POST-TENSIONING SYSTEMS

CIVIL ENGINEERING CONSTRUCTION

SPECIALISED ENGINEERED SOLUTIONS FOR STRUCTURES

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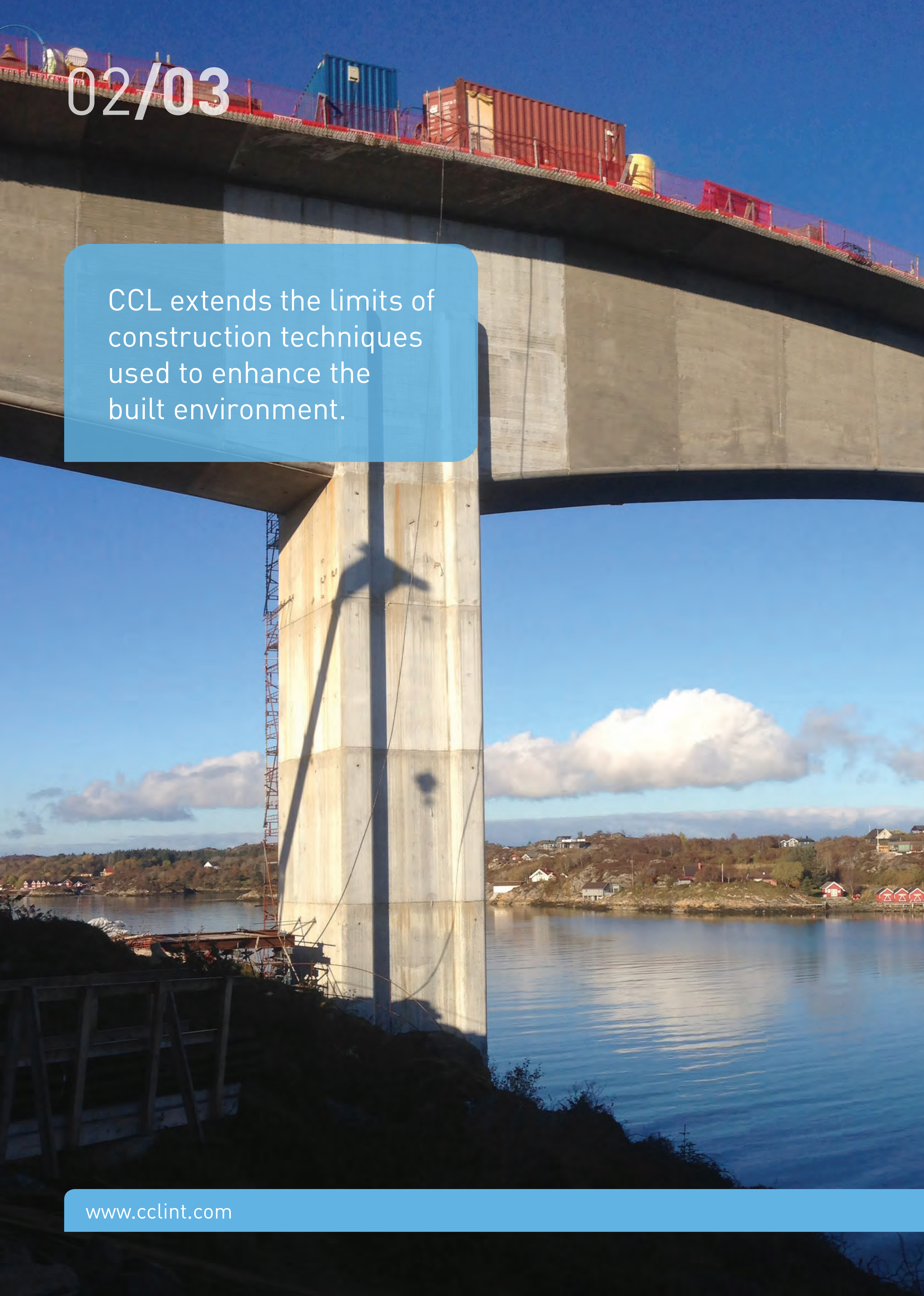


CCL extends the limits of construction techniques used to enhance the built environment.

CCL ENGINEERED SOLUTIONS

CCL EXPERIENCE

CCL has a reputation for the design, manufacture, supply and installation of innovative, world-class post-tensioning systems. Working for clients across the world, CCL has the experience and a proven ability to create solutions that help reduce timescales and deliver exceptional results.

CCL SERVICE

CCL operates a fully-integrated supply chain through its own group companies to ensure quality from conception to construction and beyond. Its local companies and licensees have access to the CCL engineering, research and development, construction and supply resources to offer an optimal solution suited to the local market.

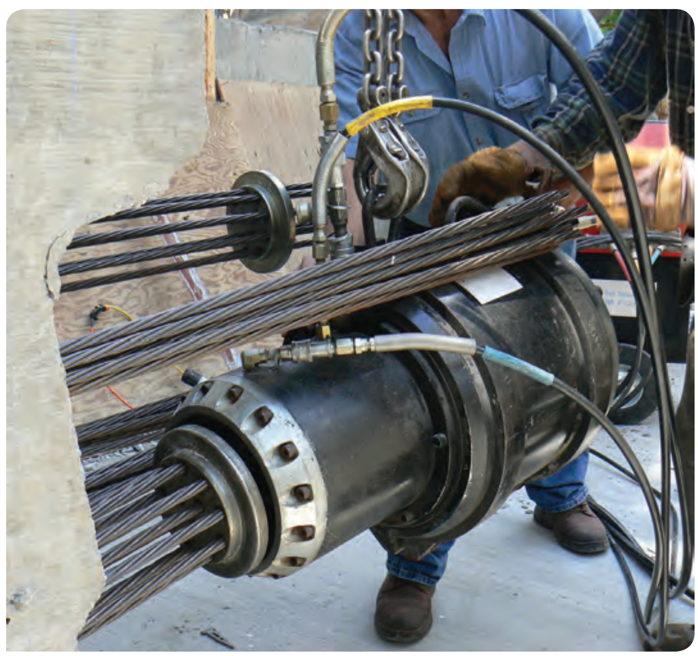
CCL's global presence, experience and expertise enables the company to offer clients a local solution backed by international engineering and construction techniques. CCL's philosophy is simple: to offer the client the best solution in terms of design, supply and construction for their market and project.

CCL QUALITY

Dedicated to a programme of continuous research and development, CCL provides an exceptional service tailored to local and regional conditions and regulations. The company operates a Quality Management System that complies with BS EN ISO 9001 and all products are manufactured to exacting standards using high specification materials. CCL uses the latest software and finite element analysis for all product design and development. CCL products are approved and tested to the latest ETAG/EAD and AASHTO requirements.

CCL COMMITMENT

Involved in projects from conception, CCL offers assistance to help clients meet the requirements of the structure and local technical standards. The company adds value throughout the project in terms of design, construction, systems, equipment and implementation. CCL has a reputation for delivering a responsive, flexible, cost-effective service and high quality civil engineering solutions worldwide.



STRAND

The strand used in CCL Post-tensioning Systems is manufactured from seven cold-drawn wires and is termed a '7 wire pre-stressing strand'. It has a straight central wire, called a core or king wire, around which six wires are spun in one layer. The outer wire is tightly spun around the central wire with a lay length between 14 and 18 times the nominal strand diameter. The diameter of the central wire is at least three per cent greater than the diameter of the outer helical wires. Strands are supplied to site typically in 3-4 tonne coils.

prEN 10138 - 3 : 2006

Steel Designation	Nominal Dia. mm	Tensile Strength MPa	Steel Area mm^2	Nominal Mass kg/m	Breaking Load F_m kN	0.1% Proof Load $F_{p0.1}$ kN	Max Strand Load F_o kN
Y1770S7	12.5	1770	93	0.726	165	145	131
Y1860S7	12.5	1860	93	0.726	173	152	137
Y1860S7G	12.7	1860	112	0.875	208	183	165
Y1770S7	12.9	1770	100	0.781	177	156	140
Y1860S7	12.9	1860	100	0.781	186	164	148
Y1860S7	13.0	1860	102	0.797	190	167	150
Y1770S7	15.2	1770	139	1.086	246	216	194
Y1860S7	15.2	1860	139	1.086	259	228	205
Y1820S7G	15.2	1820	165	1.289	300	264	240
Y1770S7	15.3	1770	140	1.093	248	218	196
Y1860S7	15.3	1860	140	1.093	260	229	206
Y1770S7	15.7	1770	150	1.172	266	234	211
Y1860S7	15.7	1860	150	1.172	279	246	221

ASTM A 416/A 416M - 06

Steel Designation	Nominal Dia.		Tensile Strength		Cross-sectional		Breaking Load	
Dia. (Grade)	in	mm	ksi	MPa	in^2	mm^2	lbf	kN
13 (250)	0.500	12.7	250	1725	0.144	92.9	36000	160.1
15 (250)	0.600	15.2	250	1725	0.216	139.4	54000	240.2
13 (270)	0.500	12.7	270	1860	0.153	98.7	41300	183.7
15 (270)	0.600	15.2	270	1860	0.217	140.0	58600	260.7

Maximum relaxation after 1000 hours for % characteristic breaking load: 60% = 1%, 70% = 2.5%, 80% = 4.5%.

XM RANGE

CCL's world-class product development ensures that the specification and mechanical properties of the CCL XM Multistrand post-tensioning range are second to none. Versatile, lightweight and compact, but immensely strong, CCL's range of bespoke and standard systems gives engineers and contractors the flexibility they need to deliver cutting-edge contemporary structures on time and within budget.

The type of anchorage is designated by type and size in the following order:

XM	60	19	15.7	L
System Type	Anchorage Size	Maximum No. of Strands	Nominal Diameter	Live End / Dead End

Example:

XM -60-19-15.7-L – Live-end multistrand anchorage with a size 60 force transfer unit having 19 strands of Ø15.7 mm.

13 mm Tendons			15 mm Tendons		
Anchorage	No. of Strands	Ø Strand	Anchorage	No. of Strands	Ø Strand
XM -10	4	12.5/12.9/13.0	XM -10	3	15.2/15.3/15.7
XM -20	6	12.5/12.9/13.0	XM -20	4	15.2/15.3/15.7
XM -30	9	12.5/12.9/13.0	XM -30	7	15.2/15.3/15.7
XM -35	12	12.5/12.9/13.0	XM -35	9	15.2/15.3/15.7
XM -40	18	12.5/12.9/13.0	XM -40	12	15.2/15.3/15.7
XM -45	19	12.5/12.9/13.0	XM -45	13	15.2/15.3/15.7
XM -50	22	12.5/12.9/13.0	XM -50	15	15.2/15.3/15.7
XM -55	25	12.5/12.9/13.0	XM -55	17	15.2/15.3/15.7
XM -60	27	12.5/12.9/13.0	XM -60	19	15.2/15.3/15.7
XM -70	31	12.5/12.9/13.0	XM -70	22	15.2/15.3/15.7
XM -75	37	12.5/12.9/13.0	XM -75	25	15.2/15.3/15.7
XM -80	40	12.5/12.9/13.0	XM -80	27	15.2/15.3/15.7
XM -90	46	12.5/12.9/13.0	XM -90	31	15.2/15.3/15.7
XM -95	51	12.5/12.9/13.0	XM -95	35	15.2/15.3/15.7
XM -100	55	12.5/12.9/13.0	XM -100	37	15.2/15.3/15.7

It is possible to use CCL XM Anchorages with a number of strands fewer than the maximum number specified. In this case, intermediate units can be modified from the existing designs provided strands lie as symmetrically as possible around the anchor head to ensure the force is safely centred.

XM RANGE 13 MM

		12.5 mm				12.9 mm				13 mm		12.7 mm Compact	
		Grade 1770		Grade 1860		Grade 1770		Grade 1860		Grade 1860		Grade 1860	
Anchorage	No. of Strands	Fpk kN	Pmax kN	Fpk kN	Pmax kN	Fpk kN	Pmax kN	Fpk kN	Pmax kN	Fpk kN	Pmax kN	Fpk kN	Pmax kN
XM -10	4	658	527	692	554	708	566	744	595	759	607	833	667
XM -20	6	1152	922	1211	969	1239	991	1302	1042	1328	1062	1458	1167
XM -30	9	1481	1185	1557	1245	1593	1274	1674	1339	1707	1366	1875	1500
XM -35	12	1975	1580	2076	1661	2124	1699	2232	1786	2277	1821	2500	2000
XM -40	18	2963	2370	3114	2491	3186	2549	3348	2678	3415	2732	3750	3000
XM -45	19	3128	2502	3287	2629	3363	2690	3534	2827	3605	2884	3958	3166
XM -50	22	3621	2897	3806	3044	3894	3115	4092	3274	4174	3339	4583	3666
XM -55	25	4115	3292	4325	3460	4425	3540	4650	3720	4743	3794	5208	4166
XM -60	27	4444	3556	4670	3736	4779	3823	5022	4018	5122	4098	5625	4500
XM -70	31	5103	4082	5362	4290	5487	4390	5766	4613	5881	4705	6458	5166
XM -75	37	6091	4872	6400	5120	6549	5239	6882	5506	7020	5616	7708	6166
XM -80	40	6584	5268	6919	5535	7080	5664	7440	5952	7589	6071	8333	6666
XM -90	46	7572	6058	7957	6366	8142	6514	8556	6845	8727	6982	9583	7666
XM -95	51	8395	6716	8822	7058	9027	7222	9486	7589	9676	7741	10624	8499
XM -100	55	9054	7243	9514	7611	9735	7788	10230	8184	10435	8348	11458	9166

Fpk and Pmax stated are respectively the ultimate breaking load and the maximum jacking load per anchorage. Actual values are contained in the national regulations set by each country.

XM RANGE 15 MM

		15.2 mm				15.3 mm				15.7 mm				15.2 mm Compact	
		Grade 1770		Grade 1860		Grade 1770		Grade 1860		Grade 1770		Grade 1860		Grade 1820	
Anchorage	No. of Strands	Fpk kN	Pmax kN	Fpk kN	Pmax kN	Fpk kN	Pmax kN	Fpk kN	Pmax kN	Fpk kN	Pmax kN	Fpk kN	Pmax kN	Fpk kN	Pmax kN
XM -10	3	738	590	776	620	743	595	781	625	797	637	837	670	901	721
XM -20	4	984	787	1034	827	991	793	1042	833	1062	850	1116	893	1201	961
XM -30	7	1722	1378	1810	1448	1735	1388	1823	1458	1859	1487	1953	1562	2102	1682
XM -35	9	2214	1771	2327	1861	2230	1784	2344	1875	2390	1912	2511	2009	2703	2162
XM -40	12	2952	2362	3102	2482	2974	2379	3125	2500	3186	2549	3348	2678	3604	2883
XM -45	13	3198	2559	3361	2689	3221	2577	3385	2708	3452	2761	3627	2902	3904	3123
XM -50	15	3690	2952	3878	3102	3717	2974	3906	3125	3983	3186	4185	3348	4505	3604
XM -55	17	4183	3346	4395	3516	4213	3370	4427	3541	4514	3611	4743	3794	5105	4084
XM -60	19	4675	3740	4912	3930	4708	3767	4948	3958	5045	4036	5301	4241	5706	4565
XM -70	22	5413	4330	5688	4550	5452	4361	5729	4583	5841	4673	6138	4910	6607	5285
XM -75	25	6151	4921	6464	5171	6195	4956	6510	5208	6638	5310	6975	5580	7508	6006
XM -80	27	6643	5314	6981	5584	6691	5352	7031	5625	7169	5735	7533	6026	8108	6486
XM -90	31	7627	6102	8015	6412	7682	6145	8072	6458	8231	6584	8649	6919	9309	7447
XM -95	35	8611	6889	9049	7239	8673	6938	9114	7291	9293	7434	9765	7812	10511	8408
XM -100	37	9103	7282	9566	7653	9169	7335	9635	7708	9824	7859	10323	8258	11111	8889

Fpk and Pmax stated are respectively the ultimate breaking load and the maximum jacking load per anchorage. Actual values are contained in the national regulations set by each country.

METAL DUCT

In order to insert the strands within the structure a void must be formed in the concrete. The most effective and economical way to do this is to cast metal corrugated duct into the concrete at the desired position and profile. After the strands have been stressed, the remaining void in the duct is grouted. This provides corrosion protection and bonds the strands to the duct. The corrugations within the duct provide an excellent bond between the grouted strands and the concrete structure.

Metal corrugated duct sheaths are made from rolled sheet with a minimum thickness of 0.3 mm. The usual guide for the required diameter of duct is 2.5 times the nominal area of the strands encased inside the duct. These should be checked against the local requirements and regulations.

		Duct		Coupler					
Anchorage	No. of Strands 13 mm/15 mm	Ø Inside mm	Ø Outside mm	Ø Inside mm	Ø Outside mm	Duct Weight kg/m	Duct Length m	Duct Area mm^2	Support Spacing mm
XM -10	4/3	55	60	60	65	0.65	6	2400	1000
XM -20	6/4	55	60	60	65	0.65	6	2400	1000
XM -30	9/7	70	75	75	80	0.82	6	3800	1000
XM -35	12/9	80	85	85	90	0.93	6	5000	1000
XM -40	18/12	80	85	85	90	1.01	6	5000	1000
XM -45	19/13	80	85	85	90	1.01	6	5000	1000
XM -50	22/15	90	95	95	100	1.07	6	6400	1000
XM -55	25/17	100	105	105	110	1.19	6	7900	1000
XM -60	27/19	100	105	105	110	1.19	6	7900	1000
XM -70	31/22	100	105	105	110	1.19	6	7900	1000
XM -75	37/25	115	120	120	125	1.31	6	10400	1000
XM -80	40/27	115	120	120	125	1.31	6	10400	1000
XM -90	46/31	125	130	130	135	1.45	6	12300	1000
XM -95	51/35	140	145	145	150	1.63	6	15400	1000
XM -100	55/37	140	145	145	150	1.63	6	15400	1000

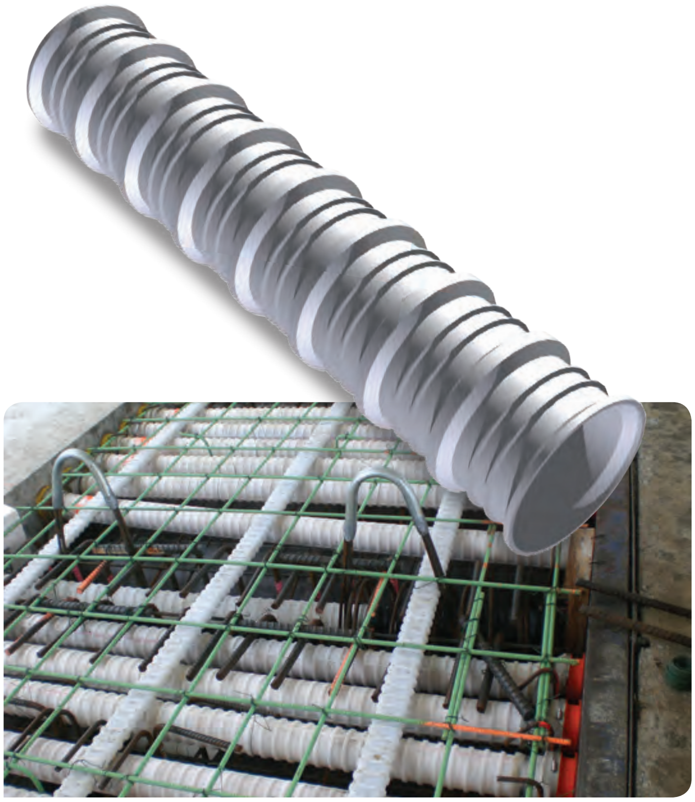
Duct weight is indicative and depends on the sheet thickness and manufacturing process.
For coefficient of friction and unintentional angular displacement please refer to page 26.

PLASTIC DUCT

CCL supplies round plastic duct where enhanced corrosion protection or improved fatigue resistance is required. Manufactured from high-density polyethylene (HDPE) or polypropylene, the duct provides excellent secondary corrosion protection in aggressive environments.

Although supplied typically in 6-metre lengths for ease of transportation, it can be manufactured to specific lengths or coils according to project requirements. It is connected using specific clam shell couplers, with or without integrated grout vents, for ease of installation and to provide secure joints.

The duct meets all applicable requirements of the fib and American DOT regulations.



Anchorage	No. of Strands 13 mm/15 mm	Ø Duct Inside mm	Ø Duct Outside* mm	Duct Wall Thickness mm	Duct Length m	Duct Area mm^2
XM -10	4/3	48	59	2.0	6	1800
XM -20	6/4	48	59	2.0	6	1800
XM -30	9/7	76	91	2.5	6	4500
XM -35	12/9	76	91	2.5	6	4500
XM -40	18/12	76	91	2.5	6	4500
XM -45	19/13	76	91	2.5	6	4500
XM -50	22/15	86	101	2.5	6	5800
XM -55	25/17	100	116	3.0	6	7900
XM -60	27/19	100	116	3.0	6	7900
XM -70	31/22	100	116	3.0	6	7900
XM -75	37/25	115	135	3.5	6	10400
XM -80	40/27	115	135	3.5	6	10400
XM -90	46/31	129	152	4.0	6	13100
XM -95	51/35	146	169	4.0	6	16700
XM -100	55/37	146	169	4.0	6	16700

*Over corrugations.

Duct weight is indicative and depends on the sheet thickness and manufacturing process.

For coefficient of friction and unintentional angular displacement please refer to page 26.

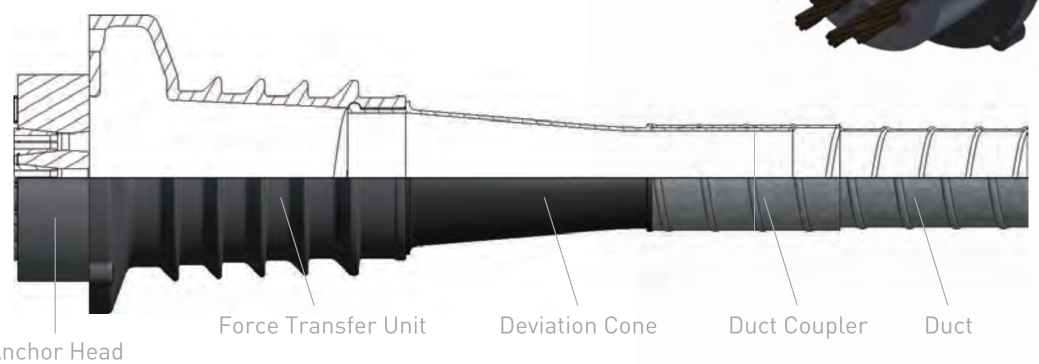
XM LIVE-END ANCHORAGES

CCL XM Live-end Anchorages are primarily designed for longitudinal tendons in beams or bridges. They can be used as active or passive anchorages if they are accessible.

The strands of the anchorage are stressed simultaneously by a jack bearing on the force transfer unit by means of a bearing ring.

The prestressing force is applied to the strands and locked in place by the wedges in the anchor head, which is supported on the force transfer unit cast into the concrete.

Transmission of the prestresssing force into the concrete is ensured by means of the force transfer unit, while smooth deviation of the strands from the anchor head to the duct is achieved by the force transfer unit and the deviation cone.



XM DEAD-END ANCHORAGES

The CCL XM Dead-end Anchorage operates as a non-accessible dead end of the tendon. The wedges are locked in place by the spring plate while the prestressing force is applied to the opposite (live) end of the tendon. The prestressing force in the strands is locked by the wedges in the anchor head which is supported on the force transfer unit cast into the concrete.

If required, dead-end anchorages can be used as buried passive anchorages with the provision of a sealing cap and a suitable grout vent. Threading of the strands must be completed before concreting.

CCL systems are approved for internal and external use with grout, grease or wax for corrosion protection depending on the application.

XeD EXTENDED DURABILITY SYSTEMS

CCL XeD Systems provide enhanced long-term protection for all levels of environmental exposure, from the lowest to the most severe where structures may be exposed to high concentrations of chlorides, chemical corrosive agents or extreme temperatures. XeD systems are to the latest international standards and have ETA approvals.

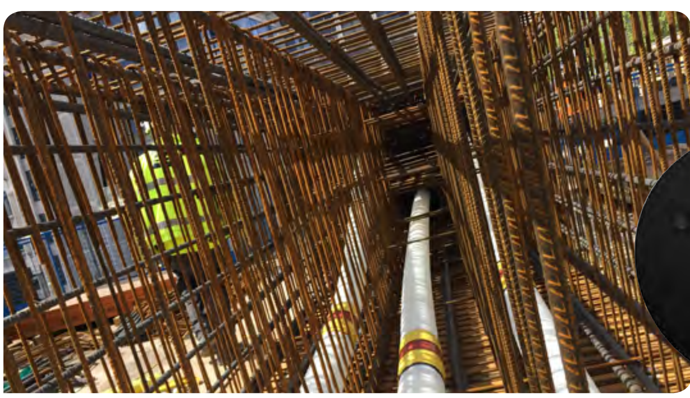
CCL systems are approved for internal and external use with grout, grease or wax for corrosion protection depending on the application.

PLASTIC DUCT SYSTEM

The plastic duct system prevents water ingress and provides an additional layer of protection for the length of the tendon. Duct connections must be sealed using anti-corrosion and waterproofing tape.

FULLY-ENCAPSULATED SYSTEM

CCL's fully-encapsulated system provides a watertight, airtight system in which the tendon is fully sealed against moisture penetration from end to end. An encapsulated grout cap and gaskets are fixed to the force transfer unit and heat shrink is used on all joints as needed. The grout port is welded to the duct and grout tube and FTU connections are sealed using special sealant or special tape.

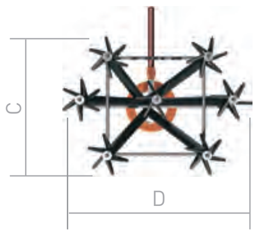


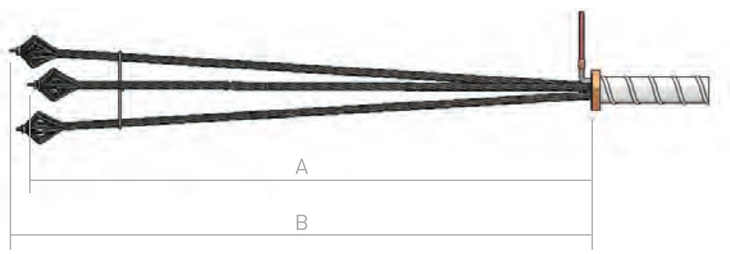
CRYOGENIC APPLICATIONS

CCL XM Multistrand Systems are also approved for use in cryogenic applications.

XM BASKET DEAD-END ANCHORAGES

Basket dead-end anchorages can be used in place of standard dead-end anchorages. The prestressing force is transferred to the concrete by bond. A rebar net is required to act as a spacer for the individual strands. Basket dead ends are constructed on site using an extrusion rig.





Anchorage	No. of Strands 13 mm/15 mm	A	B	C	D	Ø Duct*
XM -10	4/3	-	1300	220	220	55/60
XM -20	6/4	-	1300	220	220	55/60
XM -30	9/7	1150	1300	220	340	70/75
XM -35	12/9	1150	1300	220	340	80/85
XM -40	18/12	1150	1300	280	340	80/85
XM -45	19/13	1150	1300	280	460	80/85
XM -50	22/15	1150	1300	280	460	90/95
XM -55	25/17	1150	1300	340	460	100/105
XM -60	27/19	1150	1300	340	460	100/105
XM -70	31/22	1150	1300	340	580	100/105
XM -75	37/25	1150	1300	340	580	115/120
XM -80	40/27	1300	1450	340	700	115/120
XM -90	46/31	1300	1450	400	700	125/130
XM -95	51/35	1625	1775	400	700	140/145
XM -100	55/37	1625	1775	400	700	140/145

All dimensions in mm.
*Duct dimensions shown are for inside/outside diameter of metal ducts.

XM XU DEAD-END ANCHORAGE

XM PLATE DEAD-END ANCHORAGE

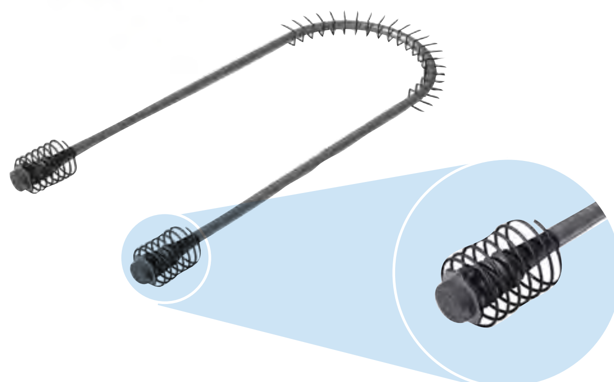
CCL XM Plate Dead-end Anchorages are used where prestressing force is required immediately behind the anchorages in inaccessible locations. The anchorages are made by threading plates onto the strands and swaging compression fittings to hold the plates in place. A shorter length of strand is required to develop full prestressing force.

XM MONO DEAD-END ANCHORAGE

An alternative to the CCL XM Plate Dead-end Anchorage, this uses CCL's monostrand XU anchors instead of plates.

XM LOOP DEAD-END ANCHORAGE

A further alternative for a dead end in inaccessible locations is the CCL Loop Dead-end Anchorage. These are used in slabs, bridges, tanks and in vertically post-tensioned elements in walls and piers. The duct is placed in the formwork prior to concreting and the strands are installed after casting of the concrete. Both ends of the strands are stressed simultaneously.



Anchorage	No. of Strands 13 mm/15 mm	Straight Duct		Loop Duct		Min. Loop Radius mm
		Ø Inside mm	Ø Outside mm	Ø Inside mm	Ø Outside mm	
XM -10	4/3	55	60	60	65	600
XM -20	6/4	55	60	65	70	650
XM -30	9/7	70	75	70	75	700
XM -35	12/9	80	85	80	85	800
XM -40	18/12	80	85	95	100	950
XM -45	19/13	80	85	95	100	950

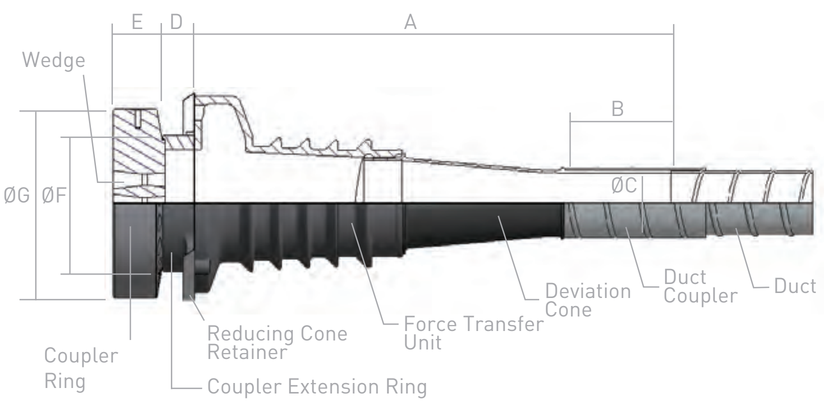
Other numbers of strands can be accommodated. Contact CCL for advice.

XM COUPLER ANCHORAGES

XM COUPLER

In continuous bridge deck construction, it is necessary to extend prestressing cables as construction proceeds. The first stage of stressing is carried out in the same way as with the standard anchorage except that a coupler ring replaces the anchor head.

When first stage stressing and grouting is complete, the second stage strands are threaded into the wedges. The strand is deviated through a shaped trumpet that also prevents the ingress of concrete during casting.



Anchorage	No. of Strands 13 mm/15 mm	A	B*	Ø C	D	E	Ø F	Ø G	Ø Duct**
XM -10	4/3	234	70	48	67	60	95	185	55/60
XM -20	6/4	300	70	50	67	60	105	195	55/60
XM -30	9/7	362	100	64	67	60	130	220	70/75
XM -35	12/9	493	113	74	67	60	155	245	80/85
XM -40	18/12	629	113	74	67	69	175	265	80/85
XM -45	19/13	629	113	74	67	71	175	265	80/85
XM -50	22/15	693	130	84	67	75	195	285	90/95
XM -55	25/17	742	150	98	67	77	210	300	100/105
XM -60	27/19	749	150	98	67	84	215	305	100/105
XM -70	31/22	913	150	98	67	86	235	325	100/105
XM -75	37/25	1001	175	113	67	92	260	350	115/120
XM -80	40/27	1001	175	113	67	96	260	375	115/120
XM -90	46/31	1118	190	123	67	109	285	410	125/130
XM -95	51/35	1079	210	138	67	112	300	430	140/145
XM -100	55/37	1089	210	138	67	116	300	435	140/145

All dimensions in mm.
*B is the dimension for the straight part of the deviation cone that links to the duct through a duct coupler.
**Duct dimensions shown are for inside/outside diameter of metal ducts.

COUPLER ANCHORAGES

COMPRESSION FITTING COUPLERS

As an alternative to the standard coupler using wedges, a system with compression fittings can be provided. In addition to the standard live end anchorage it incorporates a cast coupler ring, which is inserted between the anchor head and the force transfer unit. The coupler ring incorporates slots to accommodate the compression fittings which are swaged to the strands of the second stage cable using an extrusion rig.

The strand is deviated through a shaped trumpet that also prevents the ingress of concrete during casting. A grout exit point contained in the trumpet should be located at the top to prevent any air being trapped during grouting. The small end of the trumpet should be securely taped to the duct.

MOVEABLE COUPLERS

CCL Moveable Couplers use a special double-ended joint to connect the second stage of the tendon to the first. The special double-ended joints are extremely slim and use internal wedges to grip the strand. Unique safety pegs are used to ensure that the wedges grip the strand securely when fitting. The moveable couplers are staggered to allow for a very compact section. The assembly is contained within a steel or high-density polyethylene shroud. The double-ended joints can also be used to join monostrand systems or multistrand systems by coupling each strand individually.

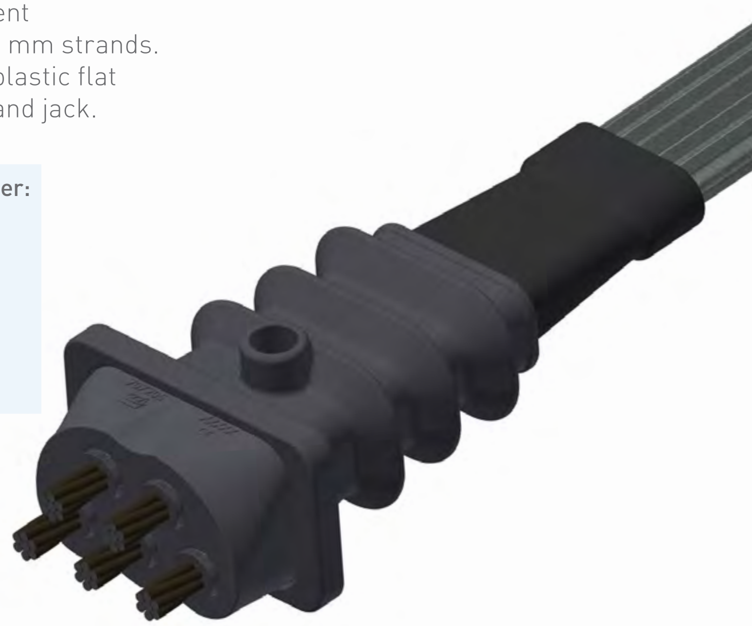
XF LIVE-END ANCHORAGES

CCL BONDED FLAT SYSTEM

The CCL XF Anchorage is a flat system used mainly in slabs and transversally in bridge decks. It can also be used in transfer beams, containment structures and other civil applications and for both 13 mm and 15 mm strands. The system connects bare strands which run through a steel or plastic flat oval duct. The strands are stressed individually using a monostrand jack.

The type of anchorage is designated by type and size in the following order:

XF	20	5	13
System Type	Anchorage Size	Maximum No. of Strands	Nominal Diameter

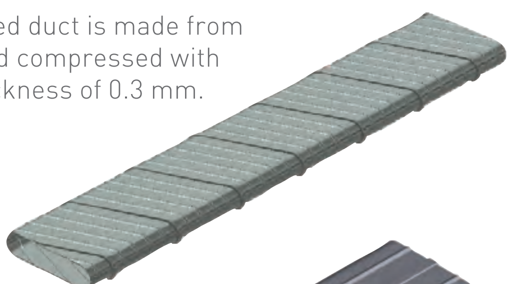


It can be noted that the 13 mm and 15 mm systems share the same force transfer unit and deviation cone so are fully interchangeable. Only the anchor heads differ to suit 13 mm or 15 mm wedges. The wedges are available in three different sizes; 13 mm, 15.2 mm and 15.7 mm.

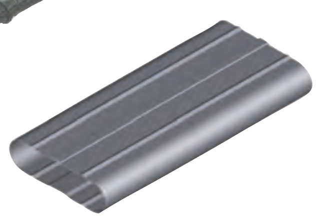
XF FLAT DUCT

METAL DUCT

CCL's corrugated duct is made from rolled sheet and compressed with a minimum thickness of 0.3 mm.

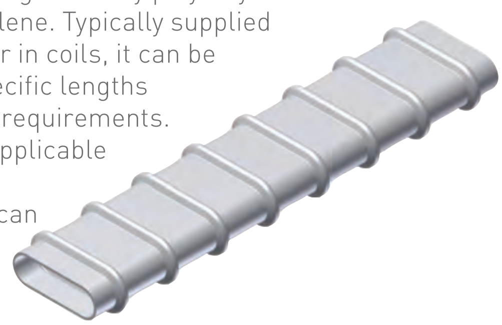


Metal duct used in some markets is roll-formed.



PLASTIC DUCT

CCL flat plastic duct provides enhanced corrosion protection and improved fatigue resistance. It is manufactured from high-density polyethylene (HDPE) or polypropylene. Typically supplied in 6-metre lengths or in coils, it can be manufactured to specific lengths according to project requirements. The duct meets all applicable requirements of the fib, ETAG and American DOT regulations.



	Metal Duct					Plastic Duct			
Anchorage	No. Strands 13 mm/15 mm	Duct Height Inner mm	Duct Width Inner mm	Duct Wall Thickness mm	Duct Area mm^2	Duct Height Inner mm	Duct Width Inner mm	Duct Wall Thickness mm	Duct Area mm^2
XF10	3/2	18	42	0.4	684	21	44	2	830
XF20	5/4	18	69	0.4	1174	21	71	2	1390
XF30	6/5	18	86	0.4	1484	21	88	2	1750

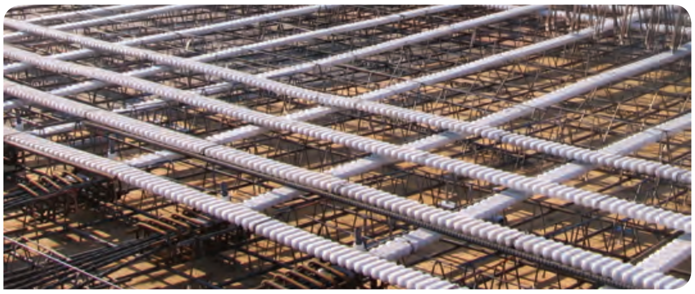
XeD EXTENDED DURABILITY SYSTEMS

For structures subject to corrosive attack, CCL's XeD Systems provide extended durability for all levels of environmental exposure, from the lowest to the most severe. Designed to extend the service life of the structure, the XeD systems deliver a lower and more accurate friction coefficient along the length of the tendon.

XeD systems are to the latest international standards and have ETA approvals.

PLASTIC DUCT SYSTEM

In this system plastic duct prevents water penetration and adds an additional layer of protection along the tendon length. Duct connections must be sealed using anti-corrosion and waterproofing tape.

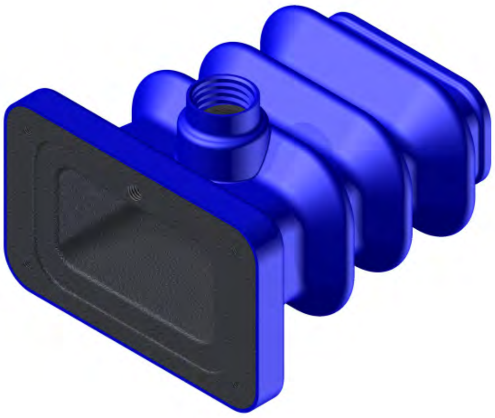


FULLY-ENCAPSULATED SYSTEM

The tendon of the fully-encapsulated system is watertight and airtight, being fully sealed against moisture penetration from end to end. An encapsulated grout cap and gaskets are fixed to the force transfer unit, and the grout port is welded to the duct. All joints are sealed using heat shrink as needed. The grout tube and FTU connections are sealed using special sealant or special tape.

XF ENCAPSULATED ANCHORAGE

CCL XF Anchorages can be supplied as encapsulated units to provide additional corrosion protection. For further information contact CCL.



XU ANCHORAGES

XU LIVE-END ANCHORAGES

The CCL XU System is a monostrand system mainly used in slabs. It can also be used in containment structures and remedial applications. The anchorages can be used for both 13 mm and 15 mm nominal diameter strands. The system connects to unbonded strands, therefore eliminating the need for duct. In some cases it is used as a monostrand bonded system or as a dead-end system on multistrand applications.

The strands are stressed individually using a monostrand jack. On completion of the stressing, the strand is cropped and the strand end and wedge are sealed with a grease filled plastic cap.

XT ANCHORAGES

XT ANCHORAGE

XT anchorages are predominately used on circular containment structures such as tanks, reservoirs and silos and are stressed using monostrand jacks. The design allows the tendon to anchor the live end of the anchorage against the passive end, so acting also as a coupler anchorage. The body of the item is cast in a single unit to provide a compact self-contained anchorage.

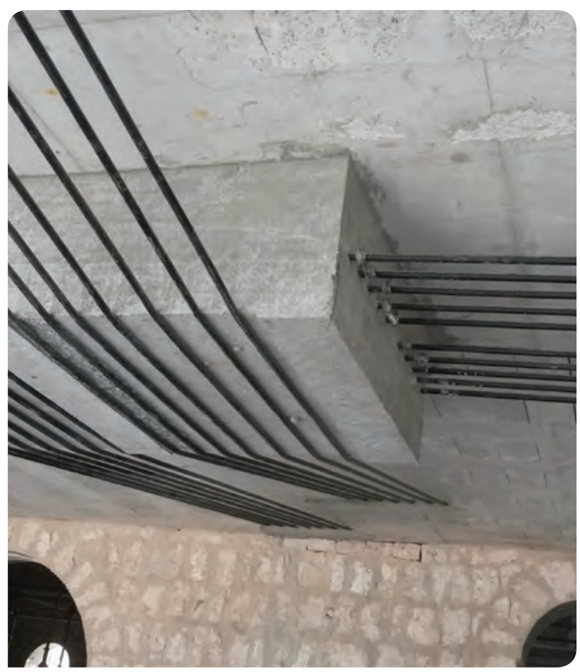
REPAIR ANCHORAGE

The repair anchorage is used mainly for the repair of post-tensioning installations, but can also be used for circumferential stressing applications.

45-DEGREE ANCHORAGE

For existing slabs requiring external reinforcement, this anchorage allows strand to be fed through the slab at an angle of 45 degrees and continue along the soffit to provide additional strengthening.

EXTERNAL POST-TENSIONING



External post-tensioning is an increasingly popular method of strengthening both new and existing structures. It can be used to extend the life of old structures including bridges, car parks, factories and residential buildings and is a highly cost-effective alternative to traditional internal post-tensioning in new structures.

In response to requirements to inspect and or replace tendons, an external post-tensioning system can be used.

External tendons reduce congestion in concrete and offer a high degree of corrosion resistance whilst allowing inspection and in some cases replacement. Friction losses are also kept to a minimum as they only occur at the deviators and anchorage points.

Deviators at intermediate points normally take the form of steel pipes curved to a radius.

CCL Systems are approved for internal and external use with grout, grease or wax for corrosion protection depending on the application. Grease and wax of various properties can be used with CCL Systems, which can be extremely beneficial for external PT. Fire protection schemes can also be accommodated depending on the exposure type and fire rating required.

MULTISTRAND JACKS

CCL Multistrand Jacks are simple to operate and easy to manoeuvre. The body of the jack can be rotated around its lifting points, enabling easy access to hydraulic connections. The jack innards can also be rotated, promoting easy alignment with the tendons. Featuring hydraulic lock-off to ensure the correct seating of the wedges, and to minimise load losses at transfer, the jacks may be operated in a vertical or horizontal position.

Two versions of the MG jack series are available: manual and auto release. Auto-release innards eliminate the need to manually remove/install the jack wedges, thereby making the stressing process faster and easier.

The CCL MG Stressing Jacks used for the CCL XM System have the following features:

- Automatic gripping of the wedges on the strands.
- Simultaneous stressing of all the strands of the tendon.
- Support of the jack on the force transfer unit, by means of a temporary bearing ring.
- Optional auto-release innards.
- Simultaneous hydraulic lock-off of all wedges in the anchor head.
- Partial stressing of the tendons with later recovery up to the final values of the prestressing force.
- Stressing by successive loadings of the jack when the final extension is greater than the full stroke of the CCL Jack.
- Different jack innards requirement for each system size.

STRESSING OPTIONS

The standard CCL MG Jack is fitted with manual innards. Auto-release innards are included on the CCL MG ARI Jack. They are also available as a retrofit option via a separate kit compatible with the standard MG jack.
The auto-release innards make the stressing process more efficient as there is no requirement to remove/install the jack wedges manually.

CCL STRESSING SEQUENCE

1. Place the anchor head plate onto the strands, ensuring that the centre mark is at the top. Fit the wedges into the anchor head, then fit the bearing ring and lock-off plate.

2. Thread the jack onto the strands. A suitable lifting device should support the weight of the jack.

3. Push the jack up to the anchorage. For jacks without auto-release innards, insert the jack wedges into the pulling plate inside the rear of the jack.

4. All stressing operations are controlled from the pump unit to ensure the operator's safety. Carry out stressing, lock-off and retraction. The lock-off pushes the lock-off plate forward, which seats the anchorage wedges firmly into the anchor head.

MONOSTRAND JACKS

The primary items of equipment in the XF and XU operations are the CCL Stressing Jacks.

The noses of the jacks can be changed to suit various applications and feature automatic gripping and lock-off on the strand. All jacks must be calibrated to a pump before use. They can be used for partial stressing and successive loading if necessary.

HR SERIES JACKS

CCL HR Series Jacks have a compact, lightweight design and are intended for site use with the CCL SRX series pump.

They are designed to stress the XF and XU anchorages. The noses of the jacks can be changed easily to suit different applications.

The standard HR jack is equipped with mechanical lock off.

The HRL jack is supplied fitted with hydraulic lock off.

STRESSOMATIC JACKS

The Stressomatic range delivers fast and consistent stressing forces up to 300 kN.

Please contact CCL for advice on appropriate jack selection for a given application.

STRESSING SEQUENCE

1. After removal of formwork the anchor head and wedges are threaded onto the strands.

2. Using the correct jack and nose combination with calibrated pump/gauge, the jack is threaded onto the strands and pushed up to the anchor head.

3. All stressing operations are controlled from the pump unit to ensure the operator's safety. The jack is extended and when the load is reached, the jack lock-off system is applied which firmly seats the wedge into the anchor head.

4. The jack is then retracted and the wedge released so the jack can be removed when the full load is reached or the operation can be repeated until the required load is achieved.

XF SEQUENCE

If missing out a strand it should be considered that the following should be omitted:

XF-10-3-13 Position 1

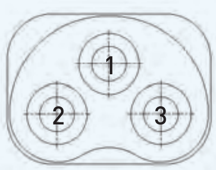
XF-20-5-13 Position 3

XF-30-6-13 Position 3

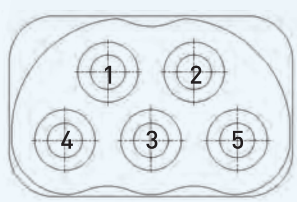
XF-10-2-15 Position 2

XF-20-4-15 Position 2

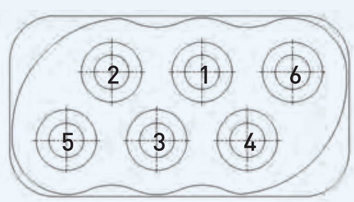
XF-30-5-15 Position 3



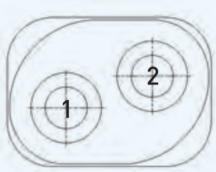
XF-10-3-13



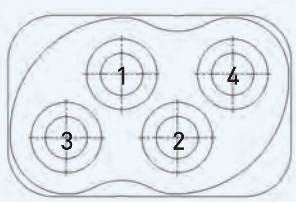
XF-20-5-13



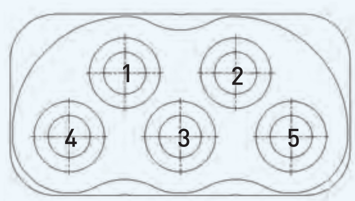
XF-30-6-13



XF-10-2-15



XF-20-4-15



XF-30-5-15

CCL PUMP UNITS

CCL Pumps deliver multiple pressures to speed up the stressing operation while maintaining control for precise stressing when needed. Pumps can be supplied in various voltages with analogue or digital readouts.

SR5000 PUMP

SR5000 pumps are heavy duty pumps to power MG Multistressing Jacks. They are specifically designed for site work and the high demands required to stress multiple strands simultaneously.

Pump	Weight kg
Multi Pump High Speed 380/415V 3Ph 50Hz	256

SR4000 PUMP

The SR4000 is designed for precast applications and provides a higher output alternative to the SR3000 PT Pump. It is compatible with all CCL Monostrand Jacks with both hydraulic lock-off and mechanical lock-off.

Pump	Weight kg
SR4000 110V 3Ph 50Hz	125
SR4000 220/240V 3Ph 50Hz	125
SR4000 380/415V 3Ph 50Hz	125

SR3000 PUMP

SR3000 pumps are of a robust design and come complete with a protective frame as standard. The high build quality and specifications of the parts used ensure reliability and a low-maintenance life for the unit.

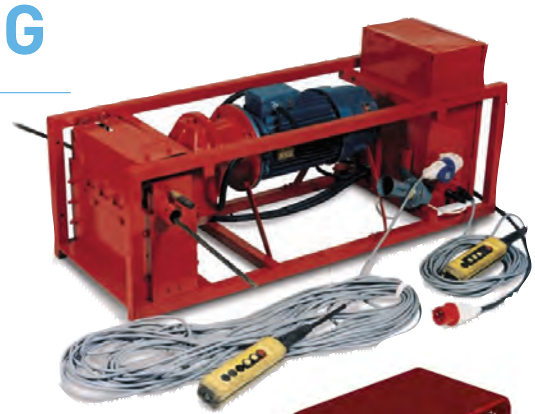
Pump	Weight kg
SR3000 PT 110V 3Ph 50Hz	125
SR3000 PT 220/240V 3Ph 50Hz	125
SR3000 PT 380/415V 3Ph 50Hz	125

SRX PUMP

SRX pumps are designed as a compact lightweight alternative to the SR3000 unit and are capable of delivering excellent performance on small strand diameters. Supplied in various voltages this pump is ideal for site work.

Pump	Weight kg
SRX Pump 110V 3Ph 50Hz with Analogue Gauge	62
SRX Pump 220/240V 3Ph 50Hz with Analogue Gauge	62
SRX Pump 415V 3Ph 50Hz with Analogue Gauge	62

INSTALLING AND GROUTING



CCL STRAND INSTALLATION

For internal prestressing the ducts are placed prior to concreting. The strand is delivered to site in coils and placed in special dispensers to prevent it from uncoiling.

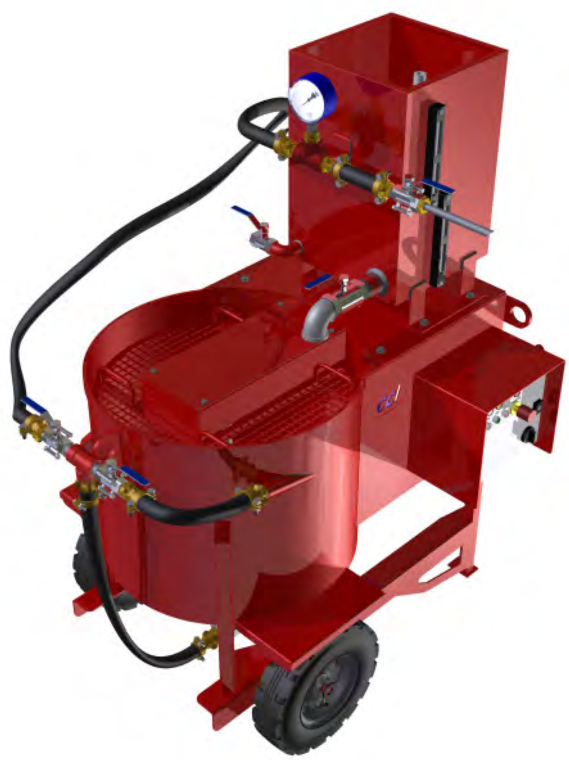
Before or after concreting, strands are pushed or winched into the duct from one end and cut to length. The installation method depends on the length of the tendon and access conditions.

The heavy duty strand pusher provides the necessary power required for pushing strand on civil applications.

A smaller version is available which is designed for use on post-tensioned slabs. Its compact but robust build makes it ideal for use on the most challenging construction sites.

THREADING BULLETS

Special threading bullets are fixed to the leading end of the strand (in the case of pushing) to ease the passage of the strands through the duct. Using CCL Strand Pushers the pushing can be controlled from both ends of the tendon (using remote controls) ensuring a safe and efficient operation.



CCL GROUTING

The durability of any post-tensioning is affected by the quality of the grouting operation. The grout, as well as providing a bond between the concrete and the tendon, provides long-term corrosion protection for the steel strand.

If the grouting is not carefully controlled and undertaken by experienced professionals, it will compromise the structure and affect its lifespan.

Grouting is undertaken through the anchor using special threaded fittings and valves to ensure a clean and effective grouting operation. Intermediate vents are created along the tendon using grout saddles.

Built for performance, safety and reliability, the CCL Grout Pump has three lifting points for ease of manoeuvrability on site and features automatic cut out when the hopper lid is raised.

FRICTION LOSSES

In post-tensioned concrete, the effect of friction between strands and sheathing during stressing is a major factor for loss of prestress.

There are three main causes of friction loss in the post-tensioned tendon:

- Friction due to the deviation of the tendon through the anchorage.
- Friction between the tendon and the duct due to unintentional lack of alignment (or wobble) of the duct.
- Friction due to the curvature of the duct.

Friction loss in CCL XM Anchorages determined from testing is 2% to 3%.

WEDGE SET

After the transfer of load from the jack to the anchorage, the strand and wedges draw a little further into the anchor head. This further movement is known as wedge set or draw-in. The wedge set leads to a loss of tension in the strand which must be taken into account in the loss and elongation calculations. The value for wedge set to be used in the calculations for all active anchorages stressed with jacks with hydraulic lock-off is:

Wedge set = 6 mm ± 2 mm

DUCT FRICTION LOSS

Friction loss in the duct for post-tensioned tendons can be estimated from:

$$\Delta P_{(x)} = P_{max}(1 - e^{-\mu(\theta+kx)})$$

Where:

$\Delta P_{(x)}$ - Loss of force due to friction

P_{max} - Force at the active end during tensioning (after losses within the anchorage)

θ - Sum of the angular displacements over a distance x (radians - irrespective of direction or sign)

μ - Coefficient of friction between strand and duct (1/radian)

k - Unintentional angular displacement (radians per unit metre)

x - Distance along the tendon from the point where the prestressing force is equal to P_{max}

NOTE: Some design software and country codes use a term K or k = wobble or unintentional friction (per unit metre). This is taken as K = μk, and the formulae is rearranged to suit.

The values for coefficient of friction and unintentional angular displacement k should be in line with EN 1992 Eurocode 2: Design of Concrete Structures, as shown in the table below.

Application	Duct Type	μ		k	
		Non-lubricated	Lubricated	Minimum	Maximum
Internal Prestressing	Corrugated Metal	0.19	0.17	0.005	0.01
	HDPE	0.12	0.10	0.005	0.01
	Steel Smooth Pipe	0.24	0.16	0.005	0.01
External Prestressing	HDPE	0.12	0.10	N/A	N/A
	Steel Smooth Pipe	0.24	0.16	N/A	N/A

When the tendon to be controlled has two active / LE anchorages, i.e. with the tendon being able to be stressed with the jack at both ends, the measurement on site of the friction loss of the tendon is possible by comparing the load applied by one jack to the load measured on the other jack.

Established in 1935, CCL has a long history of providing specialised engineered solutions for structures. Every day, CCL products and services are used in building and civil engineering structures across the world.

CCL's advanced solutions help engineers, planners and construction companies create and maintain these structures.

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