These are instructions to calculate FRTB CSR Delta capital charge:

1. **File: Important columns in "bond_sensitivities_detailed_for CSR Delta" file sheet** "Bond_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
   c) Sector: GICS sector of security. This column will be used in aggregating bucket level capital charges. This is explained later.
   d) CSR bucket: Bucket. All holdings are distributed in 4 buckets 1,2,3 and 4.
   e) CSR Risk weight: Risk weight of security in decimals, not %
   f) Tenor: GIRR Tenor in format like 0.2Y or 10.0Y etc. Below are valid values in file.

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

   g) Sensitivity: GIRR Sensitivity to tenor. This has been scaled up to position size, so no need to multiply with position size.
2. File: **"bond_sensitivities_detailed_for CSR Delta" file sheet "CSR non securitiz sectoral corr"**
   This sheet contains intra bucket correlations. This will be used in aggregating bucket capital charge into CSR non securitization Few example 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%.

3. **CSR tenors:**

Tenor
0.5Y
1.0Y
3.0Y
5.0Y

10.0Y

4. **Interpolate GIRR tenor sensitivity to CSR tenor sensitivity**: As you have noticed CSR tenors are fewer than GIRR tenors so interpolation would be required for few tenors when mapping GIRR tenor sensitivity to CSR tenor sensitivity. Below are steps:
   a) Direct mapping of tenor sensitivity of a bond: Sensitivity of common tenors like 0.5Y or 10Y will be mapped by direct assignation, no interpolation, no calculation.
   b) Interpolation for extra GIRR tenors 0.2Y and 2.0Y to CSR tenor sensitivity: Please use linear interpolation. Examples below:
      i. 0.2Y GIRR tenor sensitivity will be allocated completely to 0.5Y CSR tenor sensitivity for security.
      ii. 2.0Y GIRR tenor sensitivity will be allocated 50% each to 1.0Y and 3.0Y CSR tenor sensitivities for a security.

So now we have derived CSR sensitivities for each security at 5 tenors. All below conversation will correspond to this CSR sensitivity for tenors for securities. Forget GIRR sensitivity ever existed.

5. **Calculate weighted sensitivity:**
   Multiply Sensitivity with "CSR Risk weight". Just multiply, CSR Risk Weight is already in decimals.
6. **Calculate Medium level Correlation between weighted sensitivities within a bucket:** For example Bucket 1 has 4 holdings. There are 28 sensitivities. So we need to calculate C(n,r) = n! / (r! × (n-r)!) = 378 correlations within this bucket. Same applies to other buckets.
   Now perform below calculations for each of 378 pairs. I would appreciate if you use constants for reusable values and assign constants in python code wherever required rather than using them directly. To use constants is good programming practice.
   a) $\boldsymbol{\rho_{kl}^{(name)}}$ is equal to 1 when securities are same in correlation pair for example between 0.5Y and 5.0Y for Apple 2027 Bond. If securities are different then $\boldsymbol{\rho_{kl}^{(name)}}$ is 0.35% for example between Apple 2027 Bond 0.5Y and JPMorgan 2026 Bond 3.0Y. Point being tenor is not important, only security name is important. So the only criteria is being whether security name is different or not.
   b) $\boldsymbol{\rho_{kl}^{(tenor)}}$ is equal to 1 when tenors of sensitivities are same in correlation pair for example between Apple 2027 Bond 0.5Y and JPMorgan 2026 Bond 0.5Y. If tenors are different then $\boldsymbol{\rho_{kl}^{(tenor)}}$ is 0.65% for example between Apple 2027

Bond 0.5Y and JPMorgan 2026 Bond 5.0Y. Point being security name is not important, only tenor is important. So the only criteria is being whether tenor is different or not.

c) $\boldsymbol{\rho_{kl}^{(basis)}}$ **= 1**

d) $\boldsymbol{\rho_{kl}} = \boldsymbol{\rho_{kl}^{(name)}} \times \boldsymbol{\rho_{kl}^{(tenor)}} \times \boldsymbol{\rho_{kl}^{(basis)}}$

So now we have calculated medium level correlations $\boldsymbol{\rho_{kl}}$ which is corelation between weighted sensitivities within a bucket.

7. **High Correlations**: Based on collected medium correlations, calculate correlations of high correlation scenario. For this just multiply all medium correlations $\boldsymbol{\rho_{kl}}$ by 1.25. Correlations should be capped at 100%. So we will get 378 high correlations for bucket 1.
8. **Low Correlations**:
   Adjust each correlation in Medium correlation $\boldsymbol{\rho_{kl}}$ with below formula
   $$\rho_{kl}^{low} = \max(2 \times \rho_{kl} - 100\%; 75\% \times \rho_{kl})$$
9. **Calculate bucket capital charge for each bucket.** You will use 3 sets of correlations so 3 bucket level capital charges will be there: High Correlation bucket charge, Low correlation bucket charge and medium correlation bucket charge . We have only one set of weighted sensitivities for each bucket, no high, medium or low.
   $$\boldsymbol{K_b} = \sqrt{\boldsymbol{max}(\mathbf{0}, \sum_{\boldsymbol{k}} \boldsymbol{WS_k^2} + \sum_{\boldsymbol{k}} \sum_{\boldsymbol{k \neq l}} \rho_{kl} \times WS_k \times WS_l)}$$

   Where WS_k and WS_l = Weighted sensitivity
   ρ_{kl} is Low, Medium or High correlation matrix.

   Now we have 3 bucket capital charges for each bucket

10. Get inter-bucket Medium correlation(γ_{bc})

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

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

e) **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. **Across bucket aggregation:** Now all CSR buckets needs to be aggregated.
We will do this step 3 times.
Low correlation iteration: Use Low correlation bucket capital charge and low interbucket correlation
Medium correlation iteration: Use Low correlation bucket capital charge and low interbucket correlation
High correlation iteration: Use Low correlation bucket capital charge and low interbucket correlation.

In all these 3 iterations Bucket aggregate sensitivity step will be same so feel free to perform only once. Next 2 steps of CSR Non securitization delta capital charge will be done 3 times(low, medium, high) and Recalculation of S_b will also be done thrice(low, medium, high). Weighted sensitivities remain same.

a) **Bucket aggregate sensitivity** within each bucket by simple summation, i.e. by below formula

$$S_b = \sum WS_k$$
$$S_c = \sum WS_k$$

b) **CSR Non securitization** ***Delta capital charge*** *as below formula.*

$$\sum_b K_b^2 + \sum_b \sum_{c \neq b} \gamma_{bc} S_b S_c$$

Apply sqrt to above calculated number.
If Delta capital charge is –(ve) then go to below extra step. Capital cannot be –(ve)

c) If the sum in step (b) above gives -ve number use alternative approach as below.

I. ReCalculate S_b (Bucket aggregate sensitivity)for bucket "b"

$$\boldsymbol{S_b = max[min(\sum_k WS_k, K_b), -K_b]}$$

For bucket c

$$\boldsymbol{S_c = max[min(\sum_k WS_k, K_c), -K_c]}$$

II. **And recalculate CSR Non securitization Delta capital charge**:

$$\sum_b K_b^2 + \sum_b \sum_{c \neq b} \gamma_{bc} S_b S_c$$

12. **All the metrics calculated above must be transported in excel document. We will need 3 metrics:**
    a) Low correlation CSR Non securitization Delta capital charge
    b) Medium correlation CSR Non securitization Delta capital charge
    c) High correlation CSR Non securitization Delta capital charge