Based on the highlighted lines of the code, I would like to break-down response in two parts.

Part 1: Related to the free-face ratio

Part 2: Related to deep sources

Part 1: Related to the free-face ratio: The corresponding lines of the code are as follows:

```
if ctx.freeface_ratio.all() == 0.0:
    C = self.COEFFS_SLOPE[imt]
else:
    C = self.COEFFS_FREEFACE[imt]
    ctx.slope = ctx.freeface_ratio
```

Youd et al. (2002) developed model for estimating lateral spread displacements (PGD) corresponding to two topographic real life cases.

1. Free-face conditions: Near channel or river bank represented by eqn (1)
2. Sloping conditions: Gentle slope in ground represented by eqn (2)

$$Log\ (PGD) = -16.213 + 1.532M - 1.406LogR^{*} - 0.012R + 0.338LogS + 0.540LogT_{15} + 3.413Log(100 - F_{15}) - 0.795Log(D50_{15} + 0.1) \quad (1)$$

$$Log\ (PGD) = -16.713 + 1.532M - 1.406LogR^{*} - 0.012R + 0.592LogW + 0.540LogT_{15} + 3.413Log(100 - F_{15}) - 0.795Log(D50_{15} + 0.1) \quad (2)$$

Here, ‘S’ represents slope whereas ‘W’ represents free-face ratio. When using this model, the user would decide on the case depending upon the site under consideration. In other words, when slope case is to be used, there is no ‘W’ and when free-face case is to be used, there is no ‘S’.

Further, as you can see from the expressions, the coefficients for slope condition differ slightly from that of free-face conditions; and hence, two tables for coefficients are provided in the code, viz., COEFFS_SLOPE and COEFFS_FREEFACE. For this code, depending upon the site, the user needs to provide both the parameters, wherein, one of them should be zero. I have written code so as to switch from free-face condition to sloping ground condition based on the input values provided by the user. Accordingly, the above-mentioned lines of the code ensure that depending

upon the site condition i.e., whichever of 'slope' and 'freeface_ratio' has non-zero values, the corresponding set of coefficient tables and hence, the coefficients are chosen.

Further, code written with this logic has been validated with the provided test tables. We have now given test tables for both slope as well as free-face conditions. However, let us know if there is a need to incorporate any modifications.

Part 2: Related to deep sources: The corresponding lines of the code are as follows:

```
if ctx.hypo_depth >= 50.0:
    ctx.repi.setflags(write=1)
    ctx.repi[ctx.repi < 5.0] = 5.0
```

These lines represent an adjustment suggested specifically for deep sources, wherein source-depth > 50 km.

The expressions from Youd et al. (2002) are based on shallow-crustal earthquakes, wherein, the rupture parameter, R, is epicentral distance. While dealing with the deep sources, for sites within 5 km of epicentre, if 'R' is chosen as epicentral distance, then the computed PGDs might be over-estimated, whereas, if it is chosen as the site-to-source distance, then, PGDs might be under-estimated. Honegger et al. (2010) proposed a meaningful approach in order to extend the applicability of Youd et al. (2002) model to deep sources as well. Using this approach, we are suggesting to consider equivalent epicentral distance of 5 km for sites within 5 km of epicenter for deep sources. This is because, it was observed that for source-depth => 50 km, up to 5 km, the change in hypocentral distance is negligible.

Let us know if we need to explain in brief about this adjustment as comment in the code.

Honegger, D. G. *et al.* (2010) 'Definition of Lateral Spread Displacement for Regional Risk Assessments of Pipeline Vulnerability', in *International Pipeline Conference*, pp. 583–592.

Youd, T. L., Hansen, C. M. and Bartlett, S. F. (2002) ‘Revised Multilinear Regression Equations for Prediction of Lateral Spread Displacement’, 128(December), pp. 1007–1017.