A simplified procedure for calculation of single-fetch dependent mean and gust wind profiles based on an update of the ESDU (Harris and Deaves) strong-wind model.

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1.0 Introduction

This note describes an improved calculation procedure for gust wind speeds and turbulence starting from the Harris and Deaves (H+D) wind model and it introduces a simplified single-change of surface roughness model suitable for codification.

Technical background can be found in existing papers for which the best starting place is the ESDU Wind Engineering Data Items. These may also be used to extend the model described here to derive self-consistent wind spectra and coherence models.

It is important that the Deaves roughness transition model is for mean wind speeds and does not deal rigorously with the prediction of turbulence. In the ESDU Wind Engineering Data items curve-fitting methods are used to match measurements but, outside the range of measurements and in the absence of theory, discrepancies can become more important.

For codification in BS6399-2 and in the UK NA to EN1991-1-4:2005, NJ Cook followed a procedure from his book “The Designer’s Guide to Wind Loading of Building Structures: Part 1”, 1985, where the turbulence intensity near the ground was assumed to be the same as for a fully developed wind profile until the resulting gust speeds exceeded those of the less rough exposure preceding the roughness change. There are technical problems with this in that the matching depends on the gust peak factor used and that, while this was clearly conservative for smooth-to-rough surface transitions used for UK codification, this assumption is non-conservative for rough-to-smooth transitions. And there are systematic differences with the ESDU turbulence predictions referenced as an alternative to the code model in the code background document, PD6688-1-4.

The following is based on a concept the author gained from J. Wieringa that local properties of wind shear, u^*, and roughness length, z_0, can be height dependent. The improved model is the result of using this idea to find the simplest reasonable theoretical model of turbulence variation that also fits the Harris and Deaves model.

This note is primarily based hourly-mean windspeeds and statistics as used in the H+D and ESDU theory, but a proposal for practical code use of 10-minute means is included in the simplified wind model.

Compared to ESDU, the calculations have been also simplified by first removing effects of Coriolis from the reference speeds and adding them back after the fetch-dependent roughness calculations. This has no significant effect on the calculated wind pressures.

A simple theory-based ‘far-fetch’ correction is also proposed to replace the more empirical model of ESDU.

2.0 Background to Methodology

This section is intended as a limited summary of the simplified procedures. For more detailed background please read the original papers or the relevant ESDU Wind Engineering Data Items.

2.1 Log-Law profiles

The basic form of turbulent boundary layer development close to a surface, beyond a limited surface distance, is a logarithmic variation of wind speed associated with a relatively constant shear stress. This profile is characterised by a friction velocity, u^*, which is related to the shear stress as $\tau = \rho u^{*2}$ and a surface roughness length (boundary layer thickness scaling parameter), z_0.

For a height $z > 2.5\, z_0$ the velocity, v'_{mz}, without Coriolis, is given as

$$v'_{mz} = 2.5\, u^* \ln(z/z_0) \qquad (1)$$

2.2 Harris and Coriolis

The Harris ‘Strong-Wind’ model, e.g. with neutral atmospheric stability, has additional terms which provide for the increase of wind speed due to planetary spin (Coriolis) and describe the decay of the wind shear to zero at gradient height, the top of the atmospheric boundary layer.

The gradient height increases with friction velocity to one to two kilometres at typical EN and UK design wind speeds (50-year return) and latitudes. At more common speeds, gradient heights are lower and more likely to be affected by atmospheric stability.

The full Harris Coriolis equation can be simplified (see ESDU) so that for design-level winds up to about 500m, the correction may, a little conservatively, be described as an addition to the log-law wind speed of ‘$\sim z \sin|\lambda| /80$’. For UK latitudes (λ = 50 to 60°) this can be taken as $0.01z$ m/s. Note that this is independent of the reference speed and that the effects of latitude variations on design level windspeeds are small at the height of normal structures.

For the UK, the Coriolis effect can be removed from reference mean speeds e.g. at 10m height from UK and EN wind loading codes by subtracting 0.1 m/s (= 10 x 0.01) and subsequently restored by adding 0.01z m/s after the height and fetch adjustments.

2.3 Deaves and the Effect of Changes to Surface Roughness

When the ground roughness changes, a new wind shear condition immediately occurs at the surface depending on the new roughness length but the effect of this takes some time and distance to work its way through the full atmospheric boundary layer depth.

Deaves (see formula (2)) provides a ratio between the original and new values of friction velocity, u_1^* and u_X^* (respectively), which depends on the ratio of the surface roughnesses, z_{01} and z_0, and the upwind distance (fetch), X, of the new local roughness.

$$u_X^*/u_1^* = 1 - \frac{\ln(z_{01}/z_0)}{0.42 + \ln m_0} \tag{2}$$

$$\text{where} \qquad m_0 = \frac{0.32\, X/z_0}{\ln m_0 - 1} \tag{3}$$

Formula (3) is implicit but relatively easy to solve iteratively, and polynomial fits can also be used.

It is assumed that the mean windspeeds are the same at a matching height, z_X, where $v_{mz}(z_X) = 2.5\, u_X^* \ln(z_X/z_0) = 2.5 u_1^* \ln(z_X/z_{01})$, where the first part of this equation is used for heights up to z_X and the second part for greater heights.

While it might appear from the above that, z_X, is a function of fetch and both surface roughnesses, the effect of the upstream roughness, z_{01}, cancels within these equations so that the match height, z_X, depends on the site roughness length, z_0, and fetch, X, only.

2.4 Long-fetch correction

For long fetches, the Deaves model as above does not converge on the equilibrium result in a sufficiently rapid way. This appears to be associated with the relationship between the matching height, which increases with fetch, and the gradient height, and can be thought of as a filling process as the new turbulence remains trapped below the new gradient height.

A model has been developed by the author where the logarithm of the far-fetch surface roughness, z'_{01}, is adjusted as ratio of the matching height, z_{X}, divided by the twice equilibrium value of the gradient height. e.g.

$$\ln z_{01} = \ln z'_{01} + \ln(z_0/z'_{01}) \cdot \min(1, z_X/2z_{\mathrm{G}}) \tag{4}$$

The factor of two has been calibrated against the discrepancy in the Deaves model noted in ESDU 82026 – see Sketch A2.2. This correction has little effect on speeds for fetches of a few kilometres but becomes important after tens of kilometres.

Full convergence of mean speeds and turbulence is achieved after about 100 km in design level winds, compatible with the empirical ESDU model.

2.5 Wieringa and the Variation of Properties with Height

The physical impossibility of actually having two values of u^* (a step change in wind shear) just above and below the match height ought to be clear. At the match height $u^*(z_X) = u_1^*$ and must be associated with z_{01}. Similarly, at the surface ($z = 2.5\ z_0$) there are no options except $u^* = u_X^*$ and z_0.

What happens in between needed some additional thought. ESDU, Cook and others speculated on a region near the ground in full-equilibrium with the new roughness and proposed various fits in between, but with no consistent theory.

Following the suggestion of J. Wieringa, the use of height varying properties of u^* and z_0 was investigated by the author, with the following conclusions.

The best fit for $u^*(z)$ to achieve the Deaves variation of mean speeds with height is a linear variation with '$\ln z$' between the two values above and with the value of $\ln(z/z_0(z))$ adjusted as needed to achieve the Deaves predicted mean speeds. ('$\ln z_0(z)$' is approximately parabolic with '$\ln z$', but in practice an assumed fit is not needed.)

From first principles, the $u^*(z)$ relationship above can also be expected from consideration of wind shear stresses which also can only have discontinuities at the surface and at the limit of the developing new shear layer at z_X.

The effect of using the resulting $u^*(z)$ and $z_0(z)$ on turbulence properties has been investigated and gives a very reasonable match to ESDU both for smooth to rough and rough to smooth transitions, but eliminates the clearly artificial variations resulting from the ESDU use of arbitrary sinusoidal curve-fit transitions.

A procedure for a single fetch transition is given below.

3.0 Practical procedure for a single fetch change

The nomenclature below largely follows EN1991-1-4 and/or ESDU and Cook but may vary depending on the specific needs.

a) Calculate basic constants.

i) The Coriolis frequency, f_c, may be taken as 1.15 x 10^{-4} for the UK, or calculated from the latitude, λ, as 1.454 x 10^{-4} $\sin\lambda$.

ii) The hourly-mean reference windspeed, v_r (e.g. at 10m height in open country exposure) is $v_b/1.06$, where the basic 10-min mean windspeed, v_b, is from the UK NA to EN1991-1-4.

iii) The reference friction velocity u_r^* is calculated as

$$u_r^* = \frac{(v_r - 0.1)}{2.5\ \ln(10/z_{0r})}$$

z_{0r} may be varied but is taken as 0.03m in the UK.

NB The Coriolis correction of 0.1 m/s is good for the whole of the UK but may be replaced by $(10 \sin|\lambda|/80)$ for latitudes different from $\sim 52°$.

iv) The friction velocity, u^*, for converged equilibrium conditions may be calculated using site roughness length z_0 as

$$u^* = \frac{u_r^* \ln(10^5/z_{0r})}{\ln(10^5/z_0)} \text{ (from ESDU 82026)}$$

v) The fully converged gradient height, z_G, is calculated as

$$z_G = u^*/\ 6f_c$$

b) **Solve the implicit equation**

$$m_0 = \frac{0.32\ X/z_0}{\ln m_0 - 1}$$

A cubic solution is provided below in the form of the Divisor $= 0.42 + \ln m_0$ which eases further calculation. (e.g. See formula (2) above and c) below.)

$$\text{Divisor} = \left[\left(\left(-0.000944 \ln\left(\frac{X}{z_0}\right) + 0.039\right) \ln\left(\frac{X}{z_0}\right) + 0.366\right) \ln\left(\frac{X}{z_0}\right) + 0.8545\right]$$

NB ESDU provides a similar quadratic solution which is slightly less accurate for low values of X. Iterative solutions are also practical.

c) Calculate the match height, z_X

$$z_X = z_0\ e^{Divisor}$$

NB This is a function of X and z_0 only.

d) Correct the far-field roughness length, z'_{01} for long-fetch effects

$$\ln z_{01} = \ln z'_{01} + \ln(z_0/z'_{01}) \cdot \min(1, z_{\mathrm{X}}/2z_{\mathrm{G}})$$

e) Calculate the corrected u_1^* as

$$u_1^* = \frac{u_r^* \ln(10^5/z_{0r})}{\ln(10^5/z_{01})}$$

f) Calculate u_X^*

$$u_X^* = u_1^* \left(1 - \frac{\ln(z_{01}/z_0)}{\text{Divisor}}\right)$$

g) Calculate v'_{mz} and v_{mz}

For heights below z_X use

$$v'_{mz} = 2.5\, u_X^* \ln(z/z_0)$$

Above z_X use

$$v'_{mz} = 2.5\, u_1^* \ln(z/z_{01})$$

Apply the Coriolis correction

$$v_{mz} = v'_{mz} + 0.01z$$

NB The 0.01 may be replaced by (sin $|\lambda|$ /80) for latitudes different from ~52°.

h) Calculate $u^*(z)$ for heights below z_X as

$$u^*(z) = u_X^* + (u_1^* - u_X^*) \ln(0.4\, z/z_0) \,/\, \ln(0.4\, z_X/z_0)$$

For heights above z_X use

$$u^*(z) = u_1^*$$

i) Calculate $z_0(z)$ for heights below z_X using

$$\ln(z/z_0(z)) = 0.4\, v'_{mz}/u^*(z)$$

NB Use v'_{mz} in this equation – not the Coriolis corrected speed.

For heights above z_X use

$$z_0(z) = z_{01}$$

j) Calculate turbulence velocities, u_z as

$$u_z = \frac{7.5u^*(z)}{1 + 0.156 \ln(u^*(z)/(f_c\, z_0(z)))} \cdot (1 - 6zf_c/u^*(z)) \cdot \left(0.538 + 0.09 \ln\left(\frac{z}{z_o(z)}\right)\right)^{\left[(1-6zf_c/u^*(z))^{16}\right]}$$

$$\text{where } f_c = \frac{\pi \sin|Lat|}{21600} = 1.15 \cdot 10^{-4} \text{ for } Lat \approx 52° \text{ (UK)}$$

NB The formula above avoids use of a variable 'gradient height', which is replaced by $u^*(z)/6f_c$.

k) Calculate turbulence intensity, I_{uz}, as

$$I_{uz} = u_z/v_{mz}$$

l) Calculate gust speed, v_{pz}, as

$$v_{pz} = v_{mz}(1 + 3.5 I_{uz})$$

NB The peak factor of 3.5 is the expected value in one-hour using an 0.8 second time average. 3.0 is the corresponding value in 10-minutes.

m) Calculate 10-minute mean speeds, $v_{mz,10min}$, as

$$v_{mz,10min} = v_{pz}/(1 + 3I_{uz})$$

NB This simplification keeps the 10-minute-mean and hourly-mean turbulence intensity the same, whereas a small reduction might be expected. The peak gust speeds are not different in the two models, as is intended for UK use.

4.0 Multiple Roughness Changes

Deaves original paper does not cover multiple roughness changes. While it is practical to adapt the model above using techniques similarly used by ESDU, the procedures require additional steps and an iterative solution which are beyond the intention of this note. But a simplified code approach for two changes is provided below.

The UK NA to EN1991-1-4: Wind Actions:2026 has rules for changes from sea to country to urban terrain as in BS6399-2 and the 2005 EN.

Wind pressures (gust and mean) are precalculated for each relevant height based on single roughness changes as below, where X_s is the upwind distance from site to sea/water and X_c is the upwind distance to country from an urban site.

$q_{sc}(X_s)$ for Sea to Country ($z_{01} = 0.003$m to $z_0 = 0.03$m),

$q_{cu}(X_c)$ for Country to Urban ($z_{01} = 0.03$m to $z_0 = 0.3$m) and

$q_{su}(X_s)$ for Sea to Urban ($z_{01} = 0.003$m to $z_0 = 0.3$m).

The resulting pressure for a sea-country-urban transition is then calculated in a similar way to previously as

$$q_{scu} = \left(\frac{q_{cu}(X_c)}{q_{cu}(0)}\right) \cdot q_{sc}(X_s) \text{ but } \geq q_{su}(X_s) \tag{5}$$

The first term here represents the effect of urban terrain on a fully developed country wind profile, $q_{cu}(0)$, and the second includes the effect of proximity to sea on the country wind profile. The condition at the end is necessary when the extent of country fetch, $(X_s - X_c)$, is small, in which case the sea to urban transition may be more onerous and should be used.

NB It is necessary to use X_s for the check above, but, when $q_{su}(X_s)$ is larger, consider also the use of the more onerous values obtained using $q_{su}(X_c)$.

5.0 Conclusions

The above represents an improvement and simplification of the Harris and Deaves model given in the ESDU Wind Engineering Data Items, based on applying a concept introduced to the author by J. Wieringa of height varying friction velocity and roughness length.

The results have been compared with ESDU calculations and with previous UK codified models from BS6399-2 and the UK NA to EN1991-1-4:2005, and while there are no very major changes, the model is clearly an improvement on the Cook model, taking it closer to ESDU, and it eliminates the random effect of the sinusoidal fits used by ESDU.

Other wind turbulence properties in the lateral and vertical directions, including spectra, can be derived using the ESDU Wind Engineering models, using the new local values of friction velocity, $u^*(z)$, and roughness length, $z_0(z)$. This is not discussed further here.

The correction to 10-minute mean speeds given in procedure ‘3m)’ above is pragmatic rather than theoretical but better represents the turbulence intensity dependency of the ratio of 10-minute mean speeds (i.e. the expected maximum of 6 no. 10-minute average measurements per hour) to hourly-mean speeds. The constant 1.06 factor used in the UK NA:2006 is valid for a turbulence intensity of about 18% as expected in a standard open country reference conditions with a surface roughness length of 0.03m.

The author has investigated the other alternative models for estimation of 10-minute mean speeds but these cause practical and theoretical complications for at least one of the other variables or result in systematic variations of peak gust pressure with turbulence intensity compared to the hourly-mean calculation.

It is intended that the simplified model above is published in PD6688-1-4:2026.

The basic single roughness change model has been implemented as a single page spreadsheet with input and calculations as provided in Annex A below.

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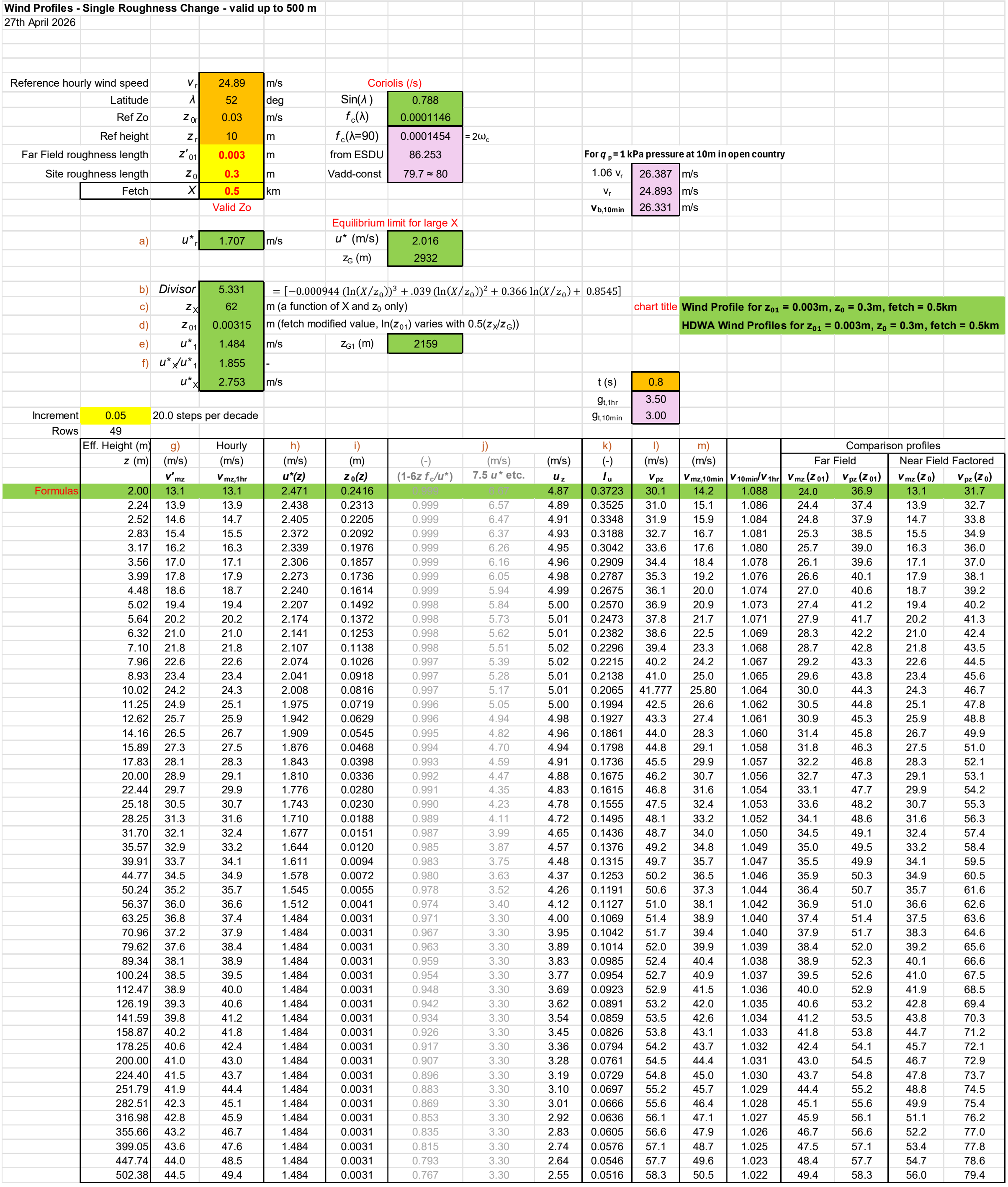
Annex A – Spreadsheet Example Layout for HDWA Single Fetch Transition

See figures A1 and A2 for an example of how to implement these calculations.

Figure A1 is an indicative spreadsheet layout used by the author to perform the calculations according to section 3.0 above. No macros are needed for the base calculations but, for reliability, these are recommended for the turbulence velocity calculation in section 3j).



Wind Profiles - Single Roughness Change - valid up to 500 m

27th April 2026

Reference hourly wind speed	v_r	24.89	m/s	Coriolis (/s)					
Latitude	λ	52	deg	Sin(λ)	0.788				
Ref Zo	z_{0r}	0.03	m/s	$f_c(\lambda)$	0.0001146				
Ref height	z_r	10	m	$f_c(\lambda=90)$	0.0001454	= 2ω$_c$			
Far Field roughness length	z'_{01}	0.003	m	from ESDU	86.253		For q_p = 1 kPa pressure at 10m in open country		
Site roughness length	z_0	0.3	m	Vadd-const	79.7 ≈ 80		1.06 v_r	26.387	m/s
Fetch	X	0.5	km				v_r	24.893	m/s
		Valid Zo					$v_{b,10min}$	26.331	m/s
				Equilibrium limit for large X					
a)	u^*_r	1.707	m/s	u^* (m/s)	2.016				
				z_G (m)	2932				

b) *Divisor* 5.331 $= [-0.000944\,(\ln(X/z_0))^3 + .039\,(\ln(X/z_0))^2 + 0.366\,\ln(X/z_0) + \;0.8545]$

c) z_X 62 m (a function of X and z_0 only)

d) z_{01} 0.00315 m (fetch modified value, ln(z_{01}) varies with 0.5(z_X/z_G))

e) u^*_1 1.484 m/s z_{G1} (m) 2159

f) u^*_X/u^*_1 1.855 -

u^*_X 2.753 m/s

chart title **Wind Profile for z_{01} = 0.003m, z_0 = 0.3m, fetch = 0.5km**

HDWA Wind Profiles for z_{01} = 0.003m, z_0 = 0.3m, fetch = 0.5km

t (s) 0.8

$g_{t,1hr}$ 3.50

$g_{t,10min}$ 3.00

Increment 0.05 20.0 steps per decade

Rows 49

	Eff. Height (m)	g)	Hourly	h)	i)		j)		k)	l)	m)		Comparison profiles			
	z (m)	(m/s)	(m/s)	(m/s)	(m)	(-)	(m/s)	(m/s)	(-)	(m/s)	(m/s)		Far Field		Near Field Factored	
		v'_{mz}	$v_{mz,1hr}$	$u^*(z)$	$z_0(z)$	(1-6z f_c/u^*)	7.5 u^* etc.	u_z	I_u	v_{pz}	$v_{mz,10min}$	v_{10min}/v_{1hr}	$v_{mz}(z_{01})$	$v_{pz}(z_{01})$	$v_{mz}(z_0)$	$v_{pz}(z_0)$
Formulas	2.00	13.1	13.1	2.471	0.2416	0.999	6.67	4.87	0.3723	30.1	14.2	1.088	24.0	36.9	13.1	31.7
	2.24	13.9	13.9	2.438	0.2313	0.999	6.57	4.89	0.3525	31.0	15.1	1.086	24.4	37.4	13.9	32.7
	2.52	14.6	14.7	2.405	0.2205	0.999	6.47	4.91	0.3348	31.9	15.9	1.084	24.8	37.9	14.7	33.8
	2.83	15.4	15.5	2.372	0.2092	0.999	6.37	4.93	0.3188	32.7	16.7	1.081	25.3	38.5	15.5	34.9
	3.17	16.2	16.3	2.339	0.1976	0.999	6.26	4.95	0.3042	33.6	17.6	1.080	25.7	39.0	16.3	36.0
	3.56	17.0	17.1	2.306	0.1857	0.999	6.16	4.96	0.2909	34.4	18.4	1.078	26.1	39.6	17.1	37.0
	3.99	17.8	17.9	2.273	0.1736	0.999	6.05	4.98	0.2787	35.3	19.2	1.076	26.6	40.1	17.9	38.1
	4.48	18.6	18.7	2.240	0.1614	0.999	5.94	4.99	0.2675	36.1	20.0	1.074	27.0	40.6	18.7	39.2
	5.02	19.4	19.4	2.207	0.1492	0.998	5.84	5.00	0.2570	36.9	20.9	1.073	27.4	41.2	19.4	40.2
	5.64	20.2	20.2	2.174	0.1372	0.998	5.73	5.01	0.2473	37.8	21.7	1.071	27.9	41.7	20.2	41.3
	6.32	21.0	21.0	2.141	0.1253	0.998	5.62	5.01	0.2382	38.6	22.5	1.069	28.3	42.2	21.0	42.4
	7.10	21.8	21.8	2.107	0.1138	0.998	5.51	5.02	0.2296	39.4	23.3	1.068	28.7	42.8	21.8	43.5
	7.96	22.6	22.6	2.074	0.1026	0.997	5.39	5.02	0.2215	40.2	24.2	1.067	29.2	43.3	22.6	44.5
	8.93	23.4	23.4	2.041	0.0918	0.997	5.28	5.01	0.2138	41.0	25.0	1.065	29.6	43.8	23.4	45.6
	10.02	24.2	24.3	2.008	0.0816	0.997	5.17	5.01	0.2065	41.777	25.80	1.064	30.0	44.3	24.3	46.7
	11.25	24.9	25.1	1.975	0.0719	0.996	5.05	5.00	0.1994	42.5	26.6	1.062	30.5	44.8	25.1	47.8
	12.62	25.7	25.9	1.942	0.0629	0.996	4.94	4.98	0.1927	43.3	27.4	1.061	30.9	45.3	25.9	48.8
	14.16	26.5	26.7	1.909	0.0545	0.995	4.82	4.96	0.1861	44.0	28.3	1.060	31.4	45.8	26.7	49.9
	15.89	27.3	27.5	1.876	0.0468	0.994	4.70	4.94	0.1798	44.8	29.1	1.058	31.8	46.3	27.5	51.0
	17.83	28.1	28.3	1.843	0.0398	0.993	4.59	4.91	0.1736	45.5	29.9	1.057	32.2	46.8	28.3	52.1
	20.00	28.9	29.1	1.810	0.0336	0.992	4.47	4.88	0.1675	46.2	30.7	1.056	32.7	47.3	29.1	53.1
	22.44	29.7	29.9	1.776	0.0280	0.991	4.35	4.83	0.1615	46.8	31.6	1.054	33.1	47.7	29.9	54.2
	25.18	30.5	30.7	1.743	0.0230	0.990	4.23	4.78	0.1555	47.5	32.4	1.053	33.6	48.2	30.7	55.3
	28.25	31.3	31.6	1.710	0.0188	0.989	4.11	4.72	0.1495	48.1	33.2	1.052	34.1	48.6	31.6	56.3
	31.70	32.1	32.4	1.677	0.0151	0.987	3.99	4.65	0.1436	48.7	34.0	1.050	34.5	49.1	32.4	57.4
	35.57	32.9	33.2	1.644	0.0120	0.985	3.87	4.57	0.1376	49.2	34.8	1.049	35.0	49.5	33.2	58.4
	39.91	33.7	34.1	1.611	0.0094	0.983	3.75	4.48	0.1315	49.7	35.7	1.047	35.5	49.9	34.1	59.5
	44.77	34.5	34.9	1.578	0.0072	0.980	3.63	4.37	0.1253	50.2	36.5	1.046	35.9	50.3	34.9	60.5
	50.24	35.2	35.7	1.545	0.0055	0.978	3.52	4.26	0.1191	50.6	37.3	1.044	36.4	50.7	35.7	61.6
	56.37	36.0	36.6	1.512	0.0041	0.974	3.40	4.12	0.1127	51.0	38.1	1.042	36.9	51.0	36.6	62.6
	63.25	36.8	37.4	1.484	0.0031	0.971	3.30	4.00	0.1069	51.4	38.9	1.040	37.4	51.4	37.5	63.6
	70.96	37.2	37.9	1.484	0.0031	0.967	3.30	3.95	0.1042	51.7	39.4	1.040	37.9	51.7	38.3	64.6
	79.62	37.6	38.4	1.484	0.0031	0.963	3.30	3.89	0.1014	52.0	39.9	1.039	38.4	52.0	39.2	65.6
	89.34	38.1	38.9	1.484	0.0031	0.959	3.30	3.83	0.0985	52.4	40.4	1.038	38.9	52.3	40.1	66.6
	100.24	38.5	39.5	1.484	0.0031	0.954	3.30	3.77	0.0954	52.7	40.9	1.037	39.5	52.6	41.0	67.5
	112.47	38.9	40.0	1.484	0.0031	0.948	3.30	3.69	0.0923	52.9	41.5	1.036	40.0	52.9	41.9	68.5
	126.19	39.3	40.6	1.484	0.0031	0.942	3.30	3.62	0.0891	53.2	42.0	1.035	40.6	53.2	42.8	69.4
	141.59	39.8	41.2	1.484	0.0031	0.934	3.30	3.54	0.0859	53.5	42.6	1.034	41.2	53.5	43.8	70.3
	158.87	40.2	41.8	1.484	0.0031	0.926	3.30	3.45	0.0826	53.8	43.1	1.033	41.8	53.8	44.7	71.2
	178.25	40.6	42.4	1.484	0.0031	0.917	3.30	3.36	0.0794	54.2	43.7	1.032	42.4	54.1	45.7	72.1
	200.00	41.0	43.0	1.484	0.0031	0.907	3.30	3.28	0.0761	54.5	44.4	1.031	43.0	54.5	46.7	72.9
	224.40	41.5	43.7	1.484	0.0031	0.896	3.30	3.19	0.0729	54.8	45.0	1.030	43.7	54.8	47.8	73.7
	251.79	41.9	44.4	1.484	0.0031	0.883	3.30	3.10	0.0697	55.2	45.7	1.029	44.4	55.2	48.8	74.5
	282.51	42.3	45.1	1.484	0.0031	0.869	3.30	3.01	0.0666	55.6	46.4	1.028	45.1	55.6	49.9	75.4
	316.98	42.8	45.9	1.484	0.0031	0.853	3.30	2.92	0.0636	56.1	47.1	1.027	45.9	56.1	51.1	76.2
	355.66	43.2	46.7	1.484	0.0031	0.835	3.30	2.83	0.0605	56.6	47.9	1.026	46.7	56.6	52.2	77.0
	399.05	43.6	47.6	1.484	0.0031	0.815	3.30	2.74	0.0576	57.1	48.7	1.025	47.5	57.1	53.4	77.8
	447.74	44.0	48.5	1.484	0.0031	0.793	3.30	2.64	0.0546	57.7	49.6	1.023	48.4	57.7	54.7	78.6
	502.38	44.5	49.4	1.484	0.0031	0.767	3.30	2.55	0.0516	58.3	50.5	1.022	49.4	58.3	56.0	79.4

Figure A1 A practical spreadsheet calculation layout

A graph comparing the detailed calculations of a particular case (see graph heading and figure A1) with those of the limiting equilibrium cases is included as figure A2.

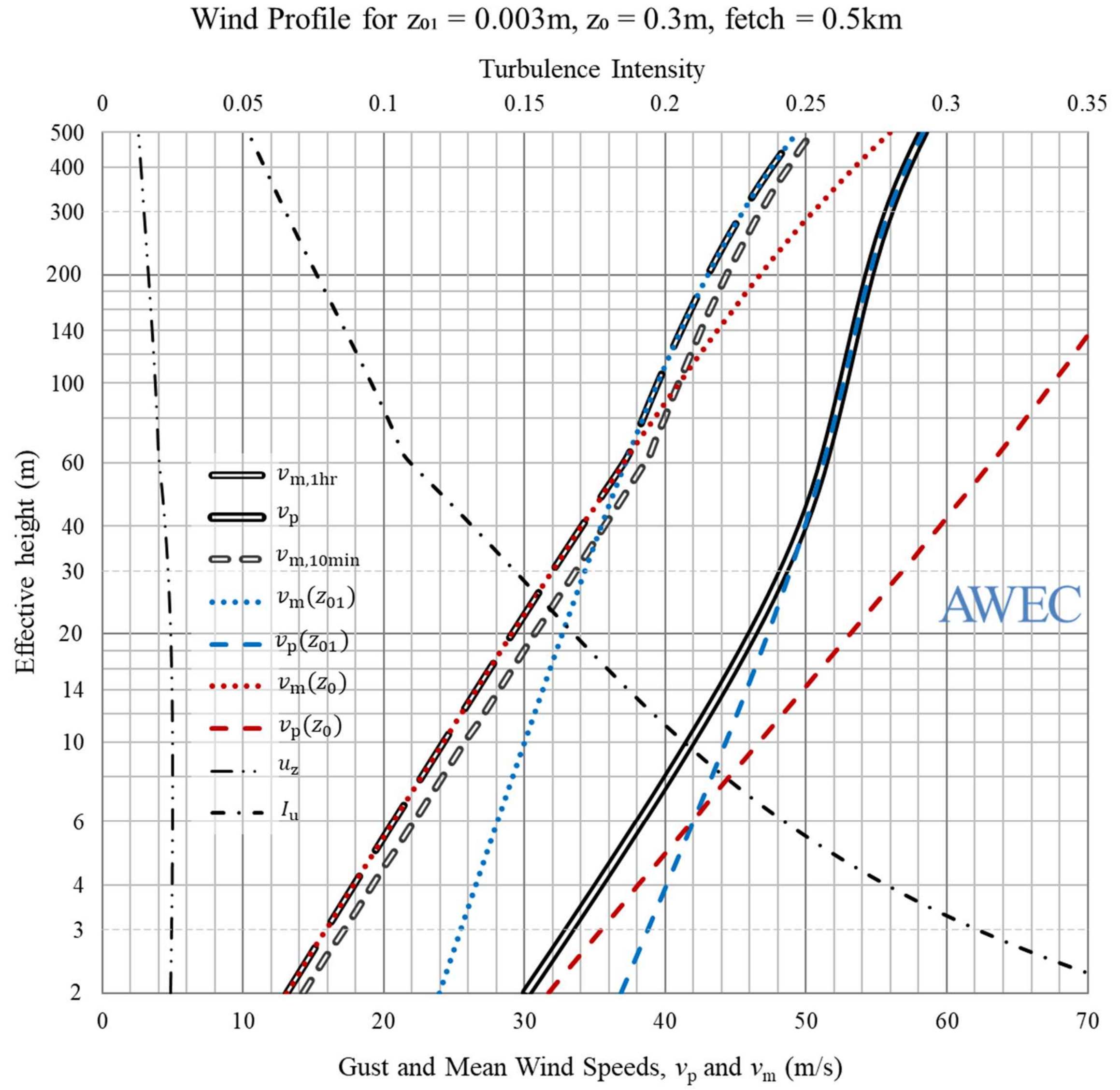


Figure A2 Graph of Calculated Windspeeds v. Height

The graph shows mean and peak gust speeds compatible with the UK NA to EN1991-1-4, including the proposed 10-min-mean profile, $v_{\mathrm{mz,10min}}$. Additional curves (in blue and red) show the corresponding factored equilibrium wind profiles and (in black) the turbulence intensity and turbulence velocity for the non-equilibrium case.