

Multistrand Post-Tensioning



tlink M7, Sydney, Australia



Ballina Bypass, Australia



PT Strands, Australia

Since 1954, designers and constructors of bridges, buildings and civil engineering worldwide over have relied on the VSL Multistrand post-tensioning system. These conventional uses of post-tensioning have been augmented by numerous applications of the system to projects such as stayed structures, offshore platforms, towers, tanks, silos, nuclear power plants, underground and submerged structures.

Patented in 36 countries, the VSL strand system complies in all respects with the Recommendations for the Acceptance and Application of Post-Tensioning Systems of the Fédération Internationale de la Précontrainte (FIP) and is approved in every country where the use of post-tensioning systems is subject to an official authorisation.

The VSL Multistrand system comprises from three to fifty-five strands (either 12.7 or 15.2mm diameter), round duct and anchorages. Prestressing force is applied to the tendons after the casting and curing of surrounding concrete. All strands are stressed simultaneously using a hydraulic jack and are fastened at the live end by wedge grips. The free space inside the duct is then pressure-filled with cement grout.

A number of features are incorporated as a result of many years of experience in the field:

- stressing carried out in any number of stages;
- accurate control of prestress force;
- No need to determine tendon length in advance;
- simultaneous stressing of all strands in a tendon, with individual locking of each strand at the anchorage point;

VSL stressing equipment is easily operated to ensure a safe and rapid stressing procedures. Special emphasis has been placed on rationalised manufacturing of equipment and anchorage parts as well as efficient work site practice.



Waiwera Viaduct, New Zealand

STRAND PROPERTIES - TO AS 4672

Nominal Diameter	Nominal Steel Area	Nominal Mass	Minimum Breaking Load	Minimum Proof Load (0.2% Offset)	Min. Elong. to Fracture in 600mm	Relaxation After 1,000hrs at 0.8 Breaking Load	Modulus of Elasticity
(mm)	(mm ²)	(kg/m)	(kN)	(kN)	(%)	(%)	(MPa)
12.7 Super	100.1	0.786	184	156.4	3.5	2.5	180-205
15.2 Super	143.3	1.125	250	212.5	3.5	2.5	x10 ³
15.2 EHT	143.3	1.125	261	221.9	3.5	2.5	

TENDON PROPERTIES

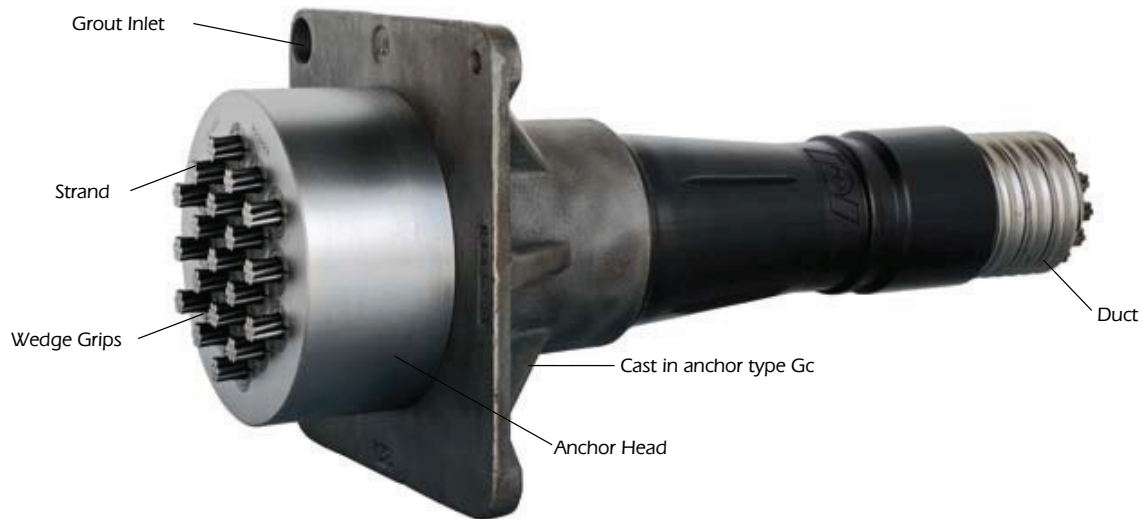
Strand Type 12.7mm Super			
Tendon Unit	No. of strands	Minimum Breaking Load (kN)	Steel Duct. Internal Diameter (mm)
5-4	2	368	40
	3	552	40
	4	736	40
5-7	5	920	50
	6	1100	50
	7	1290	50
5-12	8	1470	70
	9	1660	70
	10	1840	70
	11	2020	70
	12	2210	70
5-19	13	2390	85
	14	2580	85
	15	2760	85
	16	2940	85
	17	3130	85
	18	3310	85
	19	3500	85
5-22	20	3680	90
	21	3860	90
	22	4050	90
5-27	23	4230	95
	24	4420	95
	25	4600	95
	26	4780	95
	27	4970	95
5-31	28	5150	105
	29	5340	105
	30	5520	105
	31	5700	105
5-37	32	5890	115
	33	6070	115
	34	6260	115
	35	6440	115
	36	6620	115
	37	6810	115
5-42	38	6990	120
	39	7180	120
	40	7360	120
	41	7540	120
	42	7730	120
5-48	43	7910	130
	44	8100	130
	45	8280	130
	46	8460	130
	47	8650	130
	48	8830	130
5-55	49	9020	135
	50	9200	135
	51	9380	135
	52	9570	135
	53	9750	135
	54	9940	135
	55	10120	135

Strand Type 15.2mm Super			
Tendon Unit	No. of strands	Minimum Breaking Load (kN)	Steel Duct. Internal Diameter (mm)
6-3	2	500	40
	3	750	40
6-4	4	1000	50
6-7	5	1250	70
	6	1500	70
	7	1750	70
6-12	8	2000	85
	9	2250	85
	10	2500	85
	11	2750	85
	12	3000	85
6-19	13	3250	95
	14	3500	95
	15	3750	95
	16	4000	95
	17	4250	95
	18	4500	95
	19	4750	95
6-22	20	5000	105
	21	5250	105
	22	5500	105
6-27	23	5750	115
	24	6000	115
	25	6250	115
	26	6500	115
	27	6750	115
6-31	28	7000	120
	29	7250	120
	30	7500	120
	31	7750	120
6-37	32	8000	130
	33	8250	130
	34	8500	130
	35	8750	130
	36	9000	130
	37	9250	130
6-42	38	9500	135
	39	9750	135
	40	10000	135
	41	10250	135
	42	10500	135
6-48	43	10750	145
	44	11000	145
	45	11250	145
	46	11500	145
	47	11750	145
	48	12000	145
6-55	49	12250	155
	50	12500	155
	51	12750	155
	52	13000	155
	53	13250	155
	54	13500	155
	55	13750	155

Note: 1. Intermediate duct diameters may be available on application
 2. Duct diameters are for corrugated steel duct
 3. Duct external dia. = Inside dia. + 6mm nominal
 4. Corrugated PT-Plus® duct is also available, refer page 17
 5. For special applications other strand and tendon capacities are available

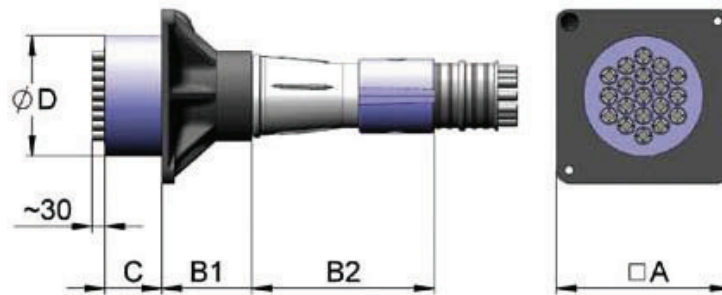
6. Anchorages for 15.2mm system are compatible with 261 EHT strand
 7. Anchorage size up to 6-91 available on special order from overseas
 8. 12-9mm, 15-7mm and 15-2mm minimum 300kN breaking load strand available as special order from overseas

Multistrand Post-Tensioning



VSL STRESSING ANCHORAGE TYPE Gc LIVE END

VSL has developed a new anchorage designed to satisfy the increasing expectations of the construction industry. The VSL Gc type anchorage is an evolution optimizing new requirements with well proven materials while maximizing cost effectiveness.



Tendon Unit	Dimensions (mm)				
	A	B1	B2	C	D
6-3	130	120	-*	50	95
6-4	140	120	-*	55	110
6-7	180	135	-*	60	135
6-12	230	220	-*	75	170
6-19	290	150	300	95	200
6-22	325	150	490	100	220
6-27	350	170	450	110	240
6-31	375	170	410	120	260
6-37	410	170	600	135	280

Subject to modification

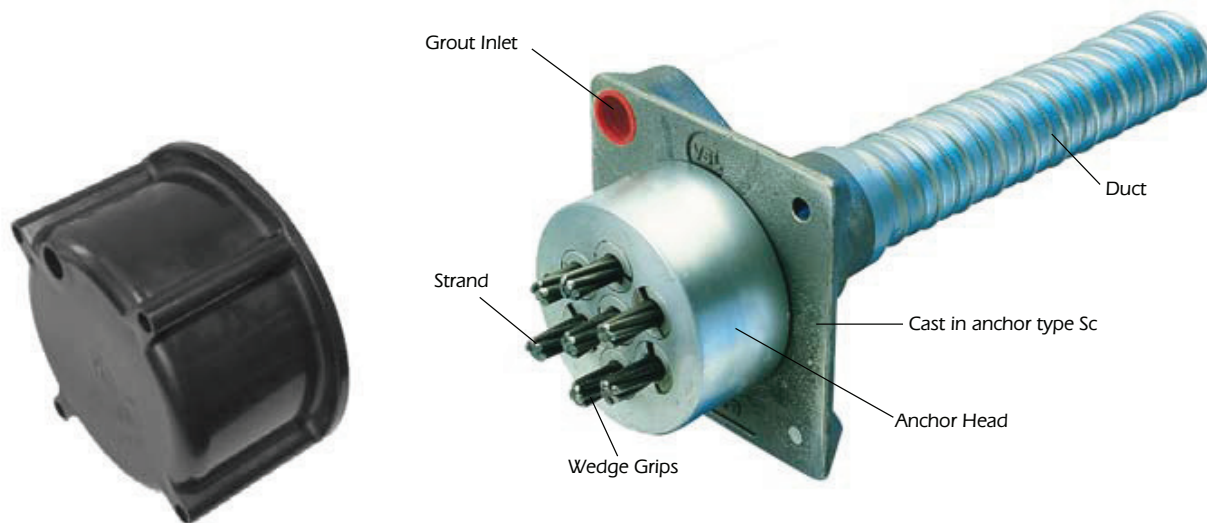
Note: 1. * These castings have no trumpet

2. Max. prestressing force may be applied when concrete reaches 80% of its nominal strength

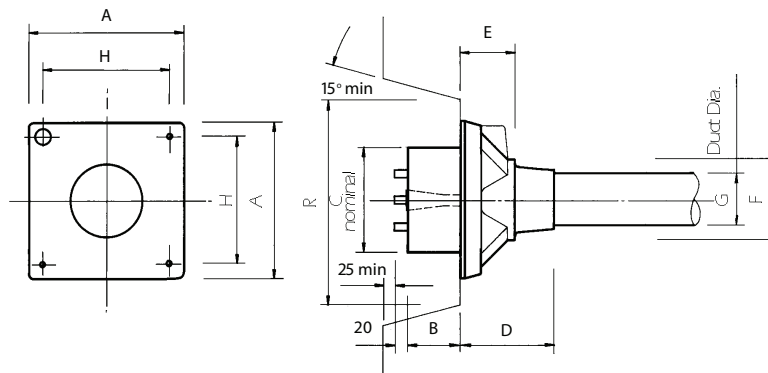
3. Max. prestressing force is 75% of min. tendon breaking load (temporary overstressing to 80%)

4. Where PT-PLUS® plastic ducts are used the trumpets for the GC have short, profiled extensions for PT-Plus® coupling

Multistrand Post-Tensioning



VSL STRESSING ANCHORAGE TYPE Sc LIVE END



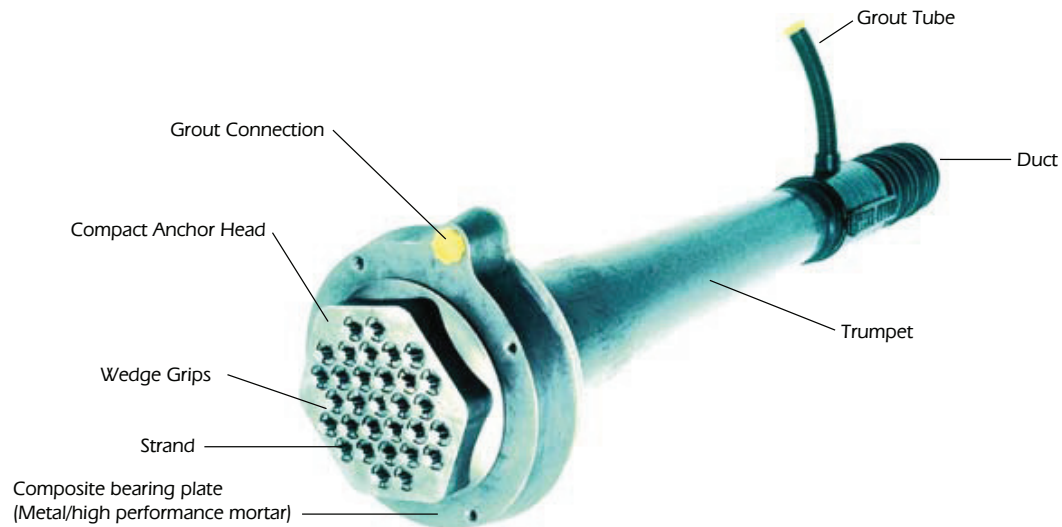
Note: Antiburst reinforcement to Engineers details not shown

	TENDON UNIT	Dimensions (mm)								
		A	B	C	D	E	F	G Int. Dia.	H	R
STRAND TYPE 12.7MM	5-4	135	57	90	100	16	64	40	95	210
	5-7	165	57	120	100	60	85	50	125	275
	5-12	215	54	160	160	84	120	70	151	320
	5-19	270	66	180	210	110	145	85	200	360
	5-22	290	80	200	215	140	153	90	230	360
	5-27	315	92	220	250	160	176	95	250	360
	5-31	315	92	230	250	161	175	105	250	360
	5-37	370	107	250	320	160	200	115	305	650
	5-42	390	112	290	346	168	217	120	325	650
	5-48	430	122	300	340	161	233	130	365	750
STRAND TYPE 15.2MM	5-55	465	142	320	340	160	250	135	400	750
	6-3	135	57	90	100	16	56	40	95	210
	6-4	165	57	120	100	60	85	50	125	270
	6-7	215	67	140	160	85	120	70	150	320
	6-12	270	74	180	210	110	145	85	200	360
	6-19	315	92	220	250	160	175	95	250	360
	6-22	315	102	230	250	160	175	105	250	360
	6-27	370	112	250	320	160	200	115	305	650
	6-31	390	122	270	340	160	217	120	325	650
	6-37	430	142	300	340	160	235	130	365	750
	6-42	465	142	320	340	160	250	135	400	750
	*6-48P	575	147	340	1035	110	269	145	495	900
	*6-55P	600	182	360	1070	120	294	155	520	900

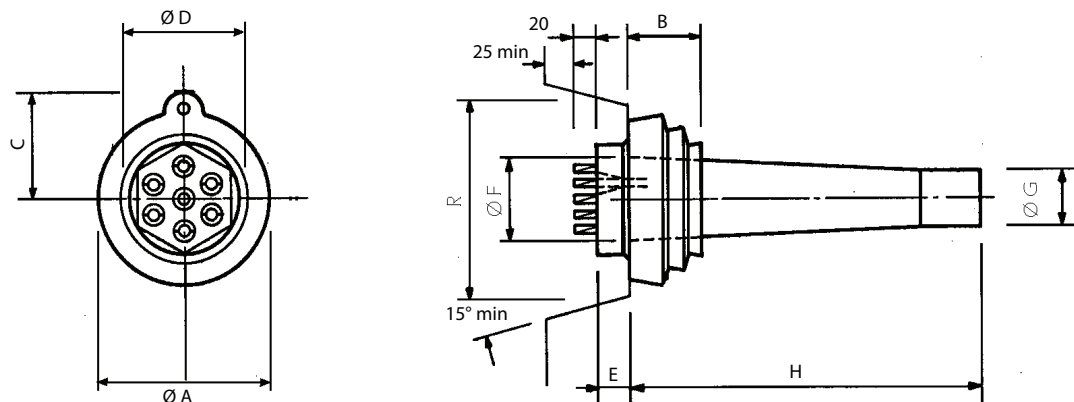
Note: 1. Dimension R does not allow for Lift off force check. Small recesses can be provided for special cases. Please check with your local VSL office for details

2. * Plate type anchorages (Type P). Also available for other tendon units

Multistrand Post-Tensioning



VSL STRESSING ANCHORAGE TYPE CS LIVE END



Tendon Unit		Dimensions (mm)									
Strand Type 12.7mm	Strand Type 15.2mm	A	B	C	D	E	F Ext. Dia.	G Ext. Dia.	H CS-Std	H CS-Plus CS-Super	R
5-12	6-7	222	60	135	153/143	49	110	80	400	535	320
5-19	6-12	258	80	149	178	49	137	95	500	638	360
	6-19	300	90	170	210	59	156	110	540	660	360
5-31	6-22	320	100	180	229	59/65	174	125	570	740	360
5-43	6-31	390	120	217	279/283	69/75	224	146	880	*	640
5-55	6-37	420	130	233	302	78/82	237	160	850	*	750

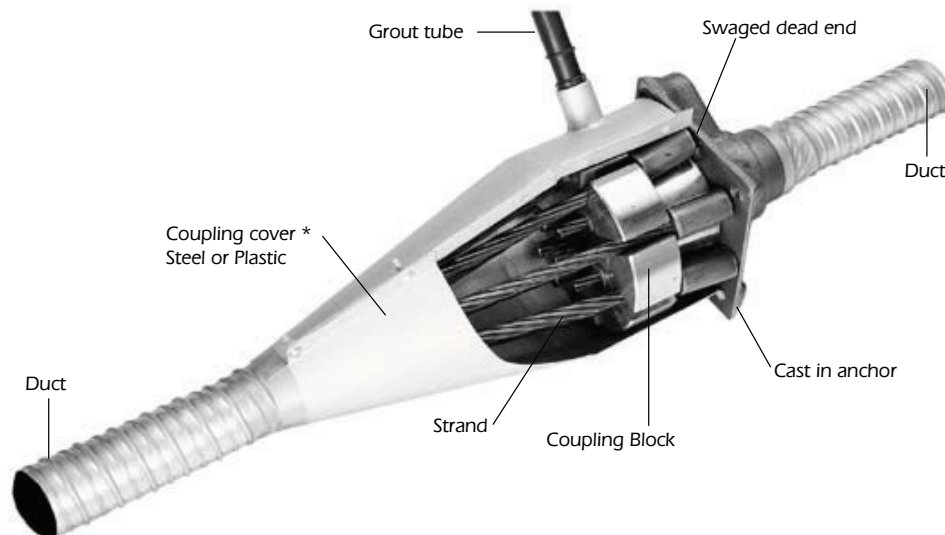
Note: 1. * Please check with your local VSL office for details. The trumpets for the CS-PLUS and CS-SUPER configurations have short, profiled extension for PT-PLUS® duct coupling

TENDON CONFIGURATIONS

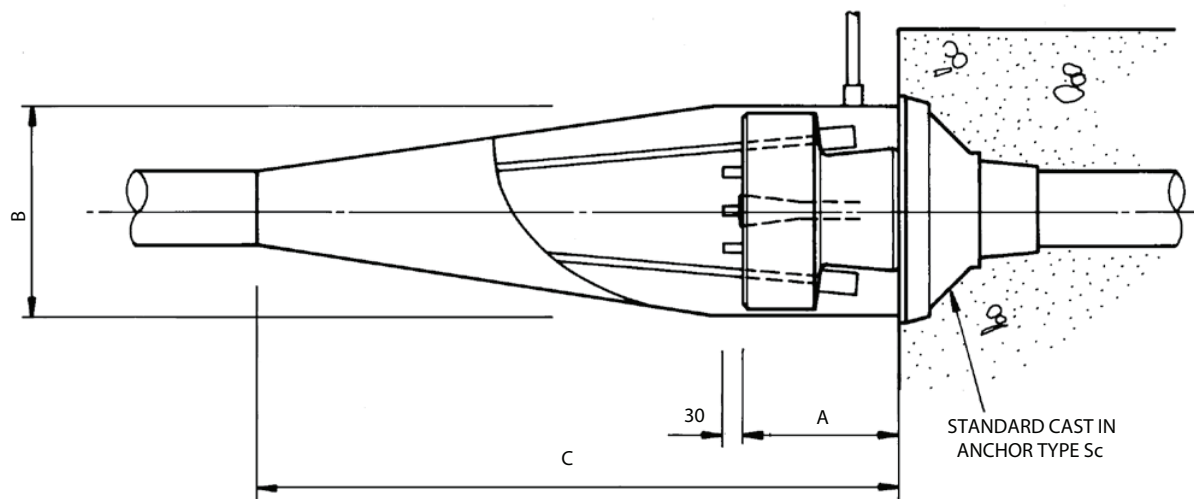
VSL SYSTEM	Anchorage Type		Duct Type		Fully Encapsulated Tendon	Electrically Isolated Tendon
	Conventional	CS	Steel	HD PE PT-PLUS®		
Conventional	•		•			
PT-PLUS®	•			•		
CS-Standard		•	•		•	
CS-Plus		•		•	•	
CS-Super		•		•		•

The Type CS anchorage is an imported anchorage and should be used for applications requiring high fatigue resistance, high corrosion resistance, reduced anchorage friction and the possibility of electrical isolation. For conventional applications the Type Sc anchorage should be used

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VSL COUPLING ANCHORAGE TYPE C

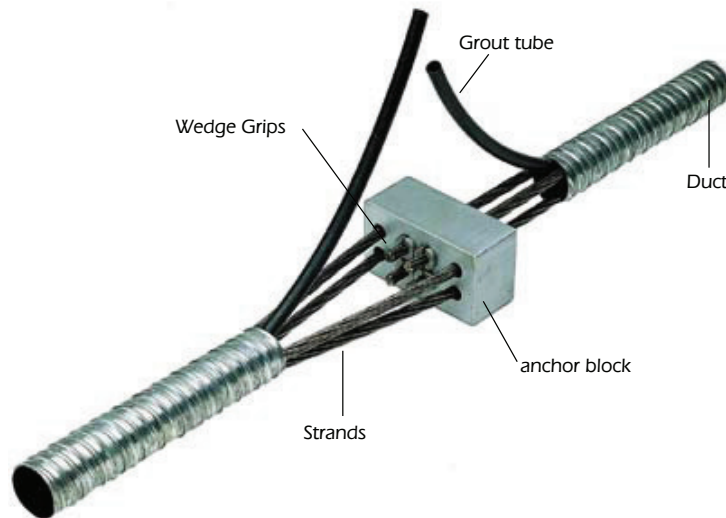


TENDON UNIT	STRAND TYPE 12.7mm		
	A	B	C
Dimensions (mm)			
5-4	108	150	500
5-7	108	170	550
5-12	108	200	650
5-19	108	230	740
5-22	108	250	830
5-27	108	300	1000
5-31	108	340	1140
5-37	148	380	1320
5-42	148	385	1320
5-48	148	410	1370
5-55	168	480	1370

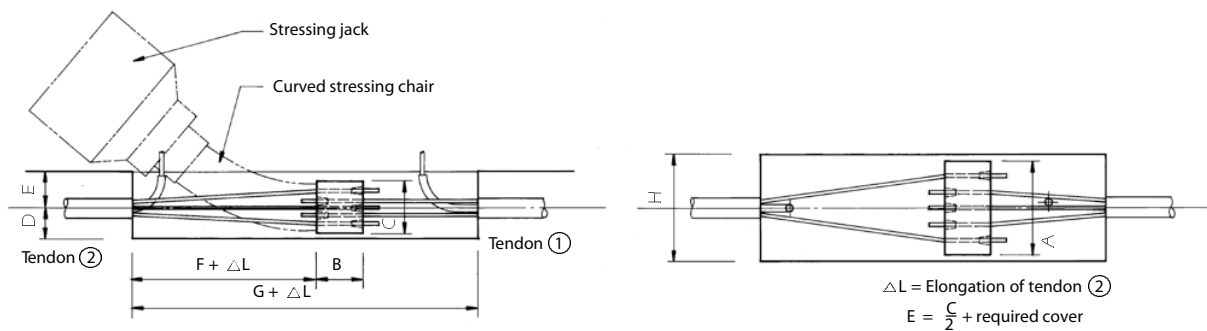
TENDON UNIT	STRAND TYPE 15.2mm		
	A	B	C
Dimensions (mm)			
6-3	125	150	490
6-4	125	160	520
6-7	125	200	630
6-12	125	230	730
6-19	125	270	860
6-22	125	300	930
6-27	135	320	1000
6-31	145	350	1090
6-37	165	410	1390

Note: 1. * In some applications the coupling cover may not be required

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INTERMEDIATE ANCHORAGE TYPE Z

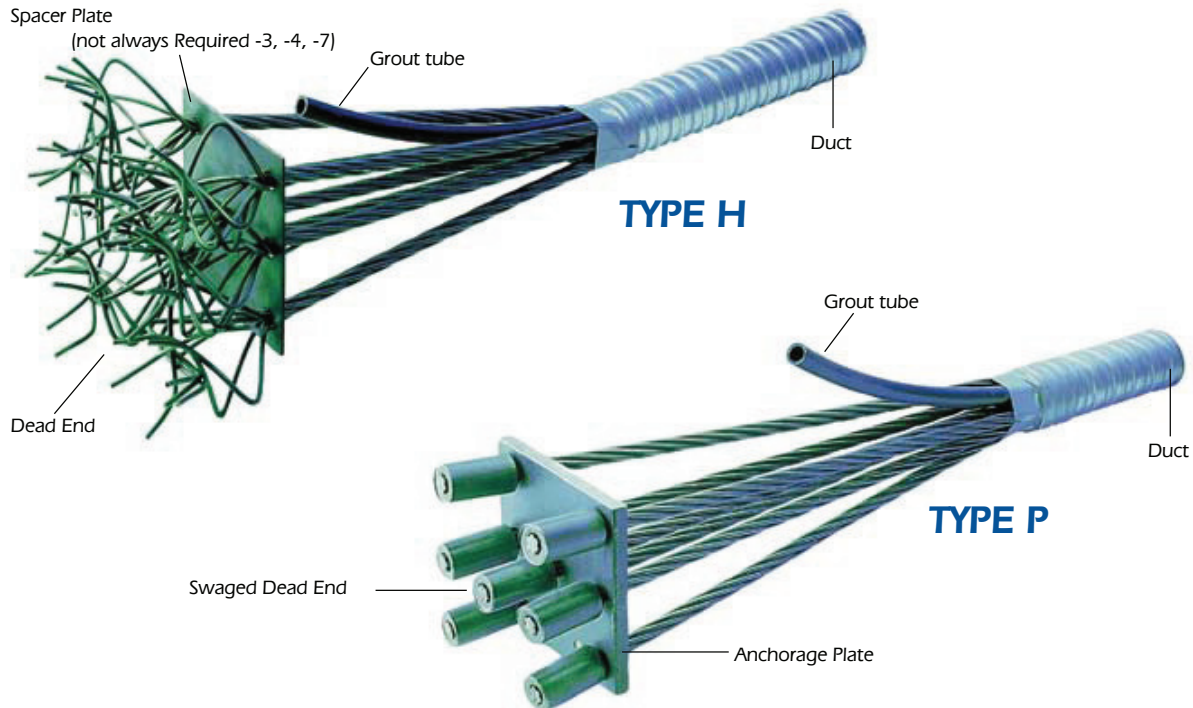


Centre-stressing anchorages are used for ring tendons in circular structures, or for those tendons where the ends cannot be fitted with normal stressing anchorages.

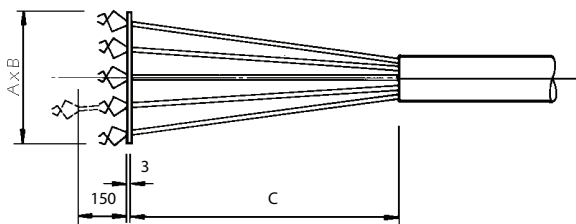
Strand Type	Tendon Type	A	B	C	D	F*	G*	H
Dimensions (mm)								
12.7mm	5-2	130	60	80	60	400	560	170
	5-4	160	70	90	65	500	720	200
	5-6	200	90	130	85	700	990	240
	5-12	280	140	140	90	1000	1490	320
	5-18	320	160	180	110	1300	1910	360
	5-22	350	160	200	120	1450	2110	390
15.2mm	6-2	140	70	90	65	450	620	180
	6-4	170	80	100	70	900	1180	210
	6-6	210	100	140	90	1000	1400	250
	6-12	300	160	160	100	1350	1960	340
	6-18	380	180	200	120	1450	2280	420
	6-22	400	180	250	145	1500	2380	440

Note: 1. * Dependent upon the shape of the concrete surface. The values stated apply for surfaces which are not curved

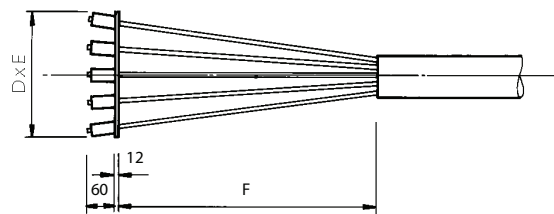
Multistrand Post-Tensioning



VSL DEAD END ANCHORAGE



Dead End Anchorage Type H



Dead End Anchorage Type P

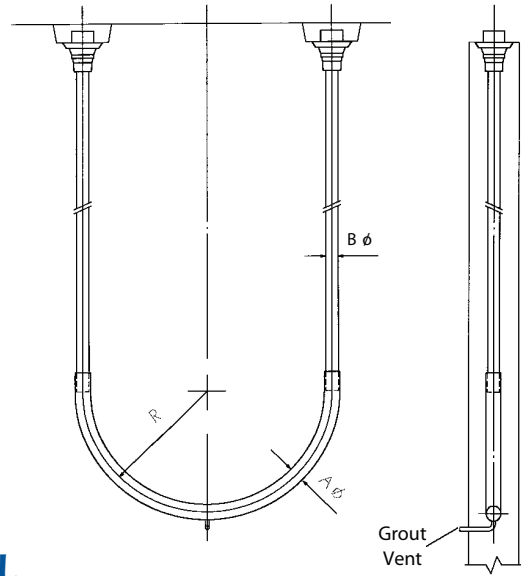
Tendon Type	Strand Type 12.7mm					
	Type 'H'			TYPE 'P'		
	A	B	C	D	E	F
5-4	125	125	600	120	120	150
5-7	175	150	1000	150	150	300
5-12	300	250	1000	200	200	350
5-19	375	300	1000	250	250	450
5-22	400	300	1000	300	250	500
5-27	450	400	1200	300	300	750
5-31	450	425	1200	350	300	750
5-37	525	450	1100	375	350	850
5-42	600	450	1400	375	375	950
5-48	645	450	1200	400	400	1000
5-55	700	500	1700	425	425	1250

Dimensions in mm

Tendon Type	Strand Type 15.2mm					
	Type 'H'			Type 'P'		
	A	B	C	D	E	F
6-3	150	150	600	150	150	250
6-4	150	150	600	150	150	250
6-7	200	170	1000	200	200	350
6-12	350	300	1000	250	250	450
6-19	450	350	1000	300	300	650
6-22	500	350	1000	300	300	500
6-27	550	450	1400	350	350	950
6-31	550	475	1400	350	350	950
6-37	600	550	1100	400	350	850
6-42	700	550	1700	400	350	1250
6-48	745	550	1200	475	475	1000
6-55	800	600	2000	550	475	1550

Dimensions in mm

Multistrand Post-Tensioning



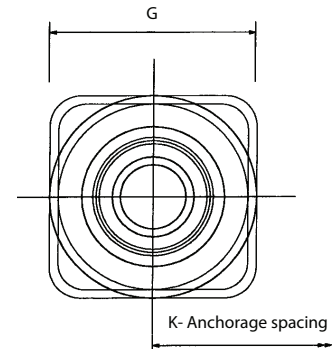
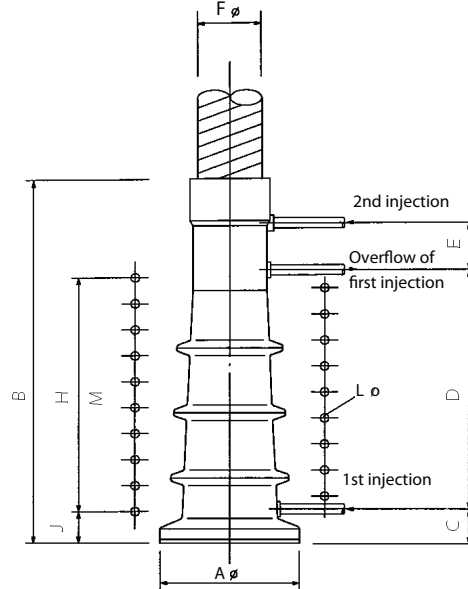
VSL DEAD END ANCHORAGE TYPE L

Stand Type 12.7mm			
Tendon Unit	A Int/Ext	B Int/Ext	R min
5-4	50/55	45/50	600
5-7	65/72	55/60	600
5-12	80/87	65/72	900
5-19	90/97	80/87	1100
5-22	95/102	85/92	1200
5-31	110/117	100/107	1400

Dimensions in mm

Stand Type 15.2mm			
Tendon Unit	A Int/Ext	B Int/Ext	R min
6-2	50/55	45/50	600
6-3	50/55	45/50	600
6-4	55/60	50/55	600
6-7	75/82	60/67	750
6-12	90/97	80/87	1000
6-19	100/117	95/102	1300

Dimensions in mm



VSL DEAD END ANCHORAGE TYPE AF

Stand Type 15.2mm												
Tendon Unit	A	B	C	D	E	F Int/Ext	G	H	J	K	L Ø	M
6-12	265	700	60	460	90	95/102	380	450	60	410	6	9
6-19	315	700	60	460	90	120/127	480	540	60	510	20	9
6-31	375	900	60	660	90	150/157	620	660	80	650	20	11

Dimensions in mm

M=Number of spiral turns or orthagonal stirrups

SHEATHING & CORROSION PROTECTION

For conventional applications, corrugated galvanised steel ducts are used.

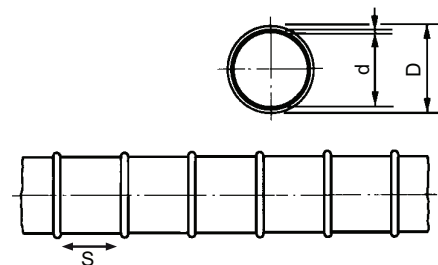
For applications requiring enhanced corrosion protection and improved fatigue resistance of the tendons, the use of the VSL PT-PLUS® System with corrugated plastic duct can provide a number of important advantages. This fully encapsulated, watertight system offers outstanding corrosion protection, and the plastic duct eliminates fretting fatigue between the strand and duct. It also provides reduced duct friction. The PT-PLUS™ System may, in conjunction with VSL CS Anchorages, be configured with special details and installation techniques to provide Electrically Isolated Tendons. These tendons may be electrically monitored at any time throughout the life of the structure.

All ducts are manufactured in a variety of standard lengths and are coupled on site.

For diameters of steel ducts see page 9.

DIMENSIONS OF PT-PLUS® DUCTS

Stand Type 12.7mm	Stand Type 15.2mm	Duct Dimensions (mm)		
Tendon Unit	TENDON UNIT	d	D	s
5-10	6-7	59	73	2
5-18	6-12	76	91	2.5
5-31	6-19/6-22	100	116	3
5-42	6-31	130	146	3
5-55	6-37	140	150	3
Other units on request				



Pt-Plus™ Duct

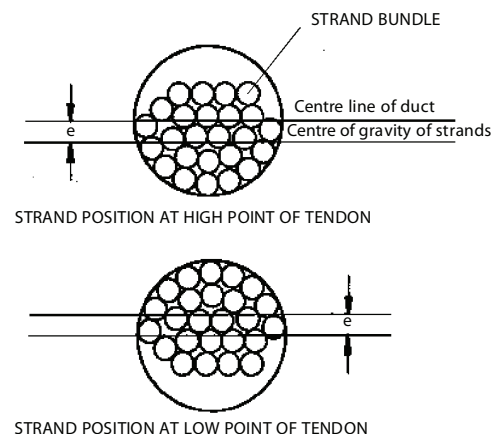


Steel Duct

ECCENTRICITY OF TENDONS

Stand Type 12.7mm		
Tendon Unit	Steel Duct e (mm)	Plastic Duct e (mm)
5-4	7	-
5-7	8	-
5-12	11	7
5-19	13	9
5-22	12	22
5-27	13	17
5-31	14	14
5-37	16	32
5-42	18	28
5-48	17	24
5-55	19	14

Stand Type 15.2mm		
Tendon Unit	Steel Duct e (mm)	Plastic Duct e (mm)
6-1	5	
6-3	6	
6-4	6	
6-7	10	9
6-12	14	12
6-19	17	18
6-22	14	15
6-27	13	32
6-31	15	28
6-37	17	19



SELECTED DESIGN CONSIDERATIONS

Tendon Supports

Recommended spacings:

- Conventional steel duct : 0.8 to 1.2m
- PT-PLUS® duct : 0.8 to 1.0m

Tendon Force Losses

The friction losses in the anchorage due to curvature of the strand and friction of the strand in the wedges usually amount to:

- Anchorage type Sc : 2 to 4%
- Anchorage type CS : 1 to 2%

Friction losses along the tendon can vary fairly widely and depend upon several factors, including: the nature and surface condition of the prestressing steel, the type, diameter and surface conditions of the duct and the installation method.

The following values may be assumed for design:

- Tendon in conventional steel duct : $\mu = 0.20$
- Tendon in PT-PLUS® duct : $\mu = 0.14$

Irrespective jack or tendon jack, a loss due to wedge draw-in of nominally 6mm occurs at lock-off. If necessary compensation can be provided by appropriate procedures.



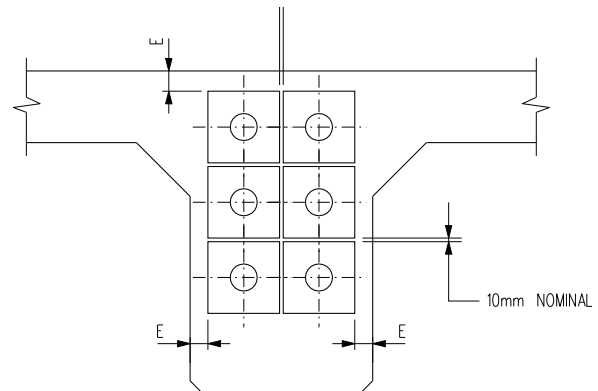
Windsor Flood Evacuation Route, Australia

Antiburst Reinforcement

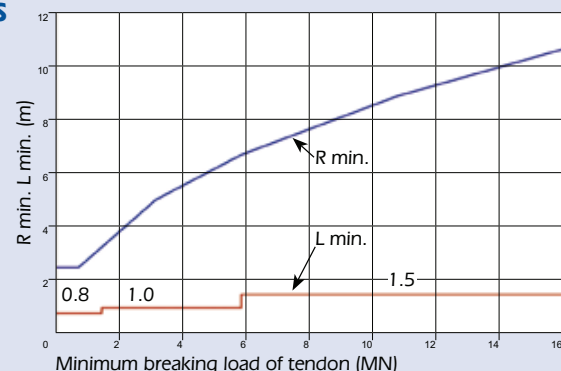
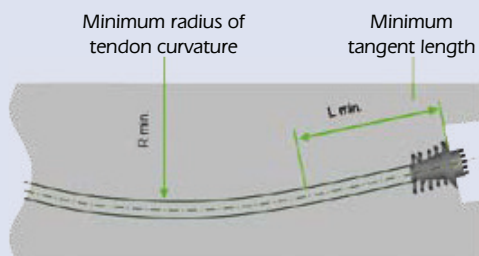
Spiral and/or rectangular stirrup reinforcement is required for all anchorages to control local zone stresses. The design of this reinforcement is the responsibility of the Consulting Engineer. For assistance, please contact your local VSL office.

EDGE DISTANCE

TENDON UNIT			E (mm)
STRAND TYPE	12.7mm	5-7	30
		5-12	50
		5-19	50
		5-27	80
		5-42	80
		5-55	80
	15.2mm	6-7	50
		6-12	50
		6-19	80
		6-27	80
		6-42	100
		6-55	100



Minimum radius of tendon curvatures and minimum straight length for internal bonded tendons



Multistrand Post-Tensioning



Placing of Anchor head



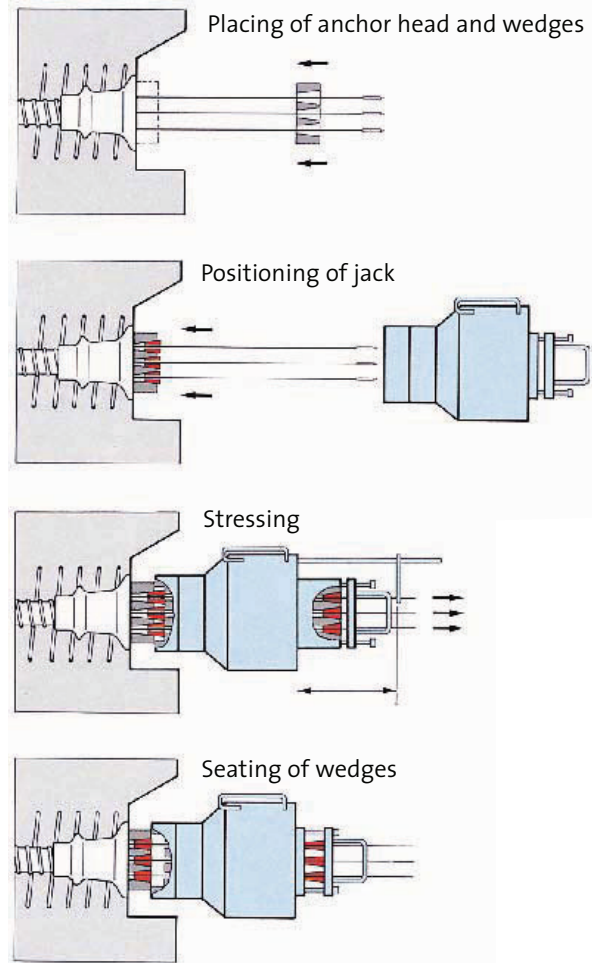
Positioning of Jack



Stressing, Measuring, Seating of Wedges



Grouting of Tendon



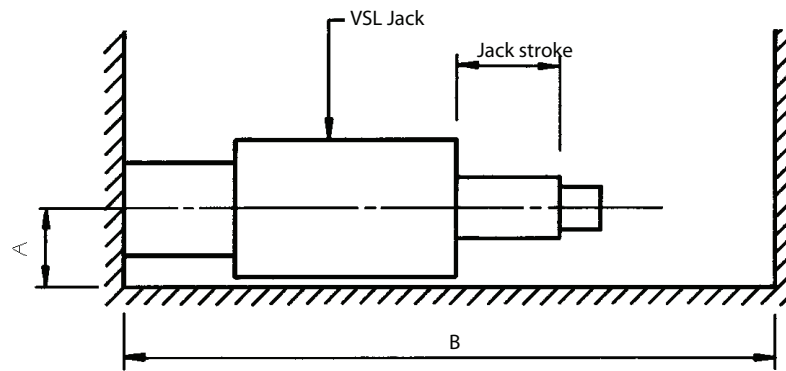
STRESSING

The wedges always remain in contact with the strands during the stressing operation. As the pressure in the jack is released, the wedges automatically lock in the conical holes of the anchor head.

GROUTING

VSL grouting equipment includes combined mixer and pump units to ensure control over the grout quality and delivery on-site. Grouting is usually carried out as soon as possible after stressing. For special applications vacuum assisted grouting procedures can be used.

Multistrand Post-Tensioning



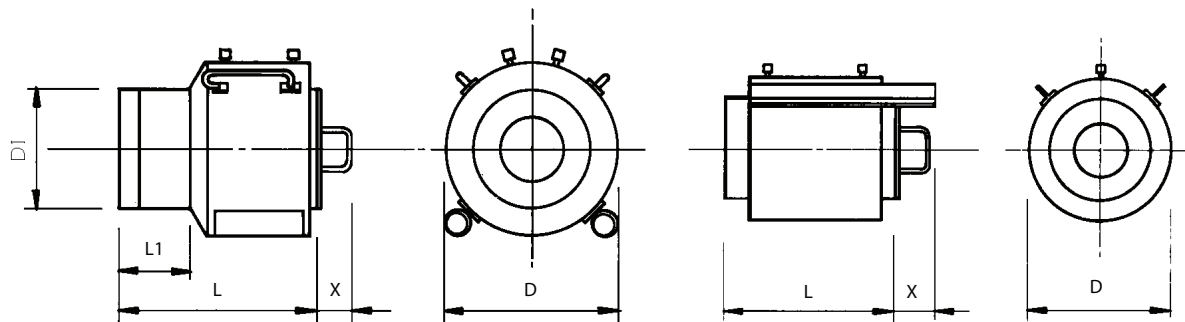
VSL670 JACK



VSL460 JACK

JACK CLEARANCE REQUIREMENTS

Dimensions (mm)	VSL Jack Type					
	VSL50	VSLB7	VSL190	VSL290	VSL460	VSL670
A	145	180	195	235	285	370
B	1000	1000	1600	1600	1400	2400
	VSL750	VSL1000	VSL1250	VSL1650	VSL1700	
A	300	435	395	495	480	
B	2600	2300	2800	1800	2600	



STRESSING JACK DETAILS

VSL Jack Type	Tendon Unit	Tendon Unit	Nominal Cap (kN)	D	D1	L Dimensions (mm)	L1	X	Stroke (mm)	Mass (kg)
VSL50	5-4	-	500	210	-	430	-	-	150	34
VSLB7	5-7	6-3 & 4	1000	275	-	405	-	-	160	76
VSL190	5-12	6-7	1900	310	230	430	200	135	100	151
VSL290	5-19	6-12	2900	390	270	450	215	240	100	202
VSL460	5-22, -27, -31	6-19	4600	485	330	510	200	85	100	425
VSL670	5-42	6-22, -27, -31	6700	660	-	840	-	250	200	1550
VSL750	5-42	6-35	7500	570	410	1030	215	165	200	1500
VSL1000	5-55	6-47	10000	790	-	885	-	165	200	2200
VSL1250	5-55	6-55	12500	710	420	1125	220	165	150	1730
VSL1650	5-64	6-55	16500	910	600	615	140	-	150	1750
VSL1700	5-91	6-91	17000	875	-	1030	-	165	150	3085

Note: 1. Other equipment is available for special situations. Please check with your local VSL office for details

Multistrand Post-Tensioning



Gateway Bridge Upgrade, Brisbane, Australia



Gateway Bridge Upgrade, Brisbane, Australia



Windsor Flood Evacuation Route, Australia



Westlink M7, Sydney, Australia

YOUR CONSTRUCTION PARTNER



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Multistrand Anchor Stressing



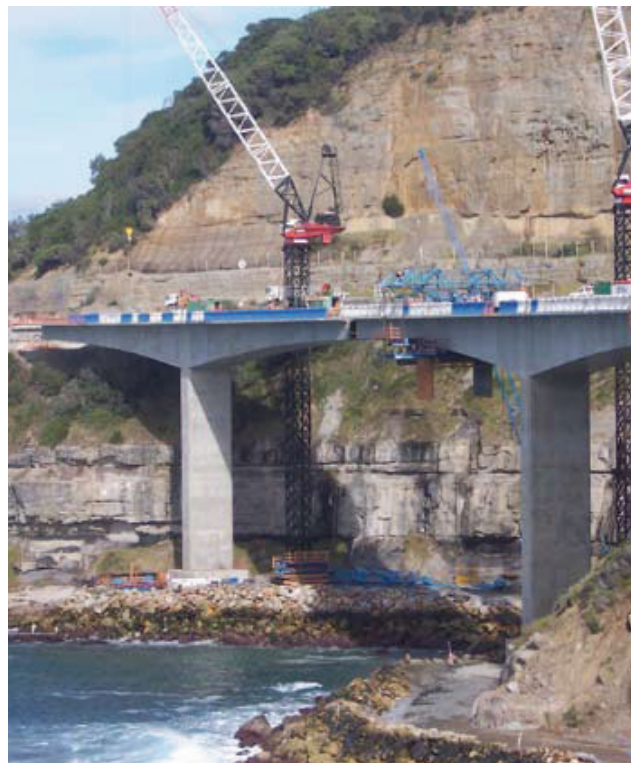
Waiwera Viaduct, New Zealand



Alfords Point Bridge, Australia



Waiwera Viaduct, New Zealand



Lawrence Hargreaves Bridge, Australia