Foundation Options for Medium to Large Wind Turbine Mono-pole Towers

Prepared by Miller Engineers & Scientists

Foundations for wind turbines on mono-pole towers incur large overturning moment due to wind, but relatively small vertical load. **The most economical foundation proportions that will counteract tower overturning with adequate safety factor and limit the base motion depends on the structure-specific soil/rock and groundwater conditions, as well as costs of various materials, labor, and equipment** for each type of foundation system. This chart summarizes several types of foundation systems that are generally expected to be practical. It is not a substitute for specific engineering analysis, but my be a useful guideline indicating which types of foundations might be evaluated for any particular location. **All foundations for substantial towers require location-specific analysis and design for reliability and economy**.

			1	2	3	4	5	6	7	8	9	10
		IBC Classification	A - B	C	C	D	D - E	D - E	E	E - F	F	F
Relative Cost I= Least III = Most	**Foundation Types**	**Subsurface Conditions**	**Competent Rock**	**Weathered Rock & Conglomerate**	**Dense Gravel**	**Dense Sand & Hard Clay**	**Medium Dense Sand & Very Stiff Clay**	**Loose Sand & Stiff Clay**	**Medium Clay**	**Very Loose Sand & Silt, Soft Clay, Peat Overlying Firm Stratum**	**Deep, Soft Sediment**	**"Sensitive", Collapsible Soils or Sites w/Liquification Potential**
		SPT (N)	N/A	≥ 50	≥ 50	≥ 30	10 - 30	4 - 10	4 - 8	≤ 4	≤ 4	Varies
I	a **SMALL RING FOUNDATION**, with drilled and grouted, post-tensioned anchors										Look for other location with better soil conditions.	Look for other location with better soil conditions.
II*	b **SMALL MAT** with drilled piers, pipe piles, or "Frankie" (gravel compaction columns), all with post-tensioned anchors											
	c **POST-TENSIONED AGGREGATE BASE** (P-TAB by Miller)											
	d **DEEP CYLINDER** (includes "tensionless tube" by Patrick & Henderson)			**But not with shallow water table**		Not Sand		Not Sand				
	e **MEDIUM SIZE MAT** with drilled and grouted, post-tensioned anchors											
III*	f **LARGE MAT**											
	g **MEDIUM SIZE MAT** with drilled piers, pipe piles, or "Frankie" (gravel compaction columns), all with tension ties											
	h **VERY LARGE WAFFLE MAT** with GEOFOAM-formed voids									** (See Note)	** (See Note)	

* The cost of any particular option for a specific location may be more or less in relation to any other option within this group. Cost analysis of site-specific, derived proportions for each candidate option is recommended to determine the most economical foundation system and proportions for any tower at any particular location. Unit costs for each component of all foundation systems vary with local prices of materials and labor, as well as with site access and ground conditions.

** Preferably, look for location with better soil conditions.

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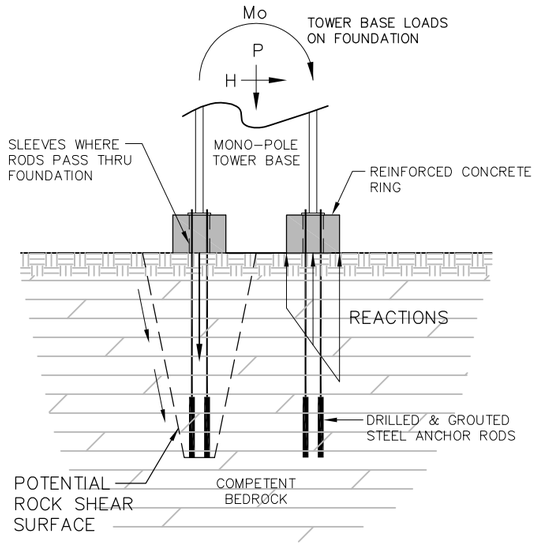
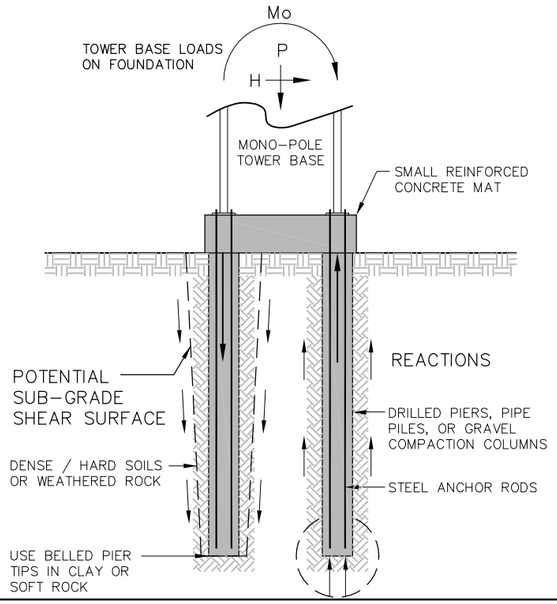
a SMALL RING FOUNDATION, post tensioned with drilled and grouted anchors in competent bedrock

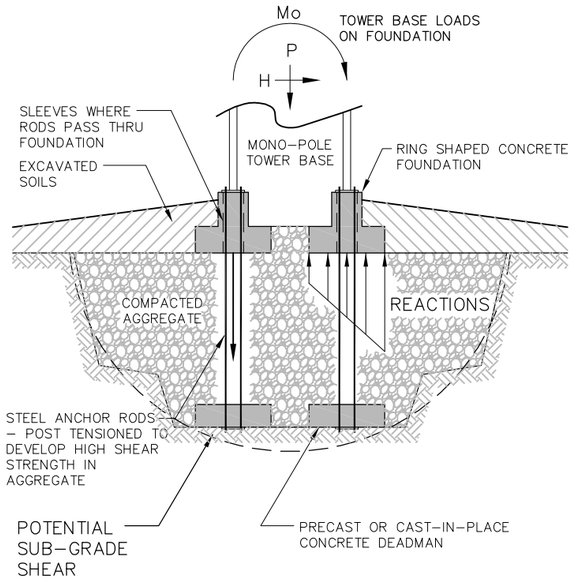


b SMALL MAT with drilled piers, pipe piles, or "Frankie" (gravel compaction) columns, all with tension ties in dense / hard soils or weathered rock

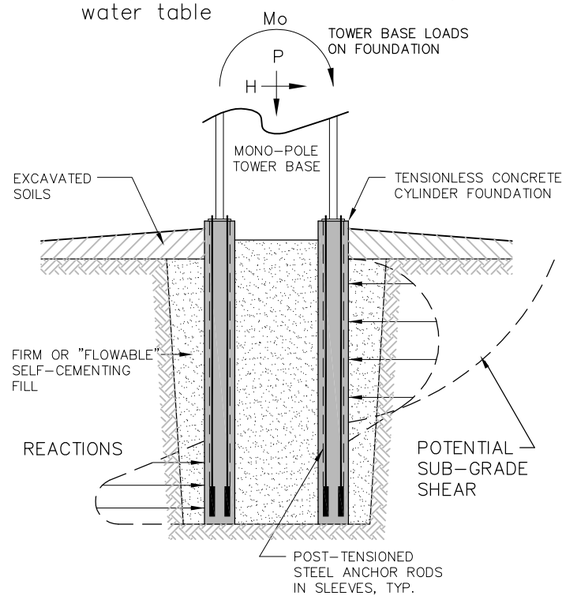


c POST-TENSIONED AGGREGATE BASE in wide range of soil conditions

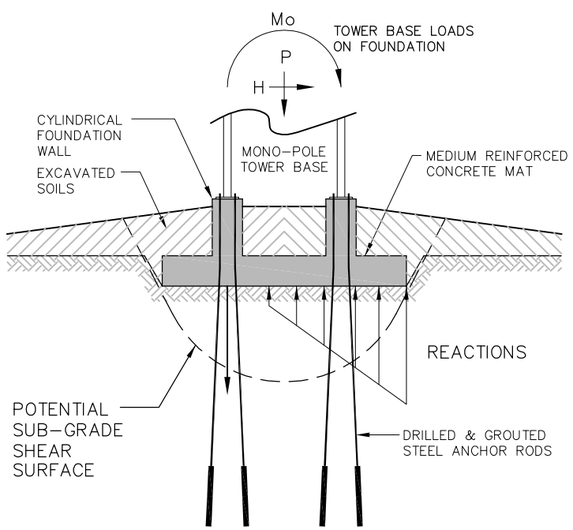
TM (pending)



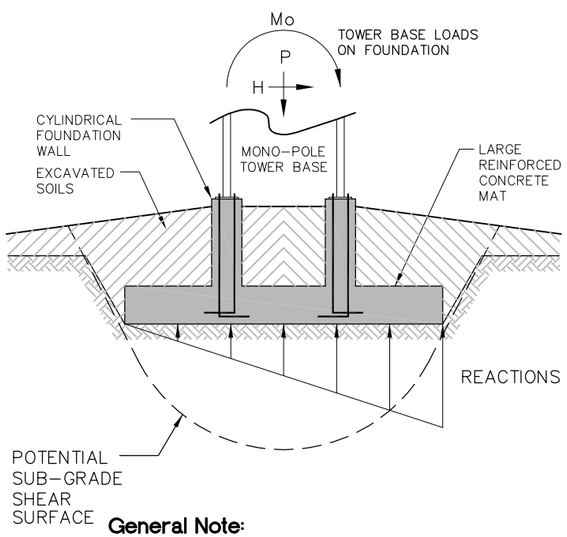
d "TENSIONLESS TUBE" – Patrick & Henderson (post-tensioned concrete cylinder) in firm soils that support steep excavation and have deep water table



e MEDIUM SIZE MAT with drilled and grouted anchors in firm soils

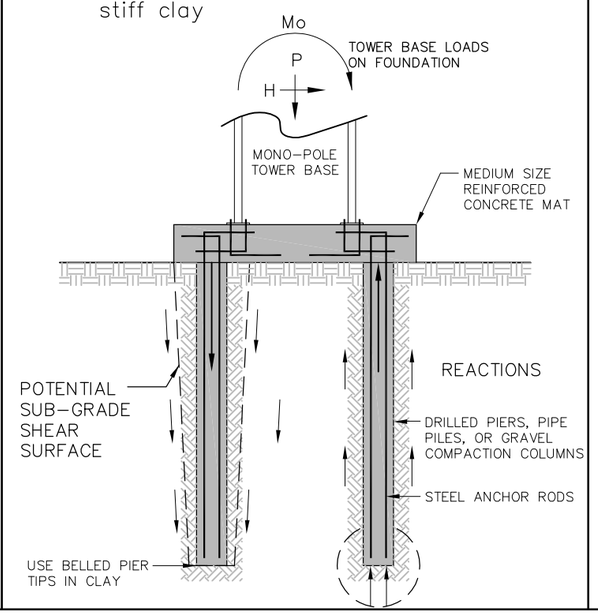


f LARGE MAT

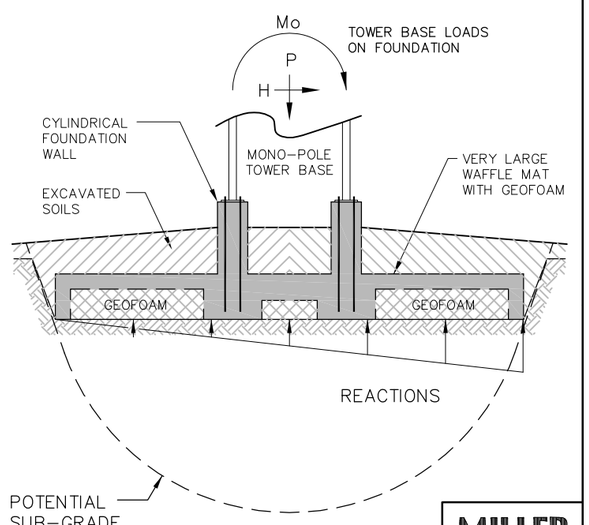


General Note:
Structural reinforcing steel in concrete foundations is not shown in any of these conceptual diagrams.

g MEDIUM MAT with drilled piers, pipe piles, or "Frankie" (gravel compaction) columns, all with tension ties in medium density sand or medium to stiff clay



h VERY LARGE WAFFLE MAT WITH GEOFOAM over deep soft or loose soils



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