CHAPTER 5
HIGH CAPACITY TENSIONED ROCK ANCHORS

5-1. General. High strength and long length cable and rod type bolts have been used in a number of cases to solve special rock reinforcement problems. Many patented systems have been allowed by specifications generally to encourage competitive bidding. The designer specifies only the hole length and orientation and the amount of effective confining force required. Table 5-1 lists some sources and sizes of available systems which have been used for rock reinforcement. Systems are made up of wires, strands, or rods. High strength reinforcement systems all have three basic features: (1) an anchoring device, (2) a tensioning device, and (3) a tendon or bar connecting these two together. The available systems differ mainly in the gripping or holding mechanisms, which are patented.

5-2. Anchorage. The use of grouted anchorages is universal with high strength systems. Several systems use a spreader plate on the end of wire, strand, or bars, although stranded cables have been installed effectively without spreader plates. The grouted anchorage should be capable of withstanding the force of the connecting element at the ultimate load of the steel. The length of grouted anchorages may be 30 feet or more depending upon local rock conditions, capacity of the anchor, and the drill hole diameter. Generally, a grout length is arbitrarily selected and proof-tested. If excess anchor slip occurs, the length of anchorage is increased.

5-3. Types of Tensioning Devices.

a. General. Tensioning of high capacity reinforcement systems is accomplished using hydraulic jacks. The transfer of the load from the connecting element to the bearing plate is accomplished by three methods: button heads, wedge grip, and threads.

b. Button Heads. The wire systems listed in table 5-1 use the cold-formed button head for load transfer. The head is formed after the wire passes separately through a machined plate. Shims are placed between the machined plate and the bearing plate. One system also has a lock nut which is threaded on the machined plate. Button heads are considered to be positive transfer mechanisms.

c. Wedge Grips. All strand systems listed in table 5-1 use wedge-grip devices for load transfer. These devices grip the strand in a machined plate (either individually or in groups) and the machine plate bears against the bearing plate. Some load elongation loss occurs while setting the grips but can be compensated for when tensioning.

Table 5-1. High Capacity Rock Anchor Systems

Type of Anchor System	Name	Ultimate Stress, ksi	Nominal Diam in.	No. of Wires	No. of Strands	Surface Condition	Max Eff Force 0.60 f's K	Tension Load Transfer Mechanism	Anchorage
Wire	BBRV	240	0.25	8-52	--	--	56.6-367.6	Button heads	Spreader plate and grout, plus button heads
		240	0.25	2-43	--	--	14.1-304.0	Button heads	Spreader plate and grout, plus button heads
	Soil and rock assemblies	240	0.25	18-108	--	-- 763.6	127.3-	Button heads plus button heads	Spreader plate and grout,
Strand	Con a (Single) in Ryco (Mult)	270	0.50	--	1-48	-- 1189.5	24.8-	Wedge grip plus wedge grip	Spreader plate and grout,
	Stressteel	270	0.50	--	1	--	24.8	Extrusion	Spreader plate and grout,
	SEEE		0.60	--	1-12	-- 388.8	32.4-	Wedge grip grip	plus extrusion wedge
	Stressteel S/H wedge	270	0.50	--	3-54	-- 1338.0	74.3-	Wedge grip plus wedge grip	Spreader plate and grout
	Monostrand rock anchors	270	0.50	--	1	--	25	Wedge grip	Grout only
			0.60	--	1	--	35		
			0.70	--	1	--	52		
	Rock and soil anchors	270	0.50	--	1-52	-- 1288.9	24.8-	Wedge grip plus diverging and converging of strands	Spreader plate and grout, con-
Bar	Dywidag	150	0.625	--	--	Deformed	26.1	Thread type deformation and nut	Grouted, plus anchor ring
			1.250	--	--	116.6			
		160	0.625	--	--	Deformed	27.8		
			1.250	--	--	124.3			
	Stressteel Bay System	145	0.750	--	--	Smooth	39	Wedge, thread wedge or threaded	Grouted, plus
			1.375	--	--	129	and nut (tapered), Howlett Grip nut		plate
		160	0.750	--	--	Smooth	42		
			1.375	--	--	143			
	Hollow Groutable	--	2.000	--	--	Deformed	120	Thread and nut	Expansion
	Solid bar Rock bolts	--	2.000	--	--	Smooth			
	Solid bar		1.875	--	--	Smooth			

d. Threads. Each bar system listed in table 5-1 uses a different thread holding mechanism. The Dywidag Bar System uses threads which are formed as deformations on the rod. Stress Steel Bar Systems use wedge, tapered thread and nut, and grip nut and sleeve holding mechanisms. The Williams Bar System uses a system similar to that used with their No. 8 and 11 rock bolts.

5-4. Types of Connecting Elements. The connecting elements which connect the anchorage to the tensioning device are classified as wires, strands, or rods. The systems listed in table 5-1 are arranged by connecting elements and each is a complete system (patented).

5-5. Tentative Recommendations. "Tentative Recommendations for Prestressed Rock and Soil Anchors," prepared by an ad hoc committee of the Prestressed Concrete Institute's Post-Tensioning Committee, is presented as Appendix E of this manual.