tau} s_{12}^{\mu\tau} e^{2i\alpha}\right) m_2 + \\ &\left(c_{13}s_{13}s_{23}e^{i(2\beta-\delta)}\right) m_3 \end{aligned} \tag{A.2}$$

$$\begin{aligned} S_{13} = &\left(c_{12}^2 c_{13}c_{23}s_{13}e^{i\delta} + s_{12}s_{23}c_{12}c_{13} - X c_{12}^{\mu\tau} s_{12}^{\mu\tau} s_{23}^{\mu\tau}\right) m_1 + \\ &\left(-c_{13}s_{12}c_{23}s_{12}s_{13}e^{i(2\alpha+\delta)} - X c_{12}^{\mu\tau} s_{12}^{\mu\tau} s_{23}^{\mu\tau} e^{2i\alpha}\right) m_2 + \\ &\left(e^{i(2\beta-\delta)} c_{13}c_{23}s_{13}\right) m_3 \end{aligned} \tag{A.3}$$

$$\begin{aligned} S_{21} = &\left(-c_{12}c_{13}c_{23}s_{12} - c_{12}^2 c_{13}s_{13}s_{23}e^{i\delta} + X c_{12}^{\mu\tau} c_{23}^{\mu\tau} s_{12}^{\mu\tau}\right) m_1 + \\ &\left(c_{13}s_{12}c_{12}c_{23}e^{2i\alpha} - s_{12}^2 s_{13}s_{23}c_{13}e^{i(2\alpha+\delta)} + X c_{12}^{\mu\tau} c_{23}^{\mu\tau} s_{12}^{\mu\tau} e^{2i\alpha}\right) m_2 + \\ &\left(e^{i(2\beta-\delta)} c_{13}s_{23}s_{13}\right) m_3 \end{aligned} \tag{A.4}$$

$$\begin{aligned} S_{22} = &\left(\left(c_{23}s_{12} - e^{i\delta}c_{12}s_{13}s_{23}\right)^2 - X c_{23}^{2\ \mu\tau} s_{12}^{2\ \mu\tau}\right) m_1 + \\ &\left(-X c_{12}^{2\ \mu\tau} c_{23}^{2\ \mu\tau} + \left(-c_{12}c_{23} - e^{i\delta}s_{12}s_{13}s_{23}\right)^2\right) m_2 e^{2i\alpha} + \\ &\left(c_{13}^2 s_{23}^2 - X s_{23}^{2\ \mu\tau} e^{2i\beta}\right) m_3 \end{aligned} \tag{A.5}$$

$$S_{23} = \Big(\Big(-c_{12}c_{23}s_{13}e^{i\delta} + s_{12}s_{23}\Big)\Big(-c_{23}s_{12} - e^{i\delta}c_{12}s_{13}s_{23}\Big) + Xc_{23}^{\mu\tau}s_{12}^{2\ \mu\tau}s_{23}^{2\ \mu\tau}\Big)m_1 + \Big(\Big(-e^{i\delta}c_{23}s_{12}s_{13} + c_{12}s_{23}\Big)\Big(-c_{12}c_{23} - e^{i\delta}s_{12}s_{13}s_{23}\Big) + Xc_{12}^{2\ \mu\tau}c_{23}^{\mu\tau}s_{23}^{\mu\tau}\Big)m_2e^{2i\alpha} + \Big(c_{13}^2c_{23}s_{23}e^{2i\beta} - c_{23}^{\mu\tau}s_{23}^{\mu\tau}\Big)m_3 \tag{A.6}$$

$$S_{31} = \Big(c_{12}^2c_{13}c_{23}s_{13}e^{i\delta} + s_{12}s_{23}c_{12}c_{13} - Xc_{12}^{\mu\tau}s_{12}^{\mu\tau}s_{23}^{\mu\tau}\Big)m_1 + \Big(c_{13}s_{12}^2e^{i\delta}c_{23}s_{13} + c_{12}s_{23}c_{13}s_{12}e^{2i\alpha} - Xc_{12}^{\mu\tau}s_{12}^{\mu\tau}s_{23}^{\mu\tau}\Big)m_2e^{2i\alpha} + \Big(e^{2i\beta-i\delta}c_{13}c_{23}s_{13}\Big)m_3 \tag{A.7}$$

$$S_{32} = \Big(\Big(-e^{i\delta}c_{12}c_{23}s_{13} + s_{12}s_{23}\Big)\Big(-c_{23}s_{12} - e^{i\delta}c_{12}s_{13}s_{23}\Big) + c_{23}^{\mu\tau}s_{12}^{2\ \mu\tau}s_{23}^{\mu\tau}\Big)m_1 \Big(\Big(-e^{i\delta}c_{23}s_{12}s_{13} + c_{12}s_{23}\Big)\Big(-c_{12}c_{23} - e^{i\delta}s_{12}s_{13}s_{23}\Big) + Xc_{12}^{2\ \mu\tau}c_{23}^{\mu\tau}s_{23}^{\mu\tau}\Big)e^{2i\alpha}m_2 \Big(c_{13}^2c_{23}s_{23} - Xc^{\mu\tau}{}_{23}s^{\mu\tau}{}_{23}\Big)e^{2i\beta}m_3 \tag{A.8}$$

$$S_{33} = \Big(\Big(-e^{i\delta}c_{12}c_{23}s_{13} + s_{12}s_{23}\Big)^2 - Xs_{12}^{2\ \mu\tau}s_{23}^{2\ \mu\tau}\Big)m_1 + \Big(\Big(-e^{i\delta}c_{23}s_{12}s_{13} + c_{12}s_{23}\Big)^2 - Xc_{12}^{2\ \mu\tau}s_{23}^{2\ \mu\tau}\Big)e^{2i\alpha}m_2 + \Big(c_{13}^2c_{23}^2 - c_{23}^{2\ \mu\tau}\Big)e^{2i\beta}m_3 \tag{A.9}$$

Where, $c_{ij}^{\mu\tau} = \cos\theta_{ij}^{\mu\tau}$, $s_{ij}^{\mu\tau} = \sin\theta_{ij}^{\mu\tau}$ represents the mixing angles for $\mu-\tau$ symmetric neutrino mass matrix (TBM, BM, HM, GRM).

A.2 Determination of M_D:

From type I SS term, $M_\nu{}^I \approx -M_D M_{RR}^{-1} M_D^T$

Again, $M_\nu{}^I = U_{(TBM)} U_{Maj} X M_\nu{}^{(diag)} U_{Maj}{}^T U_{(TBM)}{}^T$

$$M_{RR} = \frac{1}{\gamma}\left(\frac{v_R}{M_{W_L}}\right)^2 M_\nu{}^{II} \tag{A.10}$$

Where, $M_\nu{}^{II} = U_{PMNS} M_\nu{}^{(diag)} U_{PMNS}{}^T - U_{(TBM)} U_{Maj} X M_\nu{}^{(diag)} U_{Maj}{}^T U_{(TBM)}{}^T$. Considering, X=0.5, $M_{W_L} = 80$ GeV, $v_R = 5$ TeV (for one case only) and expressing $M_\nu{}^{(diag)}$ in terms of lightest neutrino mass, $m_1(m_3)$ for NH (IH), we obtained M_{RR} varying the Majorana phases α and β from 0 to 2π and lightest neutrino mass from 10^{-3} to 10^{-1}.

We have considered M_D as,

$$\mathrm{M_D} = \begin{bmatrix} a_1 & a_2 & a_3 \\ a_2 & a_4 & a_5 \\ a_3 & a_5 & a_6 \end{bmatrix}, \tag{A.11}$$

which is symmetric. Equating both sides of type I seesaw equation and solving for $a_1, a_2, a_3, a_4, a_5, a_6$, we obtain the matrix elements of one of the M_D of the form,

$$\mathrm{M_D} = \begin{bmatrix} 24776.2 + 122368.i & 70524.8 + 76561.i & -12687.1 + 21472.4i \\ 70524.8 + 76561.i & 14308.4 + 138730.i & -45802.3 - 46293.4i \\ -12687.1 + 21472.4i & -45802.3 - 46293.4i & 87313.6 + 158166.i \end{bmatrix}, \tag{A.12}$$

which we have implemented for our further analysis.

Elements of the type II Seesaw mass matrix:

$$S_{11} = \left(c_{12}^2 c_{13}^2 - X c_{12}^{2\ TBM}\right) m_1 + e^{2i(\beta-\delta)} s_{13}^2 m_3 + \left(c_{13}^2 s_{12}^2 - X s_{12}^{2\ TBM}\right) e^{2i\alpha} m_2 \tag{A.13}$$

$$\begin{aligned} S_{12} = &\left(-c_{12}c_{13}c_{23}s_{12} - c_{12}^2 c_{13} s_{13} s_{23} e^{i\delta} + X c_{12}^{TBM} c_{23}^{TBM} s_{12}^{TBM}\right) m_1 + \\ &\left(-c_{13}s_{12}c_{12}c_{23}e^{2i\alpha} - c_{13}s_{12}^2 s_{13} s_{23} e^{i(2\alpha+\delta)} + X c_{12}^{TBM} c_{23}^{TBM} s_{12}^{TBM} e^{2i\alpha}\right) m_2 + \\ &\left(c_{13} s_{13} s_{23} e^{i(2\beta-\delta)}\right) m_3 \end{aligned} \tag{A.14}$$

$$S_{13} = \left(c_{12}^2 c_{13} c_{23} s_{13} e^{i\delta} + s_{12} s_{23} c_{12} c_{13} - X c_{12}^{TBM} s_{12}^{TBM} s_{23}^{TBM}\right) m_1 + \left(-c_{13} s_{12} c_{23} s_{12} s_{13} e^{i(2\alpha+\delta)} - X c_{12}^{TBM} s_{12}^{TBM} s_{23}^{TBM} e^{2i\alpha}\right) m_2 + \left(e^{i(2\beta-\delta)} c_{13} c_{23} s_{13}\right) m_3 \quad (A.15)$$

$$S_{21} = \left(-c_{12} c_{13} c_{23} s_{12} - c_{12}^2 c_{13} s_{13} s_{23} e^{i\delta} + X c_{12}^{TBM} c_{23}^{TBM} s_{12}^{TBM}\right) m_1 + \left(c_{13} s_{12} c_{12} c_{23} e^{2i\alpha} - s_{12}^2 s_{13} s_{23} c_{13} e^{i(2\alpha+\delta)} + X c_{12}^{TBM} c_{23}^{TBM} s_{12}^{TBM} e^{2i\alpha}\right) m_2 + \left(e^{i(2\beta-\delta)} c_{13} s_{23} s_{13}\right) m_3 \quad (A.16)$$

$$S_{22} = \left(\left(c_{23} s_{12} - e^{i\delta} c_{12} s_{13} s_{23}\right)^2 - X c_{23}^{2\ TBM} s_{12}^{2\ TBM}\right) m_1 + \left(-X c_{12}^{2\ TBM} c_{23}^{2\ TBM} + \left(-c_{12} c_{23} - e^{i\delta} s_{12} s_{13} s_{23}\right)^2\right) m_2 e^{2i\alpha} + \left(c_{13}^2 s_{23}^2 - X s_{23}^{2\ TBM} e^{2i\beta}\right) m_3 \quad (A.17)$$

$$S_{23} = \left(\left(-c_{12} c_{23} s_{13} e^{i\delta} + s_{12} s_{23}\right)\left(-c_{23} s_{12} - e^{i\delta} c_{12} s_{13} s_{23}\right) + X c_{23}^{TBM} s_{12}^{2\ TBM} s_{23}^{2\ TBMu}\right) m_1 + \left(\left(-e^{i\delta} c_{23} s_{12} s_{13} + c_{12} s_{23}\right)\left(-c_{12} c_{23} - e^{i\delta} s_{12} s_{13} s_{23}\right) + X c_{12}^{2\ TBM} c_{23}^{TBM} s_{23}^{TBM}\right) m_2 e^{2i\alpha} + \left(c_{13}^2 c_{23} s_{23} e^{2i\beta} - c_{23}^{TBM} s_{23}^{TBM}\right) m_3 \quad (A.18)$$

$$S_{31} = \left(c_{12}^2 c_{13} c_{23} s_{13} e^{i\delta} + s_{12} s_{23} c_{12} c_{13} - X c_{12}^{TBM} s_{12}^{TBM} s_{23}^{TBM}\right) m_1 + \left(c_{13} s_{12}^2 e^{i\delta} c_{23} s_{13} + c_{12} s_{23} c_{13} s_{12} e^{2i\alpha} - X c_{12}^{TBM} s_{12}^{TBM} s_{23}^{TBM}\right) m_2 e^{2i\alpha} + \left(e^{2i\beta - i\delta} c_{13} c_{23} s_{13}\right) m_3 \quad (A.19)$$

$$S_{32} = \left(\left(-e^{i\delta} c_{12} c_{23} s_{13} + s_{12} s_{23}\right)\left(-c_{23} s_{12} - e^{i\delta} c_{12} s_{13} s_{23}\right) + c_{23}^{TBM} s_{12}^{2\ TBM} s_{23}^{TBM}\right) m_1 \left(\left(-e^{i\delta} c_{23} s_{12} s_{13} + c_{12} s_{23}\right)\left(-c_{12} c_{23} - e^{i\delta} s_{12} s_{13} s_{23}\right) + X c_{12}^{2\ TBM} c_{23}^{TBM} s_{23}^{TBM}\right) e^{2i\alpha} m_2 \left(c_{13}^2 c_{23} s_{23} - X c^{TBM}{}_{23} s^{TBM}{}_{23}\right) e^{2i\beta} m_3 \quad (A.20)$$

$$S_{33} = \left(\left(-e^{i\delta} c_{12} c_{23} s_{13} + s_{12} s_{23}\right)^2 - X s_{12}^{2\ TBM} s_{23}^{2\ TBM}\right) m_1 + \left(\left(-e^{i\delta} c_{23} s_{12} s_{13} + c_{12} s_{23}\right)^2 - X c_{12}^{2\ TBM} s_{23}^{2\ TBM}\right) e^{2i\alpha} m_2 + \left(c_{13}^2 c_{23}^2 - c_{23}^{2\ TBM}\right) e^{2i\beta} m_3 \quad (A.21)$$

Where, $c_{ij}^{TBM} = \cos\theta_{ij}^{TBM}$, $s_{ij}^{TBM} = \sin\theta_{ij}^{TBM}$ represents the mixing angles for TBM neutrino mass matrix.