These are instructions to calculate FRTB CSR Curvature capital charge:

1. **File: Important columns in "bond_sensitivities_detailed_for CSR Delta" file sheet** "Bond delta Sensitivities" as below:
   a) Security: These are portfolio holdings, but a single security can come in many rows because each row corresponds to sensitivity to a separate CSR tenor in column"Tenor"
   b) Type: Informational only, Calculations don't depend on this column. For FYI this is IG only, not HY
   c) **CSR bucket:** Bucket. All holdings are distributed in 4 buckets 1,2,3 and 4.
   d) Tenor: GIRR Tenor in format like 0.2Y or 10.0Y etc. Below are valid values in file. But this is just additional information. For this calculation Tenor is not relevant.

Tenor
0.2Y
0.5Y
1.0Y
2.0Y
3.0Y
5.0Y
10.0Y

   e) **Sensitivity**: GIRR delta Sensitivity to tenor. This has been scaled up to position size, so no need to multiply with position size. FYI: This is used to remove affect of delta risk charge from curvature risk charge.

2. **Aggregated bucket delta sensitivity based on CSR bucket:**
   a) Sum all Bond Sensitivities irrespective of tenor into a single number based on CSR bucket A This is Total sensitivity for bucket A.
   b) Repeat this for all CSR buckets.
3. Read "CSR_Non_Sec_curvature_parallel_shifts" file- sheet "CSR_Non_Sec_Curvature_Data", for each position. No aggregation or summation in this step. This sheet is instrumental in calculating curvature i.e. bucket risk charge.

   Important columns in sheet "CSR_Non_Sec_Curvature_Data", and some actions on them below
   a) Security
   b) CSR Bucket- Bucket. All holdings are distributed in 4 buckets 1,2,3 and 4.
   c) Notional_Exposure-Divide it by 100 to get number of bonds i.e. position size
   d) Base_Price-Multiply by position size to get V_base

e) Price_Up-Multiply by position size to get V_RW_up. Note/FYI: This was calculated based on parallel shift up of 12%. This is maximum CSR Non securitization delta risk weight at bucket 11.
f) Price_Down-Multiply by position size to get V_RW_down. Note/FYI: This was calculated based on parallel shift down of 12%. This is maximum CSR Non securitization delta risk weight at bucket 11.

4. File-CSR_Non_Sec_curvature_parallel_shifts. Sheet "CSR non securitiz sectoral corr" contains interbucket correlations. FYI: The same correlations were used in CSR Delta calculation. Few example from sheet below:
   a) Correlation between bucket 1/9 and 2/10 is 75%. Don't get confused by "/" in column and row headers this just means 1 or 9 and 2 or 10. So correlation of 75% applies between buckets 9 and 2, buckets 9 and 10, buckets 1 and 2 and buckets 1 and 10. When "/" is missing that means only 1 bucket on that side.
   b) Correlation between buckets 8 and 2/10. Correlation between buckets 8 and 2, and 8 and 10 is 10%.

5. Aggregation: Aggregate(Sum) V_base, V_RW_up, V_RW_down based on Bucket. So now for each bucket we should have a V_base, V_RW_up, and V_RW_down
6. Calculate Curvature_Up and Curvature_Down for each bucket(column = CSR Bucket)
   For bucket A
   a) Curvature_Up for a bond: Curvature_Up = -(V_RW_up - V_base - 0.12*(Sum of sensitivity for bucket A from step 2))
   b) Curvature_Down for a bond: Curvature_Down = -(V_RW_down - V_base + 0.12*(Sum of sensitivity for bucket A from step 2))

   Same has to be done for bucket B and bucket C if any. So we will get bucket wise Curvature_Up and Curvature_Down
   Note: 0.12 above is maximum risk weight of bucket 11. This multiplization nullifies delta risk charge and only curvature risk charge remains.

7. This step is FYI, no action required. Just a note: $\rho_{kl}^{(name)}$ does not come into picture to aggregate inside bucket because credit spread at all tenors of credit spread curve is moved up and down simultaneously i.e. parallel shift and in same amount. This should be added in comments.
8. Bucket charge for that bucket K_b= max(Cuvature_Up, Curvature_Down). So now we have bucket level curvature charge for all buckets.
9. Calculate ψ (psi) for each bucket pair. $\psi(K_b, K_c)$ takes the value 0 if both buckets b and c have negative sign and the value 1 otherwise. So for each bucket pair we will calculate $\psi(K_b, K_c)$.

10. **Get Medium inter-bucket correlation(γ_{bc}) . below steps except step ©(Squaring) are borrowed from CSR Non securitization delta inter bucket correlation.**

a) $\boldsymbol{\gamma_{bc}^{rating}}$ **= 1**
Where b and c are buckets. It is 1 because all my buckets are IG, so only 1 rating category. No HY. You must be wondering if this value is 1 then why bother in writing so many words for it, but this is required for audit purpose and for traceability because this value can change if in future I also include HY holdings in my portfolio.

b) $\boldsymbol{\gamma_{bc}^{sector}}$ = 1, if 2 buckets belong to same sector. Sector is a column in sheet Bond_Sensitivities. Each bucket belongs to a sector. If Sector is different of 2 buckets than please refer sheet "CSR non securitiz sectoral corr" for interbucket correlation.

c) **Calculate interbucket medium correlation**

$$\gamma_{bc} = \boldsymbol{\gamma_{bc}^{rating}} \times \boldsymbol{\gamma_{bc}^{sector}}$$

d) Square γ_{bc} . So γ_{bc} becomes $\gamma_{bc} \times \gamma_{bc}$. For example if earlier it was 0.5 after squaring it becomes 0.25

e) **High inter-bucket correlation**: Multiply interbucket medium correlation γ_{bc} by 1.25. Correlation should be capped at 100%

f) **Low inter-bucket Correlations**:
Use below formula based on interbucket medium correlation

$$\gamma_{bc}^{low} = \max\left(2 \times \gamma_{bc} - 100\%; 75\% \times \gamma_{bc}\right)$$

11. Total Curvature Risk : We will calculate 3 γ_{bc} values in all 3 curvature risk charge calculations.
    a) Low correlation curvature risk in which we will use γ_{bc}^{low}. Everything else stays same.
    b) Medium correlation curvature risk in which we will use γ_{bc}. Everything else stays same.
    c) High correlation curvature risk in which we will use γ_{bc}^{High}. Everything else stays same.
    Formula as below,

$$= \sqrt{\boldsymbol{max}(\mathbf{0}, \sum_{\boldsymbol{b}} \boldsymbol{K_b^2} + \sum_{\boldsymbol{c \neq b}} \sum_{\boldsymbol{b}} \gamma_{bc}\, \psi(K_b, K_c) \times K_b \times K_c)}$$

12. We will transport all these position level and aggregations into excel.