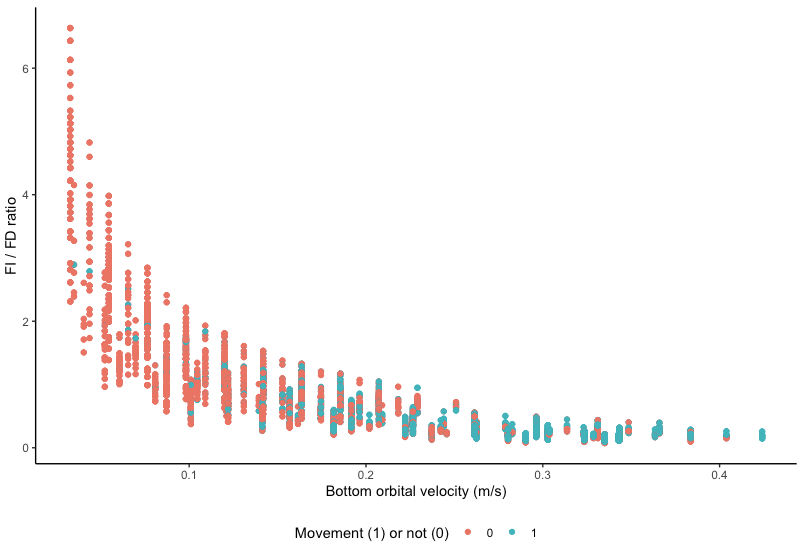
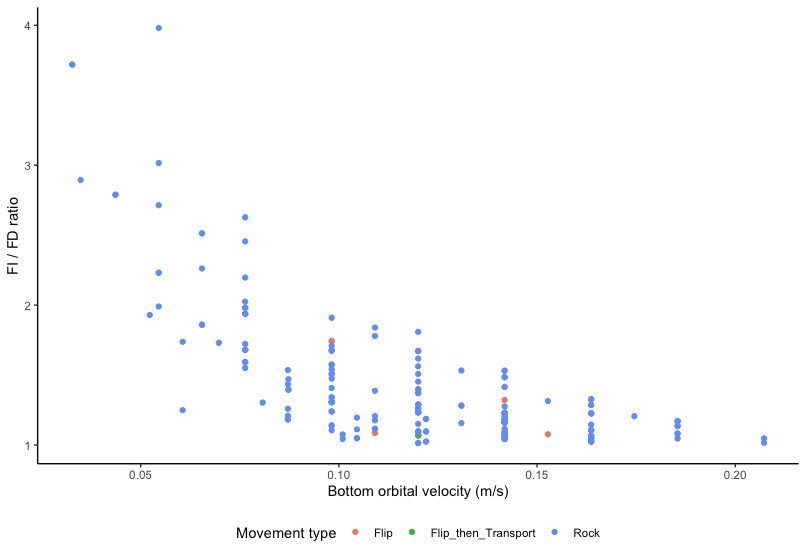
**Attachment A**

**Table A1:** The average coral rubble diameter, wave height, period, water depth, and corresponding velocities (estimated using both the Soulsby cosine approximation and Linear wave theory), inertial force component and bottom orbital excursions for all wave conditions used in determining the relationship between velocity and movement in the wave flume. KC number calculated by ‘T (s)’ multiplied by ‘Velocity (m/s)’ divided by ‘Rubble diameter (m)’. FI/FD calculated by π2 divided by ‘KC’. The KC number provides an indication of the bottom excursions while **24/KC2** indicates the contribution of the inertia force to the total maximum force as a proportion of the drag force. Note orbital displacement (S) divided by rubble diameter (D) gives KC/2π, i.e., S/D = KC/(2π).

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Depth (m)** | **H (m)** | **T (s)** | **Velocity (Soulsby Cosine Approximation) (m/s)** | **Velocity (Linear wave theory) (m/s)** | **Rubble diameter (m)** | **KC** | **FI/FD** | **24/KC2** | **Potential for inertia force to be significant?** | **Maximum force from?** |
| 0.42 | 0.03 | 1 | 0.033 | 0.032 | 0.0164 | 1.996 | 4.946 | 6.026 | Yes | Inertia |
| 0.42 | 0.02 | 1.5 | 0.035 | 0.036 | 0.0164 | 3.188 | 3.096 | 2.361 | Yes | Inertia |
| 0.42 | 0.02 | 2 | 0.040 | 0.041 | 0.0164 | 4.925 | 2.004 | 0.989 | Yes | Inertia |
| 0.42 | 0.04 | 1 | 0.044 | 0.043 | 0.0164 | 2.661 | 3.709 | 3.390 | Yes | Inertia |
| 0.42 | 0.03 | 1.5 | 0.052 | 0.054 | 0.0164 | 4.782 | 2.064 | 1.050 | Yes | Inertia |
| 0.42 | 0.05 | 1 | 0.055 | 0.054 | 0.0164 | 3.326 | 2.967 | 2.169 | Yes | Inertia |
| 0.42 | 0.03 | 2 | 0.061 | 0.062 | 0.0164 | 7.387 | 1.336 | 0.440 | Yes | Drag |
| 0.42 | 0.06 | 1 | 0.065 | 0.065 | 0.0164 | 3.991 | 2.473 | 1.507 | Yes | Inertia |
| 0.42 | 0.04 | 1.5 | 0.070 | 0.072 | 0.0164 | 6.376 | 1.548 | 0.590 | Yes | Drag |
| 0.42 | 0.07 | 1 | 0.076 | 0.076 | 0.0164 | 4.657 | 2.120 | 1.107 | Yes | Inertia |
| 0.42 | 0.04 | 2 | 0.081 | 0.083 | 0.0164 | 9.850 | 1.002 | 0.247 | No | Drag |
| 0.42 | 0.05 | 1.5 | 0.087 | 0.090 | 0.0164 | 7.970 | 1.238 | 0.378 | Yes | Drag |
| 0.42 | 0.08 | 1 | 0.087 | 0.087 | 0.0164 | 5.322 | 1.855 | 0.847 | Yes | Drag |
| 0.42 | 0.09 | 1 | 0.098 | 0.097 | 0.0164 | 5.987 | 1.649 | 0.670 | Yes | Drag |
| 0.42 | 0.05 | 2 | 0.101 | 0.104 | 0.0164 | 12.312 | 0.802 | 0.158 | No | Drag |
| 0.42 | 0.06 | 1.5 | 0.105 | 0.108 | 0.0164 | 9.564 | 1.032 | 0.262 | Yes | Drag |
| 0.42 | 0.1 | 1 | 0.109 | 0.108 | 0.0164 | 6.652 | 1.484 | 0.542 | Yes | Drag |
| 0.42 | 0.11 | 1 | 0.120 | 0.119 | 0.0164 | 7.317 | 1.349 | 0.448 | Yes | Drag |
| 0.42 | 0.06 | 2 | 0.121 | 0.124 | 0.0164 | 14.775 | 0.668 | 0.110 | No | Drag |
| 0.42 | 0.07 | 1.5 | 0.122 | 0.126 | 0.0164 | 11.158 | 0.885 | 0.193 | No | Drag |
| 0.42 | 0.12 | 1 | 0.131 | 0.130 | 0.0164 | 7.983 | 1.236 | 0.377 | Yes | Drag |
| 0.42 | 0.08 | 1.5 | 0.139 | 0.144 | 0.0164 | 12.752 | 0.774 | 0.148 | No | Drag |
| 0.42 | 0.07 | 2 | 0.141 | 0.145 | 0.0164 | 17.237 | 0.573 | 0.081 | No | Drag |
| 0.42 | 0.13 | 1 | 0.142 | 0.141 | 0.0164 | 8.648 | 1.141 | 0.321 | Yes | Drag |
| 0.42 | 0.14 | 1 | 0.153 | 0.151 | 0.0164 | 9.313 | 1.060 | 0.277 | Yes | Drag |
| 0.42 | 0.09 | 1.5 | 0.157 | 0.162 | 0.0164 | 14.346 | 0.688 | 0.117 | No | Drag |
| 0.42 | 0.08 | 2 | 0.162 | 0.166 | 0.0164 | 19.700 | 0.501 | 0.062 | No | Drag |
| 0.42 | 0.15 | 1 | 0.164 | 0.162 | 0.0164 | 9.978 | 0.989 | 0.241 | No | Drag |
| 0.42 | 0.1 | 1.5 | 0.174 | 0.180 | 0.0164 | 15.940 | 0.619 | 0.094 | No | Drag |
| 0.42 | 0.16 | 1 | 0.175 | 0.173 | 0.0164 | 10.644 | 0.927 | 0.212 | No | Drag |
| 0.42 | 0.09 | 2 | 0.182 | 0.187 | 0.0164 | 22.162 | 0.445 | 0.049 | No | Drag |
| 0.42 | 0.17 | 1 | 0.185 | 0.184 | 0.0164 | 11.309 | 0.873 | 0.188 | No | Drag |
| 0.42 | 0.11 | 1.5 | 0.192 | 0.198 | 0.0164 | 17.534 | 0.563 | 0.078 | No | Drag |
| 0.42 | 0.18 | 1 | 0.196 | 0.195 | 0.0164 | 11.974 | 0.824 | 0.167 | No | Drag |
| 0.42 | 0.1 | 2 | 0.202 | 0.207 | 0.0164 | 24.625 | 0.401 | 0.040 | No | Drag |
| 0.42 | 0.19 | 1 | 0.207 | 0.206 | 0.0164 | 12.639 | 0.781 | 0.150 | No | Drag |
| 0.42 | 0.12 | 1.5 | 0.209 | 0.216 | 0.0164 | 19.128 | 0.516 | 0.066 | No | Drag |
| 0.42 | 0.2 | 1 | 0.218 | 0.216 | 0.0164 | 13.304 | 0.742 | 0.136 | No | Drag |
| 0.42 | 0.11 | 2 | 0.222 | 0.228 | 0.0164 | 27.087 | 0.364 | 0.033 | No | Drag |
| 0.42 | 0.13 | 1.5 | 0.227 | 0.234 | 0.0164 | 20.722 | 0.476 | 0.056 | No | Drag |
| 0.42 | 0.21 | 1 | 0.229 | 0.227 | 0.0164 | 13.970 | 0.707 | 0.123 | No | Drag |
| 0.42 | 0.11 | 2.5 | 0.237 | 0.242 | 0.0164 | 36.159 | 0.273 | 0.018 | No | Drag |
| 0.42 | 0.12 | 2 | 0.242 | 0.249 | 0.0164 | 29.550 | 0.334 | 0.027 | No | Drag |
| 0.42 | 0.14 | 1.5 | 0.244 | 0.252 | 0.0164 | 22.316 | 0.442 | 0.048 | No | Drag |
| 0.42 | 0.11 | 3 | 0.246 | 0.249 | 0.0164 | 44.941 | 0.220 | 0.012 | No | Drag |
| 0.42 | 0.23 | 1 | 0.251 | 0.249 | 0.0164 | 15.300 | 0.645 | 0.103 | No | Drag |
| 0.42 | 0.15 | 1.5 | 0.261 | 0.270 | 0.0164 | 23.910 | 0.413 | 0.042 | No | Drag |
| 0.42 | 0.13 | 2 | 0.263 | 0.269 | 0.0164 | 32.012 | 0.308 | 0.023 | No | Drag |
| 0.42 | 0.16 | 1.5 | 0.279 | 0.288 | 0.0164 | 25.504 | 0.387 | 0.037 | No | Drag |
| 0.42 | 0.13 | 2.5 | 0.280 | 0.286 | 0.0164 | 42.734 | 0.231 | 0.013 | No | Drag |
| 0.42 | 0.14 | 2 | 0.283 | 0.290 | 0.0164 | 34.475 | 0.286 | 0.020 | No | Drag |
| 0.42 | 0.13 | 3 | 0.290 | 0.294 | 0.0164 | 53.112 | 0.186 | 0.009 | No | Drag |
| 0.42 | 0.17 | 1.5 | 0.296 | 0.306 | 0.0164 | 27.098 | 0.364 | 0.033 | No | Drag |
| 0.42 | 0.15 | 2 | 0.303 | 0.311 | 0.0164 | 36.937 | 0.267 | 0.018 | No | Drag |
| 0.5 | 0.17 | 2 | 0.304 | 0.313 | 0.0164 | 37.034 | 0.267 | 0.017 | No | Drag |
| 0.42 | 0.18 | 1.5 | 0.314 | 0.325 | 0.0164 | 28.692 | 0.344 | 0.029 | No | Drag |
| 0.42 | 0.16 | 2 | 0.323 | 0.332 | 0.0164 | 39.400 | 0.250 | 0.015 | No | Drag |
| 0.42 | 0.15 | 2.5 | 0.323 | 0.330 | 0.0164 | 49.308 | 0.200 | 0.010 | No | Drag |
| 0.5 | 0.17 | 2.5 | 0.329 | 0.336 | 0.0164 | 50.098 | 0.197 | 0.010 | No | Drag |
| 0.42 | 0.19 | 1.5 | 0.331 | 0.343 | 0.0164 | 30.286 | 0.326 | 0.026 | No | Drag |
| 0.42 | 0.15 | 3 | 0.335 | 0.340 | 0.0164 | 61.283 | 0.161 | 0.006 | No | Drag |
| 0.5 | 0.17 | 3 | 0.343 | 0.348 | 0.0164 | 62.699 | 0.157 | 0.006 | No | Drag |
| 0.42 | 0.17 | 2 | 0.343 | 0.352 | 0.0164 | 41.862 | 0.236 | 0.014 | No | Drag |
| 0.42 | 0.2 | 1.5 | 0.349 | 0.361 | 0.0164 | 31.880 | 0.310 | 0.024 | No | Drag |
| 0.42 | 0.18 | 2 | 0.363 | 0.373 | 0.0164 | 44.325 | 0.223 | 0.012 | No | Drag |
| 0.42 | 0.21 | 1.5 | 0.366 | 0.379 | 0.0164 | 33.474 | 0.295 | 0.021 | No | Drag |
| 0.42 | 0.17 | 2.5 | 0.367 | 0.373 | 0.0164 | 55.882 | 0.177 | 0.008 | No | Drag |
| 0.42 | 0.17 | 3 | 0.380 | 0.385 | 0.0164 | 69.454 | 0.142 | 0.005 | No | Drag |
| 0.42 | 0.19 | 2 | 0.384 | 0.394 | 0.0164 | 46.787 | 0.211 | 0.011 | No | Drag |
| 0.42 | 0.2 | 2 | 0.404 | 0.414 | 0.0164 | 49.250 | 0.200 | 0.010 | No | Drag |
| 0.42 | 0.21 | 2 | 0.424 | 0.435 | 0.0164 | 51.712 | 0.191 | 0.009 | No | Drag |

****

**Figure A1:** The relationship between bottom orbital velocity as estimated using the Soulsby Cosine Approximation and the ratio of the inertia force and drag force, FI/FD, for every individual case in the wave flume (including free and interlocked rubble pieces across multiple trials and wave conditions). Note than even when FI=FD, the contribution to the maximum total force from the inertia force is only 0.25FD. Colours indicate whether the rubble piece moved (including rocking, transport or flipping) in each case.



**Figure A2:** The relationship between bottom orbital velocity and the FI/FD (inertia to drag force) ratio for cases where a) inertia was determined to be significant and b) rubble moved. Colours indicate the type of rubble movement (majority rocked only).

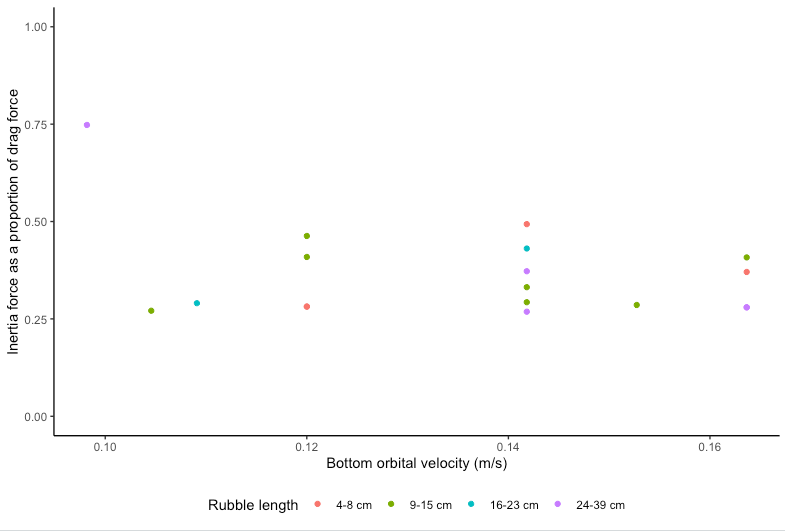
**Table A2:** The coral rubble diameter, wave height, period, water depth, and corresponding velocities (estimated using both Soulsbys cosine approximation and Linear wave theory), inertial force component (accelerations) and bottom orbital excursions for the 18 out of 2,081 identified cases where there were flipping/transport movements recorded (not rocking) under conditions that had the potential to be inertia dominant. All these cases were under ‘free’, not interlocked scenarios. \*KC number calculated by ‘T (s)’ multiplied by ‘Velocity (m/s)’ divided by ‘Rubble diameter (m)’. FI/FD calculated by π2 divided by ‘KC’. The KC number provides an indication of the bottom excursions while **24/KC2** indicates the contribution of the inertia force to the total maximum force as a proportion of the drag force. Note orbital displacement (S) divided by rubble diameter (D) gives KC/2π, i.e., S/D = KC/(2π).

| **Sub-str-ate** | **Len-gth cat.** | **Uni-que #** | **Axial**  **Len-gth (m)** | **Rub-ble diam-eter (m)** | **Type** | **Dry wei-ght (g** | **Wet wei-ght (g)** | **T (s)** | **H (m)** | **Dep-th (m)** | **E**  **value** | **u (sou-lsby)** | **u (lin-ear)** | **KC\*** | **FI/**  **FD** | **24/**  **KC2** | **Ine-rtia sign-ific-ant?** | **Max. force from?** | **rock** | **walk/ slide** | **flip** | **move**  **after walk / slide /**  **flip** | **mov-eme-nt at all** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Rub. | L | 4928 | 193 | 0.019 | Br | 105.55 | 118.43 | 1 | 0.13 | 0.42 | 0.207 | 0.142 | 0.141 | 7.464 | 1.322 | 0.431 | Yes | Inertia | 0 | 0 | 1 | 0 | 1 |
| Rub. | L | 4381 | 185 | 0.012 | UnBr | 40.81 | 44.79 | 1 | 0.1 | 0.42 | 0.207 | 0.109 | 0.108 | 9.091 | 1.086 | 0.290 | Yes | Inertia | 0 | 0 | 1 | 0 | 1 |
| Rub. | M | 6M | 110 | 0.016 | UnBr | -0.22 | 29.72 | 1 | 0.11 | 0.42 | 0.207 | 0.120 | 0.119 | 7.660 | 1.288 | 0.409 | Yes | Inertia | 1 | 0 | 1 | 0 | 1 |
| Rub. | M | 5M | 92 | 0.017 | Br | -0.22 | 40.26 | 1 | 0.13 | 0.42 | 0.207 | 0.142 | 0.141 | 8.510 | 1.160 | 0.331 | Yes | Inertia | 0 | 0 | 1 | 0 | 1 |
| Rub. | M | 5M | 92 | 0.017 | Br | -0.22 | 40.26 | 1 | 0.14 | 0.42 | 0.207 | 0.153 | 0.151 | 9.164 | 1.077 | 0.286 | Yes | Inertia | 0 | 0 | 1 | 0 | 1 |
| Rub. | M | 4M | 111 | 0.021 | UnBr | -0.22 | 43.1 | 1 | 0.15 | 0.42 | 0.207 | 0.164 | 0.162 | 7.671 | 1.287 | 0.408 | Yes | Inertia | 0 | 0 | 1 | 0 | 1 |
| Rub. | M | 5M | 92 | 0.017 | Br | -0.22 | 40.26 | 1.5 | 0.06 | 0.42 | 0.138 | 0.105 | 0.108 | 9.411 | 1.049 | 0.271 | Yes | Inertia | 0 | 0 | 1 | 0 | 1 |
| Rub. | S | 5789 | 44 | 0.013 | UnBr | 6.09 | 7.41 | 1 | 0.11 | 0.42 | 0.207 | 0.120 | 0.119 | 9.231 | 1.069 | 0.282 | Yes | Inertia | 0 | 0 | 1 | 0 | 1 |
| Rub. | S | 5987 | 38 | 0.020 | UnBr | 10.86 | 12.97 | 1 | 0.13 | 0.42 | 0.207 | 0.142 | 0.141 | 6.975 | 1.415 | 0.493 | Yes | Inertia | 0 | 0 | 1 | 0 | 1 |
| Rub. | S | 5987 | 38 | 0.020 | UnBr | 10.86 | 12.97 | 1 | 0.15 | 0.42 | 0.207 | 0.164 | 0.162 | 8.048 | 1.226 | 0.371 | Yes | Inertia | 1 | 0 | 1 | 0 | 1 |
| Rub. | XL | 5264 | 268 | 0.018 | UnBr | 111.91 | 121.96 | 1 | 0.13 | 0.42 | 0.207 | 0.142 | 0.141 | 8.028 | 1.229 | 0.372 | Yes | Inertia | 0 | 0 | 1 | 0 | 1 |
| Rub. | XL | 5264 | 268 | 0.018 | UnBr | 111.91 | 121.96 | 1 | 0.15 | 0.42 | 0.207 | 0.164 | 0.162 | 9.263 | 1.065 | 0.280 | Yes | Inertia | 1 | 0 | 1 | 0 | 1 |
| Rub. | XL | 5264 | 268 | 0.018 | UnBr | 111.91 | 121.96 | 1 | 0.15 | 0.42 | 0.207 | 0.164 | 0.162 | 9.263 | 1.065 | 0.280 | Yes | Inertia | 0 | 0 | 1 | 0 | 1 |
| Rub. | XL | 5285 | 240 | 0.015 | UnBr | 66.83 | 74.08 | 1 | 0.13 | 0.42 | 0.207 | 0.142 | 0.141 | 9.455 | 1.044 | 0.268 | Yes | Inertia | 1 | 0 | 1 | 0 | 1 |
| Sand | XXL | 5785 | 390 | 0.017 | Br | 194.05 | 213.36 | 1 | 0.09 | 0.42 | 0.207 | 0.098 | 0.097 | 5.665 | 1.742 | 0.748 | Yes | Inertia | 1 | 0 | 1 | 0 | 1 |
| Sand | S | 5789 | 44 | 0.013 | UnBr | 6.09 | 7.41 | 1 | 0.11 | 0.42 | 0.207 | 0.120 | 0.119 | 9.231 | 1.069 | 0.282 | Yes | Inertia | 0 | 0 | 1 | 1 | 1 |
| Sand | M | 5M | 92 | 0.017 | Br | -0.22 | 40.26 | 1 | 0.11 | 0.42 | 0.207 | 0.120 | 0.119 | 7.200 | 1.371 | 0.463 | Yes | Inertia | 0 | 0 | 1 | 0 | 1 |
| Sand | M | 6M | 110 | 0.016 | UnBr | -0.22 | 29.72 | 1 | 0.13 | 0.42 | 0.207 | 0.142 | 0.141 | 9.053 | 1.090 | 0.293 | Yes | Inertia | 0 | 0 | 1 | 1 | 1 |

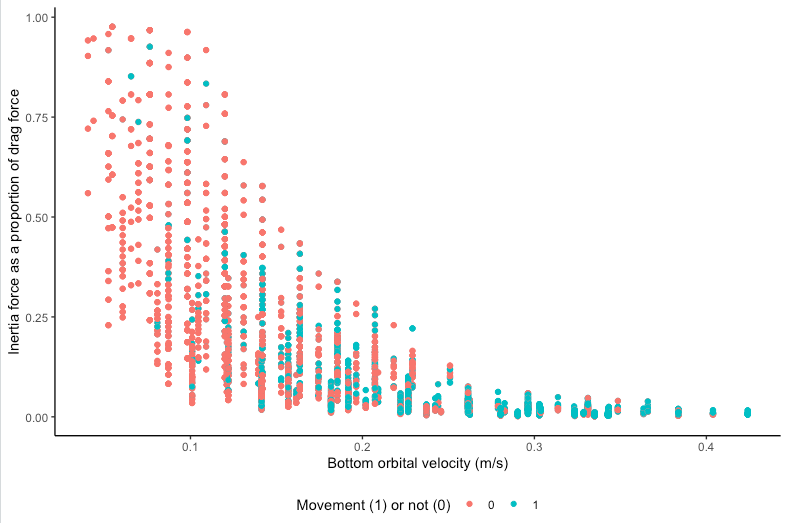
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**Figure A3:** The contribution of inertial force to the total force (proportion, i.e., the **24/KC2** value)for the 18 cases shown in Table AA2. Colours indicate rubble length categories.



**Figure A4:** The relationship between bottom orbital velocity and the contribution of inertial force to the total force (i.e., the **24/KC2** value)for the 18 cases shown in Table AA2. Colours indicate rubble length categories.



**Figure A5:** The relationship between bottom orbital velocity and the contribution of inertial force to the total force (i.e., the **24/KC2** value)for all cases where FI/FD <2. Colours indicate whether rubble moved at all or not.